TRANSACTIONS
of the
Fiftieth North American
Wildlife and Natural Resources
Conference

Conference Theme:

Taking Stock: Resource Management in the 50th Year

March 15-20, 1985
The Shoreham Hotel
Washington, D.C.

Edited by
Kenneth Sabol

Published by the
Wildlife Management Institute
Washington, D.C.
1985

Additional copies may be procured from the
WILDLIFE MANAGEMENT INSTITUTE
1101 14th Street, N.W., Suite 725
Washington, D.C. 20005

Transactions of the Fiftieth
North American Wildlife and Natural Resources Conference
ISSN 0078-1355

Printed in
U.S.A.

Wildlife Management Institute

Officers
DANIEL A. POOLE, *President*
L.R. JAHN, *Vice-President*
L.L. WILLIAMSON, *Secretary*

Program Committee
LAURENCE R. JAHN, *Chairman*
ROBERT D. NELSON, *Cochairman*
ROLLIN D. SPARROWE, *Representing the Wildlife Society*

JOHN C. BARBER, *Executive Vice-President*
Society of American Foresters, Bethesda, Maryland
ENRIQUE BELTRAN, *Director*
Instituto Mexicano de Recursos Naturales Renovables, Mexico City, Mexico
ORVILLE G. BENTLEY, *Assistant Secretary for Sciences and Education*
U.S. Department of Agriculture, Washington, D.C.
JACK H. BERRYMAN, *Executive Vice-President*
International Association of Fish and Wildlife Agencies, Washington, D.C.
WILLIAM D. BLAIR, JR., *President*
The Nature Conservancy, Arlington, Virginia
CHARLES L. BOOTHBY, *Executive Vice-President*
National Association of Conservation Districts, Washington, D.C.
SHIRLEY A. BRIGGS, *Executive Director*
Rachel Carson Council, Inc., Chevy Chase, Maryland
KENNETH E. BRYNAERT, *Executive Director*
Canadian Wildlife Federation, Ottawa, Ontario, Canada
ROBERT F. BURFORD, *Director*
Bureau of Land Management, Washington, D.C.
CHARLES H. CALLISON, *President*
Public Lands Institute, Washington, D.C.
FORREST A. CARPENTER, *President*
National Wildlife Refuge Association, Prior Lake, Minnesota
EMERY N. CASTLE, *President*
Resources for the Future, Washington, D.C.
WARREN L. CHEEK, *Secretary*
National Rifle Association of America, Washington, D.C.
WILFREDO CONTRERAS DOMINGUEZ, *Director*
Direccion General de la Flora y Fauna Silvestre, Mexico City, Mexico
RICHARD H. CROSS, JR., *Executive Director*
Commission of Game and Inland Fisheries, Richmond, Virginia
PETER D. CURRY, *President*
North American Wildlife Foundation, Montreal, Quebec, Canada
RUSSELL E. DICKENSON, *Director*
National Park Service, Washington, D.C.
KAY ELLERHOFF, *President*
Association for Conservation Information, Helena, Montana
WILLIAM G. GORDON, *Assistant Administrator for Fisheries*
National Marine Fisheries Service, Washington, D.C.
C.R. GUTERMUTH, *President*
Wildfowl Foundation, Arlington, Virginia

JAY D. HAIR, *Executive Vice-President*
National Wildlife Federation, Washington, D.C.
LT. GEN. E.R. HEIBERG III, *Chief of Engineers*
U.S. Army Corps of Engineers, Washington, D.C.
ROBERT L. HERBST, *Executive Director*
Trout Unlimited, Vienna, Virginia
A. ALLAN HILL, *Chairman*
Council on Environmental Quality, Washington, D.C.
ROBERT A. JANTZEN, *Director*
U.S. Fish and Wildlife Service, Washington, D.C.
JAMES JONES, *President*
Sea Grant Association, Ocean Springs, Mississippi
JACK LORENZ, *Executive Director*
Izaak Walton League of America, Arlington, Virginia
DONALD E. MacLAUCHLAN, *Director*
Forest, Park and Wildlife Services, Annapolis, Maryland
CHARLES E. MESLOW, *President*
The Wildlife Society, Corvallis, Oregon
H.M. MILLER, *President*
National Association of State Foresters, Salem, Oregon
KENTON R. MILLER, *Director General*
International Union for Conservation of
Nature and Natural Resources, Gland, Switzerland
PETER C. MYERS, *Chief*
Soil Conservation Service, Washington, D.C.
WALTER N. PEECHATKA, *Executive Director*
Soil Conservation Society of America, Ames, Iowa
WILLIAM S. PLATTS, *President*
American Fisheries Society, Monroe, Louisiana
RAMON PEREZGIL SALCIDO, *Director for Terrestrial Wildlife*
Direccion General de la Flora y
Fauna Silvestre, Mexico City, Mexico
R. MAX PETERSON, *Chief*
U.S. Forest Service, Washington, D.C.
RAFE POMERANCE, *Past President*
Friends of the Earth, San Francisco, California
PAUL C. PRITCHARD, *Executive Director*
National Parks and Conservation Association,
Washington, D.C.
GILBERT C. RADONSKI, *President*
Sport Fishing Institute, Washington, D.C.
EVERETT G. RANK, *Administrator*
Agricultural Stabilization and Conservation Service, Washington, D.C.
SALLY RANNEY, *President*
American Wilderness Alliance, Denver, Colorado
WILLIAM K. REILLY, *President*
The Conservation Foundation, Washington, D.C.
DOROTHY S. RIDINGS, *President*
League of Women Voters of the United States, Washington, D.C.
WILLIAM D. RUCKELSHAUS, *Administrator*
Environmental Protection Agency, Washington, D.C.
R. NEIL SAMPSON, *Executive Vice-President*
American Forestry Association, Washington, D.C.

NORMAN STRUNG, *President*
Outdoor Writers Association of America, Bend, Oregon
J. L. SCHUSTER, *President*
Society for Range Management, College Station, Texas
BERTRAND TETREAULT, *Director General*
Canadian Wildlife Service, Ottawa, Ontario, Canada
RUSSELL E. TRAIN, *President*
World Wildlife Fund (U.S.), Washington, D.C.
WILLIAM A. TURNAGE, *Executive Director*
The Wilderness Society, Washington, D.C.
DALE E. WHITESELL, *Executive Vice-President*
Ducks Unlimited, Long Grove, Illinois

LADIES COMMITTEE

Mrs. Dorothy C. Poole | Mrs. Helen F. Jahn
Mrs. Bettina S. F. Sparrowe
Mrs. Patsy S. Williamson | Mrs. Midge Nelson

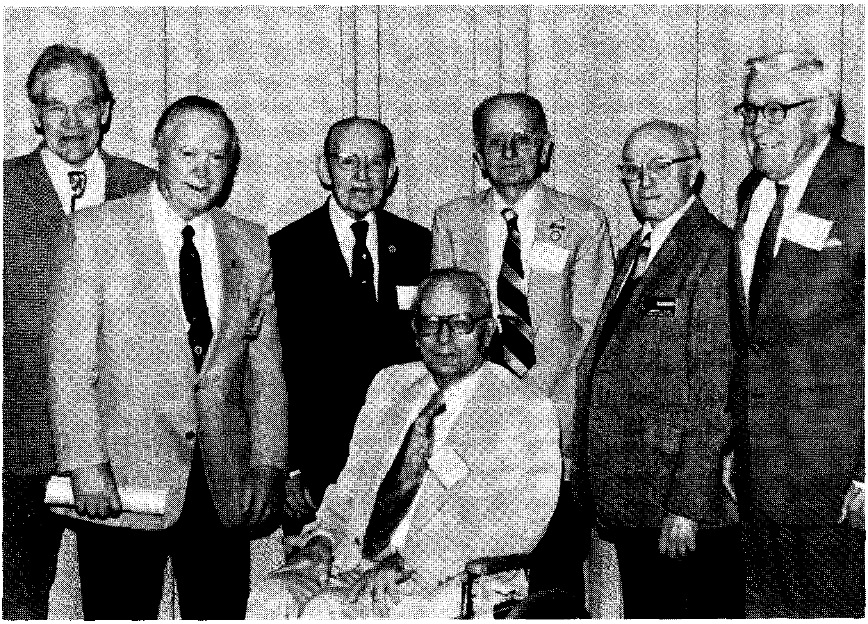
Contents

Forested Lands: Management for Multiple Benefits

Plans and Actions for Fish and Wildlife: Case Histories

Migratory Wildlife: Status, Needs and Future Management Directions

Symposium: The Role of Diseases in Marine Fisheries Management



Attendees of the 1st *and* 50th North American Wildlife and Natural Resources Conferences Taken at the 50th Conference, March 18, 1985, Shoreham Hotel, Washington, D.C. Left to right: A. Heaton Underhill, Daniel L. Leedy, C.R. "Pink" Gutermuth, Gustav A. Swanson, Reuben E. Trippensee, Durward L. Allen, Henry Clepper (missing: Lawrence V. Compton). *Photo by Francis N. "Curly" Satterlee.*

THE WHITE HOUSE

WASHINGTON

January 14, 1985

I am honored to have this opportunity to congratulate the professional natural resource managers, administrators, and researchers gathered for the Golden Anniversary meeting of the North American Wildlife and Natural Resources Conference.

During the last five decades, this assembly of dedicated professionals has met to expand the horizons and boundaries of wildlife and natural resources management and conservation efforts throughout this land. In addition, its members have led a movement to foster and enhance the American people's appreciation of our wildlife heritage and the need for natural resource conservation.

Largely through their efforts, the fledgling practice of wildlife management that began over 50 years ago has developed into an exacting branch of scientific endeavor. Today this nation boasts one of the world's finest collections of natural areas set aside and administered by governmental entities at the Federal, State, and local level, as well as private organizations to benefit a diversity of fish and wildlife resources.

New challenges lie ahead. As human populations expand and needs increase innovative approaches and methods are needed to ensure a balance between the activities of man and the life-sustaining requirements of wildlife. As you meet to mark the first half-century, I urge you to look ahead, along with all Americans, toward actions and attitudes that will ensure the conservation of this nation's soil, waters, and vital wildlife resources into the 21st century and beyond. Continued progress towards this goal will require a spirit of cooperation and teamwork at all levels.

It is my pleasure to join with you in recognition of your landmark 50th gathering and to offer my warmest congratulations upon this occasion.

Ronald Reagan

THE SECRETARY OF THE INTERIOR

WASHINGTON

CALL FOR
50TH NORTH AMERICAN WILDLIFE AND NATURAL RESOURCES CONFERENCE

It is most appropriate to take stock of our natural resources and systems for their management and conservation at this Golden Anniversary of the North American Wildlife and Natural Resources Conference.

Americans should take pride in the fact that management capability has progressed substantially in the past five decades. But as the human population continues to expand and society's activities become more evident on the landscape, new insights from research and practical experiences are needed to refine and advance management programs even further. Continued progress will require new alliances and more effective teamwork at all levels, public and private.

President Reagan joins me in urging all interested Americans to be alert to these needs and become actively, constructively and effectively involved in this conference and in coming years. The challenge at this mid-century stage is to focus our collective attention on the existing resource base and its contribution to national and individual well-being. We must re-emphasize our resolve to conserve the soil, water, plants, wildlife, fish and other resources. Our mutual objective is to have these vital resources continue to contribute to the economy and quality of life for all Americans now and in the future.

I urge you to make this 1985 Conference a milestone in our country's history.

William P. Clark

William P. Clark, Chairman
Cabinet Council on Natural Resources
and the Environment

Identifying Needs and Opportunities to Improve Natural Resources Management

Chairman:
BRYCE JORDAN
President
Pennsylvania State University
University Park, Pennsylvania

Cochairman:
RUSSELL A. COOKINGHAM
President
International Association of Fish and Wildlife Agencies, and Director
Division of Fish, Game and Wildlife
Trenton, New Jersey

Opening Remarks

Daniel A. Poole
President
Wildlife Management Institute
Washington, D.C.

Good morning, ladies and gentlemen. Welcome to the 50th North American Wildlife and Natural Resources Conference. This golden anniversary year is an occasion for celebration, for truly monumental accomplishments have been made during the past half-century. It also is a time for rededication, because obstacles to sound resource planning, protection and use are infinitely more numerous and complex than ever before.

President Franklin Delano Roosevelt convened the first conference, here in this city on February 3, 1936. He did so, he said ". . . to bring together individuals, organizations and agencies interested in the restoration and conservation of wildlife resources." "My hope," he continued, "is that through this conference new cooperation between public and private interests, and between Canada, Mexico and this country, will be developed; that from it will come constructive proposals for concrete action; that through these proposals existing State and Federal governmental agencies and conservation groups can work cooperatively for the common good."

That first Conference and those that have followed each year have striven to serve those purposes for 50 years. And for 21 years prior to 1936, the annual American Game Conference, held under the auspices of a predecessor of today's Wildlife Management Institute, was a forum for individuals and organizations that had well-founded concerns about the future of wildlife. Happily, virtually all of the species that were imperiled at the turn of the century are improving or recovered today.

But progress here, as elsewhere, is measured in paces, not quantum leaps. During these many past years, and particularly during the last 50, wildlife management has emerged as a scientifically grounded profession. Where once there were none, many colleges and universities now offer major programs of wildlife study, thereby assuring a continuous pool of trained individuals to enter the profession. Increasingly sophisticated research uncovers more information about wildlife and its environment, thereby nourishing policies, administration and management. Greatly increased numbers of conservation law enforcement officers help to discourage the abuse and misuse of wildlife. Millions of acres are devoted primarily to wildlife purposes. Old authorities have been amended and new laws enacted in response to emerging issues and opportunities. Where once there were few, agencies now in all 50 United States are charged with protecting and maintaining wildlife.

Resource management funding and staffing have increased substantially, including for federal agencies responsible for immense expanses of natural habitat. The scope of federal and state wildlife agency programs has broadened considerably. Comprehensive planning and programming for all wildlife—not mainly for game species—are gathering momentum. Thirty-two states now have some form of an income tax checkoff, which gives more members of society a convenient opportunity to contribute toward wildlife's welfare.

But new problems and new challenges rise in place of old ones. Unlike in earlier years, however, today's threatened wildlife are not the hunted. They are the nonhunted. Again and again, the wildlife management profession has demonstrated that it can resolve wildlife problems of a biological nature. But the profession makes meager headway in surmounting social and political opposition to necessary actions. Even in the straight-forward matter of well-advised regulatory changes, misguided social and political opposition proved threatening to wildlife's future. Enhanced public understanding of wildlife's circumstances and the role of scientific management must be a major goal in the years ahead.

A second and equally serious problem is the continuing alienation and loss of habitat—often mindless and wasteful of both private and public lands. Government stimulates much of it, either as concessions to special interests or as subsidies that cannot be justified in terms of resource commitment and use. Resistance to reorientation of those tax-supported programs that stimulate resource loss can and must be countered by improving public awareness, understanding, and support.

And there is yet another problem. Its source is with those who profess to care for wildlife, and unquestionably do, but whose impatience, intolerance, and lack of understanding prompt them to demean the purposes and accomplishments of wildlife management. Constructive criticism can be a pathway to progress, but factless and emotional criticism not only makes no contribution at all, but it hinders progress. No reasonable and reasoning person can realistically claim that there is a method superior to scientific management as the basis for maintaining wildlife. While management may not produce positive results with the speed or precision that each of us desires, it should be obvious to all that speed and precision are not hallmarks of our uncertain human world.

To those who would spare Bambi and thereby destroy forests, to those who fret about feral animals and thereby condone the loss of native wildlife and plants, I suggest that wildlife's well-being would benefit from your improved understanding. I urge those persons to grow and mature as scientific wildlife management has done and as its practitioners seek always to do. Wildlife's worst enemies are the indifferent and the uniformed.

The proclaimed father of modern wildlife management, Aldo Leopold, whose perceptive writings are cited by wildlife professionals and critics alike, began his career as an outspoken advocate of predator control. But he, too, grew and matured. In his classic essay, "Thinking Like a Mountain," Leopold came to recognize truth in the eyes of a dying wolf and, from that experience he gained understanding and wisdom. Anyone who will look into the constructive record of wildlife management in North America cannot help but be similarly benefited.

To do this would be in keeping with the thoughts of President Reagan in his call for this 50th Conference: ". . . I urge you to look ahead, along with all Americans, toward actions and attitudes that will ensure the conservation of this nation's soil, waters, and vital wildlife resources into the 21st century and beyond. Continued progress towards this goal will require a spirit of cooperation and teamwork at all levels."

The Need for Consensus on Natural Resources Issues

The Honorable Donald P. Hodel
Secretary of the Interior
Washington, D.C.

Good morning and thank you for the opportunity to be with you today.

It is an honor for me to participate in the 50th North American Wildlife and Natural Resources Conference. As I read over your program, I was impressed not only by the magnitude and complexity of issues you have been and are addressing, but I also was struck by the wide representation of interests participating. I want to commend the North American for continuing a worthy tradition of communication to work toward consensus on some very tough issues.

I have tried to make it known to all of the constituencies interested in Interior Department programs that I truly believe this Nation is best served by consultation, consensus, and accord on the major natural resource issues. I try to keep open to all interests. I need to hear divergent views. Then, if we can work toward agreement on those broad national policies that are right for America—and that reflect the values needs, and wishes of the American people—everyone will benefit.

I have been fortunate to have been able to meet with many of the organizations represented at this conference. And, this Saturday, I was pleased to address the National Wildlife Federation. During that speech, I tried to focus on some of the key domestic issues we are facing in wildlife and natural resources management. I also noted the series of charges given to me when President Reagan nominated me to be the 45th Secretary of the Interior:

- *to preserve* the Nation's national park, wilderness, and wildlife resources;
- *to enhance* America's ability to meet our energy and mineral needs with domestic resources;
- *to increase* the supply of quality water resources;
- *to continue* to improve the federal government's relationship with state and local governments; and
- *to develop* the economic and social resources of American Indians, Native Americans, and the people of the U.S. Territories.

I believe these goals are supported by most Americans. The question we face is: how do we move toward a consensus on the appropriate broad policies necessary to support these goals.

I have spoken about my personal appreciation for the national treasures for which I now have stewardship responsibility—an appreciation instilled in me by my father who used to marvel out loud that America is a beautiful and vast Nation blessed with land, water, mountains, forests, and wildlife. He left me convinced that those of us who love those natural resources have an obligation to encourage a national commitment to conserve and preserve them. And, from a more global perspective, our enthusiasm can instill similar spirit among our neighbors to pursue the same commitment.

I have also underscored the commitment President Reagan and I share to preserve those areas we—-through our political processes—have designated for special protection because we believe they should be preserved for present and future generations. At my confirmation hearing, I emphasized "I will not consider, I will not support, I will not permit development activities such as mining, drilling or timber harvesting in our national parks'' or ''in our Wilderness areas.'' I believe this is the right policy.

I am told that when the first North American Wildlife Conference was convened nearly a half-century ago, the overriding issue was stable and workable budgets for wildlife conservation. Thanks in great measure to some of the conservation legislation which arose from ideas first conceived at earlier North American gatherings, our Nation now enjoys healthier and more consistent funding for natural resources and wildlife management.

I recognize that there is concern about the pace of acquisition of lands for our national park and wildlife refuge systems. The issue stems from the very difficult federal budgetary situation America now faces.

I spoke earlier about the need for consensus on broad national policies. Well, it appears that if there is national consensus on anything in this country today, it is on the need to reduce the federal deficit—which now totals $180 billion.

In that context then, the deficit has necessitated difficult policy choices in the Interior budget. Those choices have meant reducing or eliminating some good programs which have produced tangible benefits and which, evaluated on their own merits or in a different budget context, would be funded. I hope it is clear, however, that this Administration believes the major resource endeavors of the National Park Service and the Fish and Wildlife Service will continue to be regarded as essential to the public good.

Let me emphasize that it is our policy to continue acquisition of lands for park, refuge, and wilderness purposes. Our budget request for acquisition—though limited—will, when coupled with carryover funds, permit us to acquire the most important lands. The budget proposals suggest deferring other acquisitions for a three-year period. Whether this deferral would be proposed in subsequent years would be dependent upon review of the issues as each future budget is developed. We believe this deferral will not impair the primary missions of the Department or affect ongoing operating programs. We are requesting $13 million for deficiencies, emergencies, and administrative costs. And, $177 million is available with 1985 appropriations and Duck Stamp receipts.

For the Fish and Wildlife Service specifically, it is likely they will have at least a $10 million carry-over in the Land and Water Conservation Fund next year. Coupled with Duck Stamp monies, up to $30 million could be available for needed habitat acquisition in FY 1986.

Wetlands protection is key to two of our major resource endeavors—protecting our national wildlife refuges and our international waterfowl resources.

With regard to refuges, I am pleased to note that the Accelerated Refuge Maintenance Management Program initiated last year has been very successful in restoring and upgrading our refuge facilities.

Our waterfowl are indeed a resource that requires concern and attention. We must work to enhance breeding and nesting areas. We must promote international cooperation in safeguarding the quality wetlands upon which these birds depend. And, we must continue to carry out sensible and fair non-toxic shot implementation as a means to enhance waterfowl populations. On this latter subject, a fact sheet is available here today on the Fish and Wildlife Service's current efforts in non-toxic zone designations. Finally, we should continue to increase public awareness of our waterfowl and wetland conservation goals.

You have probably heard about the serious drainage and salt management problems in California's San Joaquin Valley. Naturally occurring selenium—which is toxic in large concentrations—has been leaching out of the soils in the valley and ending up in the Kesterson reservoir and wildlife refuge. The problem became evident when deformed ducks were found at the reservoir.

Our position has been and will be strongly that protection of public health is of paramount importance and that any threat to health must be dealt with swiftly and surely. Based on our extensive monitoring and what we believe have been responsible corrective actions, there have been no findings of immediate danger to public health or safety. We are continuing these actions, and if an immediate threat is found, we will move expeditiously to protect public health and safety.

We also feel strongly that in addressing this issue we must act in full compliance with state and federal law. We have concluded that because the hazing program we instituted at Kesterson is not as effective as was hoped *and* because the Migratory Bird Treaty Act appears to create the possibility of a violation of criminal law without regard to intent or knowledge, immediate action must be taken.

Therefore, I have instructed the Bureau of Reclamation and the Fish and Wildlife Service to begin the process of shutting down the Kesterson Reservoir. This process will result in plugging the San Luis drain and stopping the delivery of irrigation water to lands which drain into the Reservoir. Also, we will begin the process of cleaning up the water and soil in the reservoir. The hazing program and comprehensive study program already initiated will continue.

I have also instructed the Service and the Bureau to identify any other situations, in California and elsewhere, where continued irrigation or other department actions may violate our responsibilities under the Treaty Act. It is important we recognize the potential scope of the action which may be required by that Act.

In the Kesterson situation, the Secretary of the Interior has been charged by the Congress to provide irrigated water under the Central Valley Project to the San Joaquin Valley and to enforce the strict prohibitions against the taking of migratory waterfowl under the provisions of the Treaty Act. I have concluded that my oath of office requires me to take these actions to ensure the laws are faithfully implemented. Ultimately, the Congress, which has created this legal environment of conflicting mandates, must take affirmative steps to establish priorities under which I must discharge my responsibilities.

We also recognize that we have responsibilities to those who have contracted with us for delivery of irrigation water. Irrigated agriculture clearly is important to the economy of California and the Nation. We have been and will diligently seek permanent, scientific solutions to this problem. In the interim, however, we have no choice but to take this action. We certainly can use support and help in this effort and would appreciate any you can provide.

I want to turn to some more positive initiatives for the Department and for some waterfowl, too. Among those are our accomplishments in the endangered species program. As you probably heard from Fish and Wildlife Service Director Jantzen, the Administration supports a four-year reauthorization of the Endangered Species Act. We are seeking no amendments. In the relatively short period of time the present Endangered Species Act has been with us, there have been great accomplishments in saving dozens of our native species and their habitats.

As I have thought about the need to care for our national treasures, in the context of fiscal constraints, I have been pondering ways to encourage and extend citizen participation in protecting their resources.

We have seen an increasing spirit of volunteerism in this country which is encouraging indeed—not just individual contributions but also corporate efforts to pick up where federal budgets leave off. This seems particularly manifest in the natural resources area. I am encouraged by and grateful for this spirit.

Some of you here today have been involved with us in the acquisition of important lands through exchange and donation. We will continue to pursue these efforts and to develop and use other land protection measures—such as conservation easements—which can be extremely effective.

National parks, refuges, and wildernesses are national assets, but they are also local assets. Those who are fortunate enough to live close to a national park, for example, should—and I believe do—care very deeply about protecting that asset from misuse or abuse. I would like to encourage greater involvement by our citizens and community organizations in caring for *their* resources.

An issue that relates directly to this line of thinking is that of dedicated user fees. I tried to clarify the Administration's position in my Saturday speech and will make the same attempt here. Our proposal is to increase entrance fees for national parks. As always in the federal system, we are studying the possibility of increasing cost recovery, and an increase in recreation fees is certainly a viable option. We do not plan to increase entrance fees across the board, but would look for reasonable increases where appropriate.

We will eventually seek to cover up to 25 percent of our operating costs, instead of the present 2 percent. We would hope to improve collections where fees in place are appropriate but are not being collected and, for instance, raise a $1 entrance fee that's been at that level for 30 years. We would *not* raise a $6 camping fee if it is the going rate.

I believe we all share a commitment to providing Americans with outstanding recreational opportunities. While the word "recreation" has come to mean "fun," its root is clearly "re-creation," or remaking oneself. It is in that sense that I view the word. In our increasingly industrialized and urbanized society, it is imperative that our citizens be able to enjoy *re*-creative experiences. Workers are more productive and clear-thinking if they are able to unwind. I believe we must dedicate ourselves to finding appropriate ways to ensure that all Americans can enjoy our parks and other recreation areas without damaging the resources or disturbing the experiences of others.

The recently established Presidential Commission on Outdoor Recreation Resources Review will be of great assistance in determining an approach that will preserve and create recreation opportunities. We are as anxious as many of you to name the Commission members and get them started.

Another issue on which you and your organizations have expressed to me a great interest is the Administration's position on the Wallop-Breaux fund.

As you know, our fiscal year 1986 budget proposal proposes a repeal of the *permanent* appropriation authority of the Sport Fishing Restoration Fund as a means to control federal expenditures. Obviously, such a repeal can only be done by Congress. We felt, however, that with severe cuts throughout the government, we had an obligation to suggest to Congress that an increase of more than 200 percent had to be reviewed.

I should note though that the $77 million in motorboat fuel and luxury boat import taxes are not to be diverted to the general treasury; they will go into the Wallop-Breaux Trust and build interest. Our budget request does support transfer of excise taxes from the expanded list of items to sport fishing. This is expected to provide nearly a 16 percent increase in the Sport Fish Restoration Fund next year. Admittedly, many of us wished for more. At any rate, the future of this proposal is very much a matter for the Congress to decide.

On another budgetary matter in this area, our 1986 budget request makes clear that the Fish and Wildlife Service will support all of the national fish hatcheries next year. We are not seeking to close or transfer any fish hatcheries in this budget.

I am greatly encouraged by recent steps forward in fishery conservation. President Reagan, in his trip to Quebec to meet with the Canadian Prime Minister, will exchange articles of the recently ratified U.S.-Canada Salmon Interception Treaty. This event marks a milestone in international conservation agreements and culminates a very long and detailed negotiation process to help conserve our salmon resources. And, it should prove to be good news for sport and commercial fishermen in both countries.

As we continue our efforts to protect the resources I've mentioned, we all must recognize that the great national treasures with which our Nation is blessed also include *multiple-use* lands. These are lands which *do not* possess the special qualities of parks, wilderness, refuges, or other specially protected lands.

On or under these multiple-use onshore lands or the 1-billion-acre Outer Continental Shelf (OCS) are vast energy and mineral resources. We have tremendous potential to increase our energy independence and improve our national security. It is part of the Interior Secretary's stewardship responsibilities to seek to provide access to those domestic resources while insisting upon full environmental safeguards. I am committed to doing just that.

Through consultation and consensus building, I believe we can hope, over time, to reduce the conflicts arising over these issues.

I believe it makes little sense to spend billions of dollars each year on purchases of imported oil for the Strategic Petroleum Reserve, and billions more on defense systems to protect our oil supply from the Middle East, while we foreclose access on multiple-use lands to what should recoverable domestic energy resources.

Recognizing the need to achieve energy independence while acting as steward of our Nation's resources, it is my intention to pursue the objective of energy independence insofar as the policies and programs of the Department of the Interior can contribute to its achievement.

Continued exploration and development of the energy resources of the Outer Continental Shelf can contribute to that objective. This week, we will be announcing an important step in developing the next 5-Year OCS plan to be made final in the late summer of 1986. We will present for public comment a draft proposed 5-Year OCS Plan. At this time, I am leaning toward an OCS program that emphasizes early and complete consultation with the Congress, the states, industry, and environmental interests so that we all can focus our attention and review on the promising acreage for possible leasing.

Also in some critical areas, we may slow the pace of offerings to allow more time for consultation and conflict resolution. In so doing, I hope to reduce the hostility toward the program and be in a better position to consult with state and local governments, the Congress, and interested parties to reach a consensus on appropriate leasing areas. I also hope this process will put us in a position where Congress no longer feels impelled to impose moratoria.

The idea behind our new program will be to remove environmentally unacceptable tracts at the very beginning so that we do not have to spend valuable time and money arguing about them.

The need for such a consensus is apparent, too, for effective implementation of all federal energy and mineral development programs—offshore and onshore, oil and gas, and coal. It is true, again, in our water development programs.

We have seen the success of consultation and coordination demonstrated by the Garrison Diversion Unit Commission. We appreciate the hard work of the environmental and wildlife community and other members of the Commission in developing a plan which could meet both water supply and environmental protection concerns.

The even-handed and sensitive approach of the Commission effectively quelled the controversy which had been raging around Garrison for decades, and in so doing may teach us all a lesson.

I have only briefly touched upon some of the many issues which we confront at the Department of the Interior. They are issues you as professional wildlife managers and conservationists also must address. You provide an incredibly important link between our programs and similar programs administered in the states and localities. We also share communications responsibilities—here and abroad.

Because many of these issues are particularly difficult and challenging, they may not be resolved without serious cooperation, consultation and communication among all interests. They will require extensive discussion even among friends.

As I indicated at the outset of my remarks, I recognize that I will need to leverage time in my schedule to consult on the issues, and I hope that you will be able to do likewise.

I would much rather we spend our time and hard-earned taxpayer dollars in improving the parks and wilderness systems, or in increasing our national security, than in paying lawyers to litigate.

Thank you, again, for the opportunity to talk with you today.

Special Golden Anniversary Address

These Fifty Years: The Conservation Record of North American Wildlife and Natural Resources Conferences

Durward L. Allen
Emeritus Professor of Wildlife Ecology
Department of Forestry and Natural Resources
Purdue University
West Lafayette, Indiana

Viewed in today's perspective, the world was a much different place fifty years ago. As of 1936 there were 127 million people in the United States. I don't think anyone was predicting that another 100 million would be added in the next half-century. Even if they had known it, few would have taken it seriously. At that time Americans had little perception of what it would mean, in terms of resource costs and environmental change, to service an additional hundred million citizens at our standard of living. Unfortunately, many people do not have such perception even today.

In February 1936, four employees of the Michigan Game Division, one of them a half-time student, drove a car to a major event in the nation's capital. I recall that we had no special mission, but we were part of a new profession and we had heard that great changes were under way. Amid years of grinding depression and devastating drouth, it seemed almost any change had to be for the better. The frivolous 1920s would not come back, nor did we especially want them to. How our world would look in half a century was not a specific concern.

We took a southern route to Washington, some of it through the raw edges of Appalachia. To wildlife biologists the forests had special interest. We marveled at the small cultivated openings—hanging gardens of corn stubble—that clung precariously to the high slopes of ridges, no doubt a tribute to mule power. Bleaching skeletons of blight-killed chestnut trees still were widely evident among the hardwoods. We saw much deer range but no deer.

President Franklin D. Roosevelt had called a national conference on wildlife, to be held for three days at the Mayflower Hotel. Not many graduate students were likely to attend this historic meeting; I felt privileged indeed. I knew the trip could cost me ten dollars a day, but the experience might be worth it.

The conference of 1936 was not the first of its kind. Beginning in 1915, annual meetings had been held in New York under the auspices of the American Game Protective and Propagation Association, renamed later the American Game Protective Association. In keeping with the outlook of the times, these gatherings featured discussions on game bird propagation, fish culture, predator control, illegal killing, sportsmanship, waterfowl seasons and bag limits, and the cruder kinds of politics. Progressively, however, increasing interest was shown in the scientific aspects of management. Papers appeared on wildlife disease problems and habitat manipulation, on land use and public refuges. In 1930 the American Game Protective

Association again changed its name, becoming the American Game Association; their meeting of the previous December, the 16th, had been formally designated the American Game Conference.[1]

Beginning with the 15th conference, the transactions were published in book form. Previously some of the more significant papers had appeared in *American Game*, bi-monthly magazine (a quarterly until 1927) of the association. Adding the 7 volumes from the game conferences to the 50 volumes of wildlife conference transactions, we have a six-foot shelf of books that is an unbroken record of conservation affairs in North America from 1928 through 1984. It is the most important documentary in its field.

* * *

The idea that resources should be used conservatively for lasting public benefits had stirred in many good minds since publication of *Man and Nature* by George Perkins Marsh in 1864. Promoted by the likes of George Bird Grinnell, Theodore Roosevelt, and Gifford Pinchot, the concept of responsible resource management gained followers before and after the turn of the century. This was an era of new organizations, among which the American Forestry Association (1875), the Boone and Crockett Club (1887), and the National Audubon Society (neé National Association of Audubon Societies, 1905) stood tall and included among their members most of the influential conservation leadership.

As for the word *conservation* itself, Pinchot (1947) said it dated from 1907 as his personal inspiration. He credited W. J. McGee, of the Forest Service, with its definition. McGee described conservation as "use of the natural resources for the greatest good of the greatest number for the longest time." In his history of the American Forestry Association, Clepper (1975) pointed out that Pinchot was not the first to use the term. In an earlier history, W. N. Sparhawk (1949) said that,

> In calling the preliminary organization meeting in 1875, John A. Warder stated as one objective of the proposed association, "The fostering of all interests of forest planting and conservation on this continent." The term "forest conservation," therefore, was in use more than 30 years before it was taken up and popularized by Gifford Pinchot and Theodore Roosevelt.

If Pinchot were alive today, he probably would acknowledge the literal truth that there is "nothing new under the sun." I think we can regard the McGee definition as original and eminently satisfactory.

The first decade of the twentieth century was a time of intense federal activity vitalized by the Theodore Roosevelt presidency. After that a period of rumination set in, although spotty progress continued as new leaders found their missions in local and state associations and governments. By the early 1930s, another culmination was developing in resource affairs.

During the five years before the First North American Wildlife Conference a spate of important literature appeared. Some of it berated follies of the past and

[1]Details of many of these events were brought together by the Wildlife Management Institute's long-term director of publications, James B. Trefethen (1961, 1975). We have relatively few such works dealing with wildlife. In this present enterprise, I acknowledge an additional debt to the historical accounts of T. Gilbert Pearson (1937), Gifford Pinchot (1947), Frank Graham, Jr. (1971), Henry Clepper (1975), John F. Reiger (1975), and Michael J. Bean (1983).

portrayed the urgency of management reforms. Other contributions added to the accumulating groundwork needed for a scientific handling of resource problems. Especially significant were William T. Hornaday's *Thirty Years War for Wild Life* (1931), Herbert L. Stoddard's *The Bobwhite Quail* (1931), Aldo Leopold's *Game Survey of the North Central States* (1931), and his book *Game Management* (1933), Harry B. Hawes' *Fish and Game, Now or Never* (1935), and—timely in these years of dust storms—Paul B. Sears' *Deserts on the March* (1935). It should be noted that in December 1930 Leopold and his distinguished committee gave their epochal *Report to the American Game Conference on American Game Policy.* During this period an Iowa reporter and cartoonist, J. N. "Ding" Darling, was achieving national recognition. He became a critic of the New Deal and was especially famous for his graphic handling of wildlife issues.

Considering future developments, we might properly conclude that, on the first of March 1934, the most important event of the 1930s took place when Franklin D. Roosevelt made Ding Darling chief of the Biological Survey. That month the president signed into law the Migratory Bird Hunting Stamp Act, and Darling contributed the design for what is now number 1 in the series of 50. In 1984 the duck stamp act was still in force, and the long history of appropriations would show that this tax on migratory bird hunters "has provided $285 million and has added 3.5 million acres to the National Wildlife Refuge System. All or part of 186 refuges and many small wetland areas have been purchased with duck stamp receipts" (Williamson 1984).

Although J. N. Darling held his position as chief of the Biological Survey for less than 19 months, that was an eventful period. Both houses of Congress now had Special Committees on Wildlife Resources. Aided by a sometimes-supportive President and important legislative sympathizers, Ding made the most of his opportunities. He had a sense of personal outrage that wildlife was either ignored or a consistent loser in the competition of resource decisions. He had come to Washington obsessed with the conviction that a nationwide organization of sportsmen and other outdoor interests was urgently needed. He promoted this in every way open to him, and the founding of such an organization was a principal objective of the first North American Wildlife Conference.

Darling also had other fish to fry. In Iowa he had established the first Cooperative Wildlife Research Unit at Iowa State College. An obvious shortage of trained professionals existed in the wildlife field, and many more research units would be required. Ding set about the formation of a national system. He needed money, and in April 1934 he called a meeting of interested industrialists in New York. He secured commitments of funds from representatives of duPont, Hercules Powder, and Remington Arms. As described by Trefethen (1975), "Out of this single meeting there emerged directly or indirectly, the Cooperative Wildlife Research Unit Program, the American Wildlife Institute, the North American Wildlife Foundation, the National Wildlife Federation, and the North American Wildlife and Natural Resources Conference" (as designated later).

During the summer previous to the historic convention of February 1936, many able and far-sighted people were busy. Committees were assembled, meetings were held, and plans were laid (Anon. 1936). Officially, on the first of September 1935, the American Wildlife Institute was formed to replace the American Game Association. It would operate under that name until 1946. For five months Thomas A. Beck served as its president, after which he was succeeded by retired senator Frederic C. Walcott. Beck is credited as the one who suggested to FDR that he call the First North American Wildlife Conference.

A prime mover in organizing the program was Ira N. Gabrielson, who became chief of the Biological Survey when Darling resigned in November 1935. The Forest Service chief, F. A. Silcox (1936), was chairman of the conference, and at the opening session he presented its three major objectives:

> One is to learn about facts, discoveries and information pertinent to wildlife and the wildlife situation [i.e. technical sessions]. Another is to develop an adequate national and international wildlife program. A third is to organize a permanent affiliation of all wildlife interests and groups; to create one central organization so articulate, so powerful, and effective that real progress in restoring and conserving the vanishing wildlife resources of a continent can no longer be prevented.

When Darling addressed the conference, he spelled out details of the prospective organization. At field level it would be composed of county and state associations of clubs, chapters, and other units with an interest in wildlife and the out-of-doors. No doubt he had in mind the state federations already organized largely through the efforts of C. R. Gutermuth in Indiana and Karl T. Frederick in New York. It "just happened" that a proposed constitution was on hand. It was distributed to the delegates, who were told to meet and form committees to represent them. At a meeting on the third day a temporary "General Wildlife Federation" was agreed upon, with Ding Darling as temporary chairman. The committees and other representatives went home from the conference with a mandate to organize their state federations.

Amid a pervasive enthusiasm, this plan was pursued with outstanding success. A year later, immediately after the closing of the second wildlife conference, the General Wildlife Federation held its first annual meeting. At the organizing session authorized delegations ratified the constitution, elected officers, and retained Darling officially as president.

Thus the soon-to-be-renamed National Wildlife Federation was born into the growing array of critically important outdoor organizations. The federation began selling wildlife stamps to raise money and actively promoting their causes during National Wildlife Week, which is the third week in March, first proclaimed by the president in 1938 (Trans. N. Amer. Wildl. Conf. 3:141).

It is likely that the joining together of independent and diverse organizations in the new federation was not all that Darling and others had hoped for. However, as a measure of growth and progress, last year in an off-the-cuff address, I heard Jay D. Hair, executive vice-president of the National Wildlife Federation, say that they now have 4 million members, 500 employees, and an annual budget of $42.5 million.

As another update on one of Darling's ambitions, the program of cooperative research supported by the U. S. Fish and Wildlife Service, the land-grant universities, and the Wildlife Management Institute has survived in health and productivity (see Sparrowe 1982, Lendt 1984). The units have not been immune to jeopardy; they even got by a recent threat of abolishment (Breaux 1982). But today there are 13 cooperative wildlife research units, 18 fishery units, and 11 units that combine both activities (Fish and Wildlife Service 1984).

* * *

In the foregoing I have referred to the Wildlife Management Institute. That name has a familiar ring, and contrary to precedent, the title has lasted for 39 years—since May 1946, when the new institution was created to take over what were termed "public activities" of the American Wildlife Institute. That 10-year-old organization continued legally as the North American Wildlife Foundation (see Trans. N. Amer. Wildl. Conf. 12:v-vii). It assumed custody of endowments and was the first foundation to be established especially for natural resources. Ira N. Gabrielson left his position as chief of the Fish and Wildlife Service to become president of the institute, and C. R. "Pink" Gutermuth (recently from Indiana) became vice-president. The team of Gabrielson and Gutermuth helped to write a great deal of conservation history in the next quarter century, aided by a distinguished staff in the field and here in Washington.

Today, few people know that the suppliers and manufacturers of the sporting arms industry have, for 75 years, been the principal source of private funds for programs and institutions in the wildlife conservation field. With amazing reticence, they have maintained a program—continuously growing in scope and sophistication—from 1911 through to the present. Those of us who have seen a major part of this development cannot conceive where we would stand today in wildlife science and its applications without the forever-on-the-job contributions of the industry-funded Wildlife Management Institute and its predecessor organizations. This is said with some emphasis because I have found no place in the record of conferences where this point has been made. I do admit to a lingering apprehension. In recent decades—which have been something less than prosperous in the sporting arms industry—a falling off of institute supporters has occurred. We would have a healthier outlook for the future if more companies were involved, even in a small way where necessary.

A comparable non-profit industry-supported organization is the Sport Fishing Institute, founded in Washington in 1949. R. W. Eschmeyer, well known for his fishery research in Michigan and at the Tennessee Valley Authority (TVA), came to the nation's capital as executive vice-president of the new institute, whose mission, succinctly stated at the time, was "to shorten the time between bites." In 1953, Richard H. Stroud, chief aquatic biologist in New Hampshire, joined the staff as assistant executive vice-president. He became the responsible officer on Eschmeyer's death in 1955 and occupied that position until his retirement in 1981.

The Sport Fishing Institute is supported by "over 110 manufacturers and distributers of fishing tackle, fishing accessories, outboard motors, boats, and sporting goods used directly or indirectly by anglers" (Prosser 1984). Like the Wildlife Management Institute, it has an associated foundation (the Sport Fishery Research Foundation), and it publishes a monthly news bulletin. Under policy guidance from a board of directors, the staff of fishery scientists have practically complete freedom in conducting the program of professional service, ecological research, and conservation education.

It is worth emphasis that in both of these highly effective conservation institutes the professional staff make decisions and run their business in the absence of any operational meddling by the boards to which they are responsible. One wonders what changes would be possible in many states if the conservation commission could direct affairs with some similar degree of independence.

* * *

In the various proceedings previously described, a highly significant role was played by the secretary, Carl D. Shoemaker. It was taken for granted that he would be the able scribe in just about all that went on. Carl was secretary of the Senate Special Committee on Wildlife Resources, and he drafted much of the important legislation after that committee was formed in 1930. He was the second person (following Ding Darling) who would receive the Wildlife Society's Leopold Memorial Medal, which was awarded to him at the annual dinner of the 16th North American Wildlife Conference in 1951.

At the end of the first decade of wildlife conferences—we might appropriately call it the decade of the American Wildlife Institute—Carl Shoemaker (1945) contributed a one-page paper to the transactions. In that brief report he recognized the spectre of hunger coupled with land abuse that was developing with particular rapidity in the American tropics. He concluded with a statement on a widespread threat to agricultural productivity that would be appearing repeatedly through these 50 years of meetings.

> I believe . . . that the greatest conservation problem that confronts us today is that of conserving our soil. And this can only be accomplished by fundamental understanding brought about by education, both in the school and the political arena.

As Shoemaker well knew, ills of the land were not confined to regions south of the border. During the 1930s, successive years of disastrous drouth and the appalling tragedy of the dust bowl had brought into clear view the penalties of our own mismanagement. In 1933 the Soil Erosion Service was created, and a crusading soil scientist, Hugh Hammond Bennett, became its head. Two years later, under a new act, this agency was moved from Interior to Agriculture and began a long career as the Soil Conservation Service (SCS).

From the beginning, it was assumed that wildlife management benefits would accrue from the soil and water conservation program. Ernest G. Holt, first biologist of the agency, gave papers on this subject in four successive national conferences, beginning with the 20th game conference in 1934. Other biologists of the SCS, in addition to the chief himself, appeared frequently on the conference programs and also produced books on wildlife and land-use relationships (see Bennett 1939, Davison 1949, Edminster 1947, Graham 1944, 1947, Van Dersal 1938, 1943). The national program of soil and water conservation provided the logical basis for managing all products of agricultural lands. The commitment of the SCS to the inclusion of wildlife in land planning was clearly stated by Bennett (1946) at the 11th conference and further conceptualized by another director, Salter (1953), in the 18th:

> A basic tenet of the Service program long has been that the conservation of land, water, forest, grass, cultivated crops, and wildlife must be tied together and scientifically coordinated on the basis of land capability and need. Encouragement of beneficial wildlife is an integral part of our soil conservation objectives.

In the years immediately after World War II an increased public consciousness of land-use problems stimulated active support for the national soil conservation effort. Regional offices of the SCS were manned by an impressive array of technical experts, and the formation of state-administered soil conservation districts was promoted.[2]

The SCS had no authority to do research, so a cooperative plan developed for the Fish and Wildlife Service to establish a program of wildlife investigations on agricultural lands. This work got off to a good start in the southeastern region, where quail management was an issue and where good cooperation on privately owned lands was available. Eventually this project—continued with private support as government interest waned—produced a book on the quail (Rosene 1969) that stands high among the game-bird management literature of the world. Other than this work in the Southeast, no regional projects were established under the Fish and Wildlife Service program. In the 1950s, the effort foundered for lack of support amid the budgetary competition of the cold war.

In these annual volumes of transactions, several dozen papers attest to the vitality of our national soil and water conservation program. But this great resource enterprise has had its ups and downs. After the election of 1952, new concepts took over; regional offices were dismantled, and the Service was reorganized at state level. In his incisive comments opening the 19th conference, Gabrielson (1954) said that the new administration in the Department of Agriculture had "emasculated the Soil Conservation Service's technical staff, and no one can tell how adverse the effect of this action will be on the basic soil conservation program."

Probably no totally objective appraisal on that score is possible. The SCS was staffed by too many able and dedicated people to fail badly in its mission because of administrative changes. However, I doubt that the agency ever fully recovered from the breaking up of the regional quality-control teams.

During the next 30 years a basic sentiment developed among agriculturalists that the total acreage of cropland should be reduced, especially by converting marginal areas to grazing, forestry, and recreational use (Harmon 1969). However, on the best croplands a build-up of land-use intensity occurred, especially under the stimulus of high prices during the 1970s (see Atwood et al. 1970). Shelterbelts and fencerows were taken out, land was leveled, and large ownerships were converted to the continuous production of cash crops. Big business farming required big investments, big machinery, big applications of petroleum-derived energy and chemicals. It produced foreign exchange, but also big crop surpluses, which the taxpayer purchased to keep food prices high. It induced big set-asides of land that, properly handled, could be a productive adjunct to state wildlife management programs.

The Soil Conservation Service has adapted in the only possible ways to problems posed by the laying bare of great areas to wind and rain for the growing of row crops every year. Erosion control technology now features specialized tillage methods designed to keep crop residues on the surface (McLaughlin 1983). New land-saving practices have had active support by the Agricultural Extension Service and the Great Plains Agricultural Council. The latter organization is urging the need for longer-term commitments in legislation governing idle-acres programs. Their wildlife resources committee has prepared a handbook of regionally-adapted guidelines for extension agents and landowners. It seeks to make maximum use of cropping

[2]Already in 1958, soil conservation districts comprised 93 percent of all farms and ranches and 88 percent of the farmland (Williams 1958).

systems, set-asides, and marginal sites to improve habitat for the wildlife by-product (Henderson et al. 1984).

The USDA national erosion survey of 1977 provided a reliable updating of trends in the SCS program. On this basis, a prospectus for the future has been assembled in an 18-month study made by the American Farmland Trust (1984).

The study points out that traditional conservation practices have been most widely applied on lands of only modest erosion hazard. The program now in effect is expected to reduce erosion by only about 2 percent in a 5-year period. A major proportion of U.S. soil losses is taking place on a relatively small acreage of highly erodible land. In 1977 about 38 million acres (15 million ha) of non-irrigated cropland lost more than 15 tons per acre. Thus, 11 percent of the land accounted for 53 percent of the erosion loss.

The farmland trust advances a national conservation plan involving the classification of all croplands into three categories based on vulnerability to erosion. The bulk of our agricultural production should depend on the most secure lands (class 1), where conservation tillage is the most promising erosion control practice. Costly set-aside programs have not been highly effective in reducing the total production of important crops, but the continued need for such limitation is recognized. This would be one of the functions of a "conservation reserve," which would take the more erodible lands (class 3) out of production. Thus, lands of the highest soil loss would be shifted to uses involving permanent cover—mainly hay, pasture, or timber production. Set asides would involve a commitment for 7 to 10 years, after which the reserved acreage would be removed from the landowner's cropping base. Wildlife is one of the products expected to be managed advantageously on non-cropped areas.

In general, this is a constructive outlook, but the hour is late in the world's learning about land husbandry (see Brown and Wolf 1984). Quite literally, we are losing ground. In this country and abroad, man's blundering misuse of topsoil is a regime of desertification. By many social, economic, and ecological ties—which steadily become more evident—we are locked into a confrontation with global problems that have the urgency of exponential growth: overpopulation, soil erosion, deforestation, destruction of grasslands, water and air pollution, and depletion of many resources.

For a timely summation of these issues I recommend the Worldwatch Institute report, *State of the World 1984* (Brown et al. 1984). The problems are not new. They have appeared in many volumes of transactions over these 50 years. The integration of wildlife with a great array of human and resource trends was recognized in 1960 when this annual meeting was officially designated the North American Wildlife and Natural Resources Conference (Gabrielson 1960).

* * *

The management of soils is also, in large degree, the management of water, and no component of wildlife habitat is more strikingly influential than water in controlling vegetation types and the kinds of animals that can be supported. If any one wildlife management measure were selected out as "most successful" in agricultural lands, it undoubtedly would be the farm pond (see Edminster 1964). As of 1984, the Soil Conservation Service estimated that approximately 2.5 million ponds of 5 acres (2.2 ha) or less had been built, most of them with SCS assistance.

The critical role of natural wetlands and shallow waters as habitat for a wide variety of vertebrate and invertebrate life has been a taken-for-granted feature of wild nature since men began to observe such things. During the past half-century, the destruction of water-related habitats has been a growing concern for all who have a conscious interest in the out-of-doors.

Throughout these years of meetings, discussions have been held, practically on an annual basis, of the status of the continental waterfowl resource, and of the wetlands and other areas on which waterfowl depend. The great drouth of the 1930s was a dominating subject in early papers; at the 16th game conference Hoyes Lloyd (1929) of Canada talked of precipitation cycles and what they would mean to bird harvests of the future. Prophetically, he recognized also what would be an even more critical factor: "the invasion of their breeding ground by agriculture."

The drainage of marshes for mosquito control, dredging and filling of construction sites, and flooding by impounded waters have taken their toll of aquatic habitats, but by a wide margin the losses most significant to waterfowl have been agriculture related.

It is illustrative of a common outlook that, when economic or agricultural authorities compute the carrying capacity of the earth for human beings, any land encumbered by trees, grass, or water that could be used for cultivated crops is counted in as part of the food-producing potential. At the 18th wildlife conference, Anderson (1953) remarked that a majority of people regard land that is "to wet to plow, but unsuitable for swimming or motor boating, as useless." He went further and quoted an address by Robert M. Salter, chief of the Soil Conservation Service:

> If price were no factor, we have millions of additional acres in this country that could be put into agricultural use . . . Along the East Coast and Gulf States, there are at least 10 million acres that could be drained . . . Furthermore, on hundreds of thousands of farms throughout the country, there are corners or patches of idle wet land . . . that could be drained and made productive.

In the Yearbook of Agriculture for 1955, Shaw and Crissey quoted USDA figures that some 50 million acres (20 million ha) of wetlands in the United States could be drained for productive cropping. About three-fifths of this land was already in some kind of agricultural use. "If the 1945-1952 trend in land development continues, we can expect that 15 million of the 20 million acres [6-8 million ha] of undeveloped wetlands will eventually be used for cultivated crops..." In all justice it should be said that many good biologists in the SCS did not share these views.

Early computations of the original area of swamps and marshes in the 48 states undoubtedly were conservative, as were estimates of losses, which were based mainly on drainage statistics. In the first wildlife oriented national survey of wetlands, Shaw and Fredine (1956) could account for a minimum loss of about 45 million acres [18 million ha]. As for what remained, "we now have in this country about 82 million acres [33 million ha] of land... on which drainage or flood control operations have so far had little effect on their original wet condition."

From the mid-1950s to the mid-1970s, record keeping improved greatly, and for that 20-year period the tabulated reduction of wetlands was 11 million acres. (4.4 million ha). About 2 million acres (809,000 ha) were gained—mainly through the building of farm ponds and other impoundments—leaving a net wetland loss of 9 million acres. (3.6 million ha). Surveys then current indicated that, of an original total of 215 million acres (87 million ha) (revised estimate) of wetlands in the lower

48 states at the time of settlement, about 46 percent, or 99 million acres (40 million ha), remained in 1975 (Frayer et al. 1983). The annual loss rate was 440,000 acres (178,000 ha) of inland freshwater swamps and marshes plus 18,000 acres (7,300 ha) of tidal marshes.

In 1984 two major reports were issued on the status of wetlands: the National Wetlands Inventory by the Fish and Wildlife Service (Tiner), and the report to Congress by the Office of Technology Assessment (OTA). These studies confirm that a half or more of the marshes and swamps in the conterminous states have been destroyed as wildlife habitat. The losses were largely a result of considered public policy, implemented at public expense.

Much of the drainage carried out between 1940 and 1980 was made possible by cost-sharing under the Agricultural Conservation Program and by technical help from the Soil Conservation Service, which included extensive stream channelization (Erickson et al. 1979) as provided for in Public Law 83-566 (small watershed) operations. Government assistance to the destruction of wetland habitats engendered widespread public resistance. As a result, through legislation, executive orders, and agency policy directives (see Harmon 1969), this type of subsidy is now largely a thing of the past. However, tax write-offs of various kinds still help to reduce the cost of drainage (see Horwitz 1978, Office of Technology Assessment 1984). Coastal wetlands have gained protection under section 404 of the Clean Water Act as amended in 1977. This gave the Corps of Engineers responsibility for regulating the discharge of dredge and fill material into waters of the United States (see Dawson 1983).

In addition to federal initiatives to reduce losses of aquatic habitats, about half of the states have laws regulating the use of such areas. Controls of this kind are most common in the Pacific, Gulf, and Atlantic coastal zones, the Northeast (including New York and Pennsylvania), and the northern lake states (Minnesota, Wisconsin, and Michigan).

Public pressures for wetland conservation have built up steadily. That they have been at least partially successful is witnessed by the OTA statement "that present national wetland-conversion rates are about half of those measured in the 1950s and 1960s or about 300,000 acres, [121,400 ha] per year. This reduction is due primarily to declining rates of agricultural drainage and secondarily to government programs that regulate wetlands use."

The progress of recent years is encouraging, but the critically important habitats of migratory waterfowl and many species of resident wildlife are still being reduced at a prohibitive rate. The National Wetlands Inventory of 1984 (Tiner 1984) identified the following major problem areas:

1. Estuarine wetlands of the U.S. coastal zone.
2. Coastal marshes of Louisiana.
3. Submerged aquatic beds of Chesapeake Bay.
4. Palustrine wetlands of south Florida.
5. Emergent wetlands of the prairie pothole region.
6. Wetlands of the Nebraska Sandhills and Rainwater Basin.
7. Forested wetlands of the lower Mississippi alluvial plain.
8. Pocosin wetlands of North Carolina.
9. Riparian wetlands in the West.

Obviously, a large job of habitat protection and restoration remains to be done.

* * *

The region of prairie pothole marshes—the most important duck producing range in North America—covers some 300,000 square miles (777,000km^2) in south-central Canada and north-central United States. It comprises about 10 percent of the waterfowl breeding grounds of the continent, "yet it produces 50 percent of the duck crop in an average year—more than that in bumper years" (Smith et al.1964).

About a third of the pothole region lies south of the border. Centering on the Dakotas, the areas of high nesting density thin out to northwestern Montana and eastward into Minnesota. A former extension into Iowa has been eliminated by drainage. On the south, lakes of the sandhills country continue the waterfowl breeding ground into Nebraska. That segment is under the hazard of an advancing crop irrigation system.

In the Dakotas, potholes once covered some 7 million acres (2.8 million ha); nearly 4 million acres (1.6 million ha) have now been lost. In Minnesota a vigorous drainage program reduced the original rich resource of duck-producing marshes by 9 million acres (3.6 million ha); more than 5 million acres (2 million ha) were drained under the government Agricultural Conservation Program (ACP). An extensive literature details these losses of critical habitat, in which federal assistance programs played a major role (see Peterson 1952, Dushinske 1953, Schrader 1955, Shaw and Crissey 1955, Burwell and Sugden 1964, DeBates 1967, Tiner 1984).

In the Canadian two-thirds of the pothole region, agricultural conversion of the prairie has been somewhat slower than below the border, but after World War II developments were accelerating, and drainage of wetlands was catching up at an alarming rate (Gavin 1953, LaRose 1969, Lodge 1969, Brynaert 1983). By the early 1960s, a start had been made on provincial and federal habitat programs (Munro 1964), and greater efforts are now in planning stages (MacLennan 1983, Tetreault 1983). In Canada, public enthusiasm for investing in waterfowl habitat is dampened somewhat by the reality that the bulk of the annual bird harvest is taken in the United States.[3] Thus, it is appropriate that a major private initiative originating in this country has been acquiring and improving wetlands in the Canadian breeding range since 1937. As of 1983, Ducks Unlimited had raised and spent $146 million on 2,100 projects involving more than 3 million acres (1.2 million ha) (Gavin 1964, Whitesell 1976, 1983).

The U.S. Congress has enacted several measures partially or wholly intended to preserve wetlands through public ownership. The "duck stamp act" of 1934 was a first step in providing support for such efforts. The federal aid acts of 1937 and 1950 have been a major source of funds for the states in developing their own water and wetlands acquisition programs (e.g., Davidson 1952). The Land and Water Conservation Fund Act has been effective since 1965 and in 15 years enabled the Fish and Wildlife Service to purchase 221,000 acres (89,400 ha) of land, a part of which was wetland habitat (OTA 1984).

In 1958 wetland acquisition in the pothole region was advanced substantially by passage of Public Law 85-585 (amending the law of 1934), which raised the price of a duck stamp to three dollars and restricted the use of Migratory Bird Conservation Funds to the acquisition of refuge lands and waterfowl production areas. However,

[3]Canadians also have to deal with a serious waterfowl depredations problem in their prairie grain fields (Mair 1953).

available moneys were still inadequate, and passage of the Wetlands Loan Act followed in 1961, authorizing the expenditure of $105 million, to be repaid from future duck stamp receipts.

The first wetlands acquisition office of the Fish and Wildlife Service was opened in 1960 in the heart of the pothole country, Jamestown, North Dakota.[4] Others were to follow in North Dakota, South Dakota, Minnesota, and Nebraska (DeBates 1967). During the first ten years of operation in this primary waterfowl production area, the Service took ownership of more than 200,000 acres (80,900 ha) of permanent potholes, sloughs, and adjacent upland habitat. "Easements that protect seasonal or temporary wetlands from draining, filling, and burning were purchased for... 770,000 acres [311,600 ha], mostly in the two Dakotas and Minnesota" (Fish and Wildlife Service news release, 2 Sept. 1970).

Another major effort in the purchase of easements was made possible by the Water Bank Act of 1970 (see Phillips 1975). This legislation, administered by the Agriculture Stabilization and Conservation Service, has impeccably broad objectives (OTA 1984). It aims to preserve, restore, and improve wetlands and thereby to secure a range of benefits including (1) the conservation of surface waters, (2) the preservation and improvement of habitat for migratory waterfowl and other wildlife, (3) the reduction of runoff and erosion, (4) promoting the recharge of subsurface waters, and (5) other well-conceived objectives.

Under the Water Bank, in important waterfowl nesting areas, farmers may enter into 10-year agreements and be paid to protect tracts of 10 acres (4 ha) or more according to a plan developed with the local soil and water conservation district and utilizing the technical help of the Soil Conservation Service (Womach 1977). In the first 10 years of the program, 185,000 acres (74,900 ha) of marshes and sloughs and 480,000 acres (194,200 ha) of adjacent lands were covered by 6,000 agreements with landowners. Funding was renewed in 1982.

It is evident that a major effort has been made to salvage wetlands in the northern prairie region, but these areas continue to be converted into cropfields. In the early 1980s North Dakota was producing more ducks than any other state except Alaska, but waterfowl habitat was disappearing at the rate of about 20,000 acres (8,090 ha) per year.

Beginning in 1977, the wetlands acquisition program went into the doldrums—a state of affairs that persists to the present. The North Dakota governor forbade any federal land acquisition in the state, a move followed by confirming acts in the legislature, which were later ruled unconstitutional in federal court. After 1980, the Fish and Wildlife Service wetlands acquisition offices were closed and the personnel scattered. All sources of funding for land purchase and easements were reduced or withheld.

A dominating feature of events in the 1980s was the resurgence in North Dakota of a major water project. The Garrison Diversion Unit of the Bureau of Reclamation had been held in abeyance for many years after its original authorization in 1944. In 1965, a time of reauthorization, the estimated cost of the giant scheme to divert Missouri River water for irrigation was $207 million (Holden 1984). However, steady escalation had brought this figure to $1.2 billion by 1984—possibly a factor

[4]Ironically, this office, the most important in the nation, would be the first to be closed by the new administration in September 1981.

in consolidating support among North Dakota politicians and business interests. Construction began in 1968 and was less than 26 percent complete in 1984.

The foremost organized opponent of the Garrison project was the National Audubon Society (1984), which stalled construction for five years by way of a court order in 1976. The society's dissatisfactions centered on the prospect that in order to

1. convert dry-farmed crops to the production of irrigated crops already in surplus,
2. on 6 tenths of one percent of North Dakota's cropland,
3. at a cost of $3,886 per benefitted acre,
4. the project's 3,000-odd miles (4,800km) of canals, channelized streams, and reservoirs,
5. would destroy wetlands and native prairie in some of the best waterfowl habitat in the state,
6. destroy or damage at least nine of the state's dozen national wildlife refuges,
7. reduce the production of ducks by some 178,000 birds annually,
8. and open the way for rough fishes and other aquatic life to invade waters of the Hudson Bay drainage, in violation of an international agreement and against the strenuous objections of the Canadians.

In light of this break-down of project costs and environmental liabilities, it is instructive to review a Bureau of Reclamation statement in the Interior Department Conservation Yearbook for 1970 (p. 86):

> The initial phase of the Garrison Diversion Unit in North Dakota provides for the acquisition and development [sic, "mitigation"] of 147,000 acres [59,000 ha] of land for fish and wildlife purposes. This area is on the Nation's most heavily used waterfowl flyway. It is probably the largest single Federal "pothole restoration" project outside the regular waterfowl restoration program.

The figure of 147,000 acres used in this statement appears to reflect a plan to purchase and develop a compensatory acreage based on the following calculation (Fish & Wildlife Service) of wetland habitat losses:

Prairie wetlands destroyed	60,087 acres	(24,316.6 ha)
Prairie wetlands degraded	13,175	(5,531.8)
Fluvial wetlands destroyed	2,170	(878.2)
National Wildlife refuges,		
wetlands destroyed	490	(198.3)
wetlands adversely affected	70,420	(28,498.3)
total	146,342	(59,423.2)

Much is heard about what is called "mitigation" in connection with the big development projects. Essentially it means that when wildlife habitat is destroyed in one place it will be created in another in order to mitigate the total harm done by the developments.

But how do you recreate a floodplain, a stand of oldgrowth timber, a flowing stream? Mitigation can be, and often is, makeshift. Some seem to think it can be accomplished simply by not destroying something that is already there. To the big thinkers in development, mitigation is largely a nuisance value. You meet the problem by pouring in more dollars. In this connection we can profitably recall the words of Gabrielson (1965) at the 30th conference in speaking of public works:

> The point I want to make about any program that attempts a regional rejuvenation is that conservation needs are not automatically assured by the commitment of huge sums of money . . . Exactly the opposite may be the case. Resources values may be impaired or destroyed by programs that lack an ecological conscience in their planning and execution.

I would not try to discourage mitigation—we can always use the money—but sometimes it appears that getting an authentic job done is like trying to buy a halo.[5]

By a 100-vote margin in 1982, the House of Representatives deleted funding for the Garrison Diversion Unit. In committee the funds were restored (both N. D. senators were on the appropriations committee). In the Department of the Interior, the administration strongly supported the project and requested $53.6 million in funding in the omnibus appropriations bill for 1985.

In view of mounting opposition, proponents of Garrison agreed to a compromise with the National Audubon Society. On 1 October 1984 all construction work was suspended. A 12-member commission, appointed by the Interior Secretary, was given three months to work out a different plan and a new set of objectives.

The Commission reported, and certain objectionable features of the original plan were removed (Garrison Diversion Unit Commission 1984, Hoxie 1985). However, important controversial issues were left unresolved. A report by the Water Projects Committee of the North Dakota Chapter of The Wildlife Society (1985) specified numerous shortcomings of the revised proposal and stated that it ". . . would not resolve the economic, environmental or international issues identified with the Garrison Diversion Unit as authorized. Rather, the Commission Plan would have greater potential environmental impacts and significantly higher potential costs, and it would remove the principal safeguards against transfer of Missouri River biota into the Hudson Bay Basin."

Given the public interest in waterfowl, it is to be expected that wetlands conservation will get back on track in North Dakota and elsewhere (Ladd 1978). The government programs already provided for by acts of congress are well conceived, but a new dimension in this field is much needed, and it should be widely applied over the 48 contiguous states.

Land-use decisions by individual landowners are the key to preserving wetland wildlife habitats. There must be reasons why these decisions will favor the retention of headwater marshes for all their values (see Eisenlohr and Sloan 1968), including wildlife production.

A design for accomplishing this has long lurked in the minds of conservationists (Peterson and Madsen 1981). If landowners could be given a federal tax rebate for preserving or restoring uncropped wetlands—perhaps according to a formula based on the taxes they pay on their most productive acres—the entire picture of wetland drainage and habitat destruction might be changed. Not only would habitat be preserved and improved, but the landowner and the public could realize the many benefits from well-managed wetlands that are stated so clearly in the Water Bank Act (OTA 1984).

[5]Probably the most elaborate and expensive attempt at mitigating the loss of a biological resource is that now in operation as a result of the building of Bonneville and other dams on the Columbia River (Bolman 1972). The calculated investment in hydroelectric developments—in place and planned—is $3.2 billion. As of 1969, the investment in facilities to protect salmon runs was $239 million plus annual operations of $5.5 million.

Pacific salmon stocks have been depleted, and some races have been lost. However the Columbia River still produces about 25 percent of the Pacific Northwest salmon catch. After 1988, benefits of the mitigation measures are expected to exceed costs. Possibly this situation resolves into a question of what a salmon run is worth for all time to come? Or, more practically, what is *part* of a salmon resource worth (Anderson 1950)?

Administrative agencies are already well organized to handle such a program of incentives. The expertise is available. It is time for Congress to face the problem and act.

State and federal efforts to preserve the habitats of aquatic wildlife are critically important, but private institutions also have a useful role. In fact, the lands and waters they reserve may well have some advantages. For example, such areas are less subject to the political demands for incompatible uses that often plague the National Wildlife Refuge System.

Reference has been made to the wetlands program of Ducks Unlimited in the Canadian prairie provinces. Supplementing that effort of 35 years, in 1972 DU began a similar project in Mexico, and recently they have broadened their purview further to include the prairie pothole region of the United States (Whitesell 1983). As another private enterprise of this kind, The Nature Conservancy is now acquiring wetlands and has received a grant of $25 million for this purpose from the Richard King Mellon Foundation. The National Audubon Society has important waterfowl and wading bird habitat in its 76-area sanctuary system (see also Jenkins 1978).

The American people are being asked to contribute to many causes. They are urgently in need of standards by which to judge such requests. It would be a worthy test of our tax-free contributions that they should buy an investment in the future. This might mean beating an environmental disaster like the Garrison Diversion. It could mean keeping an irreplaceable swamp, a prairie, or a place where black-footed ferrets can survive. These are the solid investments that will draw compound interest as natural features become increasingly rare.

* * *

Since about 80 percent of our migratory waterfowl—including geese, ducks, swans, and cranes—nest in Canada and Alaska, the wintering grounds must be a main concern in the 48 states. Below the Canadian border, breeding areas are primarily in northern states, and these commonly serve as localities for feeding and resting on the fall and spring migrations. Management by flyways, which are biologically real and administratively convenient, has proved to be a workable system. Since 1948, regulations have been promulgated annually on a flyway basis (Hickey 1955, Glover 1964).

From Washington and Oregon eastward and southward, the preponderance of waterfowl habitat is man-created or man-modified in connection with irrigation developments (Jensen and Chattin 1964). Diversions of water from bird concentration areas have provoked frequent controversies in the past, and the problems continue (see Gabrielson 1943 on Lake Malheur, the Klamath Basin, and the Bear River marshes). The primary western staging area for sandhill cranes—half a million of them—and also an important stopover and wintering ground for white-fronted geese and other migrants, is on the Big Bend of the Platte River in Nebraska. Some 69 percent of the river's flow has already been intercepted upstream, and plans are afoot to divert what is left (Krapu et al. 1982 a, b). The National Audubon Society and other organizations are embattled to save this critical site.

The wildlife conference transactions contain a sampling of other problems in areas where North America's waterfowl spend the cold season. A brief consideration of some of them may help to define the conservation job that lies ahead.

The primary wintering ground for Pacific Flyway waterfowl is the Central Valley of California, where a huge flight of birds from the north once was accommodated by an estimated 5 million acres (2 million ha) of wetlands. The inventory of 1954 indicated that about half a million acres (200,000 ha) of that habitat remains, of which three-fifths is now preserved in private duck clubs (Anderson 1953, Anderson and Kozlik 1964, Shannon 1965, Gilmer et al. 1982). The food dependence of more than 5 million waterfowl rests on the management of public and private dedicated areas and contiguous agricultural lands. It is a fact of life that if duck club properties ever lose their value for hunting, a major portion of the Central Valley wetlands will immediately be converted into cropfields.

A portion of the annual southward migration, especially in the two western flyways, goes on to the coastal and interior waters of Mexico, and even farther into Central America (see Shaw and Crissey 1955, Saunders 1964). There, problems of hunting regulations and law enforcement (Leopold 1964, Hernandez Corso 1965) recall our own earlier difficulties on Maryland's eastern shore and other historic shooting grounds.

Eastward from California, the next major wintering area for wildfowl is in the southern high plains, the "Staked Plain" of former times, in the Texas Panhandle and eastern New Mexico. Here the shallow basins of numerous playa lakes catch runoff and tailwaters from irrigated cotton and cereal crops. The region of the playas provides water and feed (principally corn) for 1 to 2 million ducks in favorable years (Bolen and Guthery 1982, Guthery et al. 1982).

Somewhat reminiscent of conditions in California, this man-made situation is under the jeopardy of change. Irrigation water is pumped from the largely unrecharged southern end of the Ogalalla aquifer at a drawdown rate that may make further pumping uneconomic in about 40 years. Many of the fertile marshes have been incorporated into the plowland and now appear as slight depressions or dark areas in the wind-blown surface of the fields. The prospective disappearance of irrigation will dry up most of the remaining lakes and marshes and will greatly reduce carrying capacity for waterfowl.

The most important wintering range for water-dependent birds of the Central Flyway is farther south. Large concentrations of ducks, geese, and other fowl use the wetlands and adjacent waters of the Texas coastal plain and similar habitats eastward into the delta region of Louisiana.

In that area we may appropriately recognize that plans are under way to salvage a choice unit of wildlife habitat that lies in the way of progress. It is in the Atchafalaya Basin, and in a way the new plan is a symbolic act of compensation for what has happened to one of the most extensive and richly productive wildlife environments that adorned this continent in early times.

Only a century ago, a broad floodplain forest of hardwoods, interspersed with swampy backwaters, bayous, and marshes, cradled the mighty Mississippi and conducted it south from Illinois and Missouri 600 miles (960km) to the Gulf. It harbored many kinds of wildlife. A primary migration route, it fed and wintered millions of migratory birds of the Mississippi Flyway.

In 1928—practically at the beginning of these recorded conferences—the Congress and the Corps of Engineers set about some drastic changes. It was a program of clearing, diking, draining, and channeling that would change the 25-million-acre (10-million ha) bottomland into cultivated fields (Korte and Fredrickson 1977, MacDonald et al. 1979, Fredrickson 1980, Spencer 1981). Along the way, about

643,000 acres (260,200 ha) of lowland hardwoods were retained in various state and federal ownerships, much of it with altered drainage and siltation regimes.

After 1950, the development of soybean markets provided added stimulus to the bulldozing and burning of timber and the rapid conversion to agriculture. By 1981 only 3 million acres (1.2 million ha) of the riverine habitat remained, and the annual loss rate was 300,000 acres (121,000 ha). The fate of important remnants still hangs in the balance (e.g., Hancock and Barkley 1980).

The prize remaining unit is Louisiana's Atchafalaya Basin Floodway, an accessory channel of the Mississippi and Red rivers at times of high water. "The 575,000-acre [232,700 ha] floodway contains a maze of overflow swamps, lakes, bayous, and distributaries and is among the most productive fish and wildlife areas in North America" (Sanders and Soileau 1980). The bottomland hardwoods of the floodway represent about a quarter of the surviving acreage of this type in the lower Mississippi floodplain (Forsythe and Gard 1980). When the Corps of Engineers made an economic survey of the basin in the early 1970s, they found that the commercial fishery—including a crayfish harvest of 22 million pounds (1 million kg)—and recreational uses contributed $97 million annually to the local economy.

In the absence of forthright action, this remnant of the original Mississippi bottomland will go into soybean fields, like most of the rest. An opportunity exists to rescue for public use the largest stand of lowland hardwoods and associated wetlands that remains to us. The planning is under way; it has involved the office of the Governor, citizen organizations, the Corps of Engineers, the Fish and Wildlife Service, and the congress, which appropriated $10 million.

It appears that some kind of Atchafalaya reserve will come out of all this—a public area that will continue the flood control functions of the basin, maintain its natural character through land purchase and conservation easements, and secure the rights of public access for the future.

* * *

All around the gulf, salt marshes, brackish estuaries, and favorable inland waters help to sustain the flights of birds that have retreated from their winter-locked nesting habitats in the north. Freshwater wintering areas are plentiful in parts of the Southeast, especially the swamps, lakes, and everglades of Florida and the pocosins (shrubby wetlands) of the coastal plain farther north. However, of the 32 million acres (13 million ha) of coastal and inland wetland habitat in the Atlantic Flyway, about a third is significantly used by waterfowl, and only about 4 million acres (1.6 million ha) is of moderate to high value (Addy 1964). The southeastern wintering ground accommodates some 15 percent of the ducks, 20 percent of the geese (excepting brant), a quarter of the coots, and half of the whistling swans of North America. Although brant, seaducks, and local concentrations of other species occur farther north, the bulk of wintering waterfowl are found from Chesapeake Bay southward.

Vast changes have attended the buildup of metropolitan centers, and population in general, along the Atlantic seaboard and around the Gulf to Texas. They have competed tellingly for the waterfowl habitat. But the estuarine waters and tidal marshes of the coastal zone are much more than winter habitat for migrant birds. They are the essential production areas for our seafood and salt-water sport fishing resources (see Skud and Wilson 1960, Massman 1964, Cain 1967, Walford 1967, Boyle 1969). Acre for acre, in biological yield and economic value, they outrank any other environmental type on earth.

The salt-marsh nurseries of offshore fisheries, the shellfish beds of protected waters, the aquatic habitats of many kinds of wildlife, have been profligately sacrificed in the rush of many coastal developments (Allen 1964, Sykes 1967). Routinely, they have been obliterated by drainage and the building of new land for construction sites (classic west-coast example: San Francisco Bay. Bodovitz 1967). Often they are altered by the dredging of channels and waterways and by spoil disposal. They are exposed to silt from uncontrolled erosion and degraded by a smorgasbord of domestic and industrial pollutants (see also Hunt and Ewing 1953). As of 1979, the most recent National Shellfish Register showed that, of the 14.6 million acres (5.9 million ha) of commercial shellfish waters, 4 million acres (1.6 million ha) had been closed by pollution (Council on Environmental Quality 1979).

The plight of what Cronin (1967) called "the most valuable and vulnerable large estuary in the world" is a model of sublime natural endowment in conflict with the teeming ills of human irruption. Although research on Chesapeake Bay and its problems has long been in progress (e.g., Pritchard 1951), these were the subject of a special session of the 46th conference. As of 1974, the tidal region of the bay was occupied by 8.2 million people. Its population had increased to 9 million by 1980, and the projection for 2020 is 16.3 million (Cronin 1981, Gottschalk 1981).

Some trends of the past are obscure for lack of sufficient records, but the present pollution overload is characteristic of waters in areas of high residential, industrial, and agricultural activity. Which means excessive nutrients, sedimentation, sewage, petroleum products, and toxic substances of many kinds (Bricker 1981, DeMoss et al. 1981, Ohlendorf 1981). The latter include the usual heavy metals, organochlorines, and PCBs. Every kind of management and control—including the study of pollution sources—is complicated by the presence in the watershed of six state jurisdictions, the District of Columbia, and the U.S. Government.

State research and clean-up efforts are under way (see Horton 1984), especially in Maryland and Virginia. Pennsylvania is involved as the source of runoff from the great Susquehanna watershed, which contributes to the nitrogen-phosphorus build-up (eutrophication) in the bay. In 1976 Congress commissioned a 6-year pollution study by EPA with a funding of $27 million (see Hair 1983). A state-federal monitoring program costing $2.5 million a year was established in 1984 to provide essential readings on the health of the bay. A stirring of public interest is evident, and citizen organizations are much involved (Gottschalk 1981).

Fishery landings, including oysters and the prized blue crab, have had peaks and depressions in the past, sometimes from presumed natural factors and also from over-harvest (Cronin 1967, Rothschild et al. 1981). With today's intensified use of bay waters and the build-up of some types of pollution (and decline of others), the interactions of environmental factors are sufficiently complex that research workers are abiding their time about definitive cause-and-effect conclusions. However, recent changes in fauna and flora are strongly suggestive that something new is happening, and many long-term observers have no doubts about it (McClosky 1984).

Despite an expensive management program, the recent catch of oysters has been about a third of what it was a generation ago, and soft-shell clams are down. In the past 10 years, the striped bass has fallen off by 90 percent. Something similar has happened to the American shad—a spring tradition in Washington and Baltimore restaurants. Extensive aquatic weedbeds—important to shellfish and other invertebrates, and a feeding ground for waterfowl—declined drastically in the early 1970s, although there is evidence of some recovery (Orth and Moore 1981). For the most part, the fishes showing declines are those (anadromous) that spawn in fresh or only slightly brackish water, notably shad and striped bass. On the other hand, salt-water spawners at the lower end of the bay are doing well, as exemplified by weakfish and menhaden. The blue crab, which breeds in salt water, sustained about average production through the 1970s, but with some recent decline. The trends in various species suggest that those moving downstream into the heavily polluted mid-portion of the bay are the ones in greatest trouble. The possibility exists that some of the salt-water spawners are carried into the bay via a backflow from the ocean. The design of what is happening should be revealed more adequately by research now in progress.

Historically, Chesapeake Bay has been a world-renown wildfowling area. The 1.5 million birds wintering there have included about 15 percent of the diving ducks in the Atlantic Flyway. Human occupancy and agricultural developments have reduced shoreline habitats, although recent changes in water quality and the bay environment have not greatly altered the pattern of waterfowl use. The most significant change affecting diving ducks is the reduction of submerged weedbeds. Long-term food studies show that the diversity of available food organisms, both plant and animal, has declined. Recent increases of two choice game species, canvasback and redhead, in the flyway were not matched by similar increases in the bay, where the numbers of these birds have leveled off since the mid-1960s. Some changes in food habits and in distribution have been observed (Perry et al. 1981).

Since restrictions on the use of DDT, Dieldrin, and other organochlorine compounds became effective in the early 1970s, the benefits to various predatory and fish-eating birds have been striking. On the Pacific, Gulf, and lower Atlantic coasts the brown pelican—seemingly headed for extinction in the 1960s—has shown a gratifying recovery. A similar improvement in the status of the osprey and bald eagle has been evident on the Chesapeake. While the organochlorines, PCBs, and other toxic compounds are still present in the bay environment,[6] a diminution of eggshell thinning and the evident improvement of reproductive success is testimony to improved conditions. Actual concentrations of toxic compounds in the tissues of birds recovered have been monitored at the nearby Fish and Wildlife Service laboratory at Laurel, Maryland. Ohlendorf (1981) has concluded:

> . . . it appears that the impact of these chemicals in the future should be much less than it has been in the past 35 years. In the Chesapeake Bay attention should be focused on fish-eating birds, primarily bald eagles and ospreys, but it is unlikely that organochlorines will represent a serious threat to these species, or others of the Chesapeake Bay region.

The many-faceted relationships of population, technology, environmental pollution, and wildlife on North America's great estuary might justifiably be considered a paradigm of what is happening to man on earth. On whatever scale, the outcome is likely to be the same.

* * *

[6]and elsewhere (Fleming and Clark 1983).

In one form or another, environmental pollution is a concern of every citizen. However, the hunter of waterfowl confronts a problem directly relevant to his sport. It is practically unique in its exclusive and well-understood cause, and in its possibilities for a cure when the hunter takes it seriously.

The challenge of this problem is not a recent finding. In his book published in 1901, *American Duck Shooting*, George Bird Grinnell[7] said that "a quite unexpected danger to wildfowl, which was discovered only in 1894, having been then announced in *Forest and Stream* [Grinnell 1894], is the self-poisoning of ducks, by means of lead taken into the stomach in the form of shot." The lead poisoning threat became generally recognized after it was described by Alexander Wetmore in 1919.

From the first wildlife conference on, papers appeared with relative frequency on various aspects of the subject (e.g., Hunt 1960). Especially significant research was done at the Illinois Natural History Survey on the incidence and dynamics of lead shot in marshes, on the toxicity of various shot alloys, and on the alternatives to lead in the manufacture and use of shot (Jordan and Bellrose 1950, Bellrose 1951, 1959). The principal source of information on technicalities and economics in the field was the research and development work of Winchester-Western, reported on by Baker (1966) at the 31st conference. As compared with lead, iron shot cost more and it had performance disadvantages. But Bellrose's conclusion on these matters was that "There are no insurmountable obstacles to the use of iron shot for waterfowl hunting."

Bellrose estimated (1964) that the annual mortality of waterfowl to lead poisoning was 2 to 3 percent of the population, which converts to 1.6 to 2.4 million birds (Fish and Wildlife Service 1976a). The loss includes rare and endangered species—both kinds of North American swans, and even a recent record of a whooping crane. Various raptors pick up lead secondarily, and the bald eagle has exhibited particular vulnerability (Pattee and Hennes 1983).

In 1976 the Fish and Wildlife Service published its final environmental statement on the proposed *Use of Steel Shot for Hunting Waterfowl in the United States*. The summation of information left little doubt that the major technical objections to a general conversion to iron (steel) shot had been eliminated or greatly reduced—with further improvements probably to be taken for granted. That hunters would have to adapt to new ballistic characteristics and use well-made modern weapons must also be assumed. They probably can do this, as they adapted to the elimination of spring shooting, baiting, the use of live decoys, and guns larger than 10 gauge.

Changing to iron shot for waterfowl hunting is bound to be a nuisance to nearly any of the 3-million-odd who follow this sport. It is understandable if many of them regard it as just another bureaucratic indignity. Protests have been loud and clear. But the problem will not go away; we tried that, and it did not work. Ducks are awasting, and the situation can only get worse. The nation's largest organization of sportsmen (the National Wildlife Federation) is strongly in support of change (see Myers 1984), as are other citizen groups with an interest in birds.

Political maneuvering on the steel shot issue now has a history of about 10 years, and relatively little has been done (see Clark 1983, Peterlik 1984). The Fish and Wildlife Service generously decided that each state should make its own decision in

[7]If ever a conservation hall of fame should be established, it might appropriately be named for Grinnell.

abolishing lead shot for waterfowl. Of course, that is their right anyway, and at least three states have done so. But it is no escape for the Washington office. Waterfowl are interstate and international—a federal responsibility since 1918. If industry is to retool enough to supply iron shot for duck hunting, they must at least have the benefit of a national market.

We have known about lead in the marshes for 90 years. It is time we made our move.

* * *

In the 50 volumes of conference transactions, many hundreds of papers have appeared on the life history, habits, ecology, diseases, and special management problems of individual species. A great variety of fishes, mammals, and birds are represented, and the wide diversity of subject matter defies any attempt at summary or generalization. Early in the century, popular ideas of management—especially of fish or game birds—commonly featured the operation of hatcheries and putting the product almost anywhere on a basis of public demand. In major degree, the put-and-take kind of stocking to supply *public* hunting and fishing has proven uneconomic, and where it is done today the cost usually is paid directly by those who benefit.

The public faith in fish hatcheries was especially insistent, and the building of such facilities became much involved with politics, both in the states and in the federal government. In the Fish and Wildlife Service two programs were well known for having their direct budgetary pipelines to Congress; fish hatcheries was one of these.[8] For the members of Congress, bringing home a hatchery became a sort of mini-boondoggle that helped to consolidate support among the local electorate. A great deal of the fish stocking was done on a public-opinion basis. However, as more sophisticated programs developed, hatcheries came to serve valid purposes in fish management, and today it is likely that most of them are contributing worthwhile benefits as part of a reliably designed plan.

From the late 1930s on through the 1940s fishery biologists were looking critically at the stocking programs on which a great deal of fish management money was being spent. A large volume of literature appeared during this period, much of it in transactions of the American Fisheries Society. However, the trend of research results and the development of new policies are evident also in wildlife conference papers (Shetter 1939, Gee 1942, Holloway and Chamberlain 1942, Cooper 1948, Meehan 1948, Needham 1939, 1950, 1959). A major emphasis in this work was on the stocking of trout and other cold-water fish. Needham remarked that "the fine work done by a host of workers dealing with such warm-water fishes as the basses, sunfish, and catfish have clearly outlined the proper role of fish culture for these fish. We need an equally clear outline for its proper role with cold-water fishes."

A major finding in practically all such investigations was that the indiscriminate stocking of small size classes of hatchery fish was insignificant in terms of benefits to the fisherman. The survival of stocked fish over winter was nearly always extremely low. The liberation of legal-size fish for immediate catching produced much better returns, but it was excessively expensive as a means of supporting public fishing. It was evident that the widespread stocking of hatchery-produced fry and fingerlings in

[8]The other was predator and rodent control.

natural lakes and streams had yielded little but impressive statistics (Eschmeyer 1949).

Introductory stocking of small fish in barren lakes—a practice common in the mountainous West—or in new impoundments without appropriate species was a different matter. Usually it was the economical way to establish a species, or even to support hook-and-line fishing in suitable waters where spawning habitat was absent (Solman et al. 1952). It became evident that good research had converted fish stocking from a misleading cure-all into an important tool of management. It now remained to wean the average angler away from long-cherished misconceptions.

The growing understanding of fish population dynamics and inter-species relationships had applications in every kind of management (Lagler 1941, 1944, Thorpe 1942, Van Oosten 1944, Schneberger 1948, Moyle 1949). Fishes in general were found to be highly prolific and hence subject to high natural mortality rates and the rapid turnover of generations. The "excess" production of young fish was a normal mechanism for recycling nutrients in the aquatic community. Within limits based on food habits, the carrying capacity of waters, irrespective of fish numbers and size classes, could be expressed in pounds per surface acre. Thus, overcrowding meant competition for food, low growth rates, and poor fishing. Thinning out a numerous population (or generation) resulted in more rapid growth and more catchable fish.

The thinning-out process, of course, opened the way to innovative management. The long growing season and rapid turnover of fish in southern waters spelled high productivity—so high that under some conditions a commercial catch with seines was not only permissible, but it helped to improve the sport fishing (DeQuine 1952).

The above generalizations hold well for lakes, ponds, and impounded waters, but widespread work on trout and other cold-water species in small streams demonstrated that this was a realm of special conditions. Producing fish and utilizing them to best advantage in serving public demand called for specific kinds of management and regulations. Habitat improvement, whether in slack waters or in steams, was an obvious approach to better fishing that received early attention in Michigan and elsewhere (Tarzwell 1936a, 1936b, 1938, Hazzard 1937, Hubbs and Eschmeyer 1937, 1938, Hunter et al. 1940).

Historically, catch limits, closed seasons, and the regulation of gear represented the first public efforts to preserve the resource and ration out the annual crop of fish (Langlois 1944). Since regulations were largely based on guesswork and faulty assumptions, many of them proved to be unnecessary or counterproductive. The results of mismanagement became widely evident when the reasons for poor fishing were seriously analyzed. At the seventh conference, New York's senior aquatic biologist (Greene 1942) expressed his misgivings:

> Compared with the farmer the fishery worker is in a state of aboriginal ignorance with relation to his stock in trade. He blithely plucks his harvest from the bounty of nature, usually without any activity corresponding to soil cultivation or crop culture and often with a fine disregard for consequences to future maintenance of resources.

Greene was especially concerned for the effects of selective fishing for choice species. He identified this continuing process "as a principal cause of poorly balanced fish populations commonly characterized by increase of the smaller sizes and of the less desirable coarse fish at the expense of the larger, more desirable food and game species." He referred to examples of corrective (commercial) harvest of less popular species as one of the options of management. At the time, work of this kind was under way at the TVA reservoirs (Tarzwell 1941, Bryan and Tarzwell 1941, Wiebe 1942).

At the 17th conference, Stroud (1952) described surveys of Massachusetts waters that revealed a similar imbalance among fish populations as judged by the quality of fishing. Reductions of overcrowded and stunted panfish and "weed" species were accomplished by seining, poisoning, destruction of spawning beds, and drainage. Good public acceptance of such methods was achieved by demonstration seining and analysis of numbers and age classes. A finding of particular significance was that a substantial part of the available harvest of sport fish was never taken by anglers. Stroud also discussed habitat improvement for game fishes, corrective stocking of predatory species, and a general liberalizing of regulations.

It was evident that management was taking new directions in promoting better utilization of naturally produced fish populations and in augmenting recreational satisfactions of the public.

* * *

In the first 20 years of wildlife conferences, two especially significant developments in fishery management were reported, each by a series of papers.

Research and experimentation on reservoirs of the Tennessee Valley Authority suggested strongly that under the usual kinds of regulation the sport fishery was being inefficiently managed. The state cooperated in a major trial of year-around fishing, which proved to be outstandingly successful. The favorable results of this experiment in Tennessee led to a new appraisal in many states of the need for closed seasons on hook-and-line angling for warm-water fish, with consequent gains in annual catch by the fishing public.

At the Alabama Agricultural Experiment Station, many years of work on several dozen experimental ponds resulted in the formulation of management measures easily applicable by landowners. The proven methods vastly increased the productivity of thousands of farm fishponds constructed with the help of the Soil Conservation Service.

The work in Tennessee began in 1938 on Norris Reservoir on the Clinch River. On this and other large impoundments of the TVA system, R. W. Eschmeyer and his co-workers carried out biological studies of fish populations and detailed surveys of fishing pressure and catch (Eschmeyer and Tarzwell 1940, Eschmeyer 1942, 1944, Eschmeyer et al. 1946).

Returns from tagging demonstrated that in those waters fish grew rapidly and the largest of them were not found in the catch after age five. Many fish were dying of old age. Studies of food habits and fish distribution showed why fishing tended to be fair to poor in summer, fall, and winter. It was best in spring, the time of spawning, when fish were protected by the April-May closed season. Information on years when spawning was abnormally early or late indicated that the high catches at such times had no limiting effect on the take in subsequent fishing.

In 1944, at the recommendation of the biologists, the Tennessee Department of Conservation opened the season for the entire year on Norris Lake. In the 59-day spring season, formerly closed to fishing, the harvest by anglers was 275,000 pounds (124,740kg)—nearly twice the regular catch for the rest of the year, and in addition to it. In following years the permanent open season was extended to all of the reservoirs, with continuing high yields, as confirmed by follow-up research (Eschmeyer 1945, 1950).

Eschmeyer was cautious about any implication that the TVA findings were a basis for changing regulations elsewhere. However, many fishery biologists were reporting research results that called to question the widespread limitations on sport fishing. In an analysis of fishing on 20 artificial lakes in Illinois, Bennett (1945) found that on one of them, after an exceptionally large harvest of bass and crappies—700 pounds (317kg) from a 2-acre (0.8-ha) pond—the catch of the following year was reduced. He remarked that this was the single instance of "overfishing" that he knew about.

At the 15th conference, Murphy (1950) reported on similar work in California, with like conclusions relative to the need for a closed season. He stated that

> The number of states permitting year-round fishing for warm-water species increased from 3 to 15 during the period 1943-1949. Many others, such as California, allow year-round fishing on some of their waters.

A gradient from south to north is evident in the need for size and creel limits and closed seasons. Long growing seasons and other conditions in southern states have permitted a general relaxing of restrictions, and this applies commonly to panfish farther north. Closed seasons and other limitations have been found most necessary in northernmost states and Canada, where winters are long. Fish are long-lived and grow slowly. Under these conditions heavy fishing pressure can deplete the large predator fish, which never are replaced because they do not escape the angler for enough years to grow up.

In the mid-1930s, at Auburn, Alabama, Homer S. Swingle and E. V. Smith established a program to devise practical methods for the management of small fishponds. They reported preliminary results at the fourth wildlife conference (1939).

Their carefully documented measurements of key environmental conditions, species combinations, carrying capacities, growth rates, and seasonal production served to confirm many aspects of the generally developing knowledge of fish population dynamics. Controlled experiments, principally with largemouth bass and bluegills (bream or "brim" in the South) demonstrated that the pounds of fish per acre, regardless of size classes, depended on water fertility and the growth of plankton that formed the basic food supply. Fish production could be augmented by applications of commercial fertilizer. Unfertilized ponds produced 100 to 200 pounds of fish per acre (112-224 kg per ha) per year, as compared with a maximum of 580 pounds (263 kg) (cost 3 to 6 cents per pound) in fertilized ponds. Heavy stocking or the use of larger fingerlings did not improve production. In overly dense populations, competition for food reduced growth rates and tied up nutrients (i.e., carrying capacity) in stunted fish.

In subsequent reports, Swingle and Smith elaborated their specifications for pond management and for the rehabilitation of old ponds (Swingle and Smith 1940, 1942, Smith and Swingle 1943, Swingle 1945, 1949, 1956). The primary reason why farm ponds did not produce good fishing was that they were not properly stocked, which prevented the attainment of a proper balance between predator and prey fish, which could then be maintained.

The prolific, insect-feeding bluegill was found to be the most efficient forage fish, and the largemouth (black) bass functioned best as a predator, the effective stocking ratio being 1500 to 100 fingerlings per acre. If other (competing) species were present, their removal by draining or poisoning the pond was necessary. Ponds correctly stocked gave good fishing in one year. Over-fishing was no problem, since not more than 50 percent of the eligible fish could be taken by hook and line.

To produce good fishing a pond should be fertile enough to yield at least 100 pounds (45 kg) of fish per year, and the bulk of the weight must be in catchable-size game and pan fish. In addition to increasing the standing crop of fish, the fertilization of ponds had another important benefit. It induced a dark green bloom of algae and other plankton suspended in the water (the basis of the food chain), which shaded out the weed beds that would develop otherwise. Any growth of weeds impeded an adequate reduction of bluegill fry by the bass and an adequate harvest of fish by the angler.

The fertilization of fishponds for higher yield was practical under the long growing season of the Deep South. However, it proved inadvisable in northern states where ice and snow cut off sunlight and induced oxygen depletion during winter months. In some areas other factors evidently prevented bass from keeping up with the multiplying bluegills. Swingle knew that his specifications for pond management in Alabama would not work everywhere; he seined and analyzed ponds as far north as Maine. But the species he worked with and the understanding of relationships he created were the basis and the stimulus for constructive experimentation and modification in many states (e.g., Krumholz 1950, Ball 1952).

Swingle was the acknowledged authority on pond management. The results of his devotion to this field of research have been applied on a large portion of the 2.5 million farm ponds now in operation. The public benefits are inestimable.

* * *

One could hardly attempt even a brief, high-spot review of water management without a recognition of the most political and least admirable resource-use activity handled by our national legislature. Intuitive people (some in the congress), conscious of the semantic needs of the times, have described it in such terms as pork-barrel, log-rolling, and boondoggling. On bills that sometimes go to the White House for a presidential veto (necessitating an overriding vote), the terminology used may be public works, rivers and harbors, omnibus water projects.

In the late 1940s Bernard DeVoto wrote a column for *Harpers Magazine* called "The Easy Chair." The occupant of that chair was classically uneasy about what he called "the lobby that can't be licked." It was a tri-partite living-in-sin by the United States Congress, the Corps of Engineers, and the Bureau of Reclamation. U.S. taxpayers furnished the money. Business interests who could profit by the uninhibited spending furnished dependable political support. Politicians, both state and federal, received generous campaign remembrance and got kept in office. Many of them were senior citizens in the congress, often strategically located to get any kind of job done. They traded votes for things meritorious and things outrageous and provided abundant funding for the bureaus that did the work and developed more plans (see Reid 1944).

By such manipulations the public bread was spread upon the waters, and substantial amounts of it came back reliably at election time. How could you beat such a system? DeVoto thought you probably could not.

As I have faintly implied, some good comes of all this. Certain water projects undoubtedly represent appropriate public investments. With equal certainty, others have been cynical raids on the treasury. Shady economic practices have been routine.

Often, cost-benefit ratios were falsified—either they were, or the people who did the planning were not qualified to do the planning. Estimates of ultimate cost commonly lack credibility to begin with and then fall far short of the mark. Discount rates on funds the government must borrow have seldom been realistic (see Cicchetti et al. 1972, Carroll et al. 1979).

Most of the big water projects have included little consideration for natural or cultural features that were destroyed, in fact for any value that could not be expressed in dollars (Cain 1966). What is a salmon run worth for all time to come (see Darling 1937, Jackson 1947)? Or the winter range of a big game herd? Or the archaeological treasures in sites occupied by early man? Congress has made laws that would quickly eliminate any private entrepreneur who misled the public by methods that are common practice in boondoggling.

At the 12th conference, in 1947, the chief of Fish and Game in Missouri, M. O. Steen, expressed his sense of outrage. He said that American citizens do not know the truth, and he called upon them to look to Washington:

> There you will see your government appropriating 45 million dollars to the Soil Conservation Service to finance their work of holding America's water where it falls and soil where it lies, and, at the same time appropriating 185 million dollars to the War Department with which to make down payments on dams designed to stop the water that doesn't linger where it falls and the soil that doesn't stay where it lies.

Like all serious conservationists, Steen understood that flood prevention, erosion control, the recharge of aquifers, and all their side benefits begin at the height of land (Hope 1952, Males 1960). This is the management of watersheds, a primary concern of the professionals who work with soils, forests, grasslands, and every kind of animal life.

It is not a main concern of those whose business it is to promote big dams and reservoirs for flood control, irrigation, power development, and—last but not incidental—the economic benefits of construction accruing to the proper people in a state or a congressional district.

If Americans do not know the truth about such things, it is because they are not supposed to know. An editor from Oklahoma City (Peterson 1953) remarked, "It is almost as if there were a conspiracy to keep actual facts from the people."

In the national and local press coverage of disastrous floods, the average reader never hears about floodplains. He is led to believe that floods are an illegal encroachment on the properties of innocent people. There is no mention that the low-ground housing and other developments by misled people *are where they should not be.* Such rhetoric has no place in the propaganda that represents another big reservoir as insurance against further disasters.[9]

As for the big impoundments themselves, the person who pays the bills is not told that every reservoir is temporary, that it is a silt-catching basin with a useful life that will be long or short (Stevens 1936, Brown 1944). This is information well known to the engineers, but it is not a part of the *public* planning. This is a point on which conservationists have been critical, and at times they will not be denied.

[9]Historically, the average American paid the disaster relief bill for property damage in flood-prone bottomlands and in areas of high hurricane hazard on barrier islands and exposed beaches. Supposedly, this situation is now being changed.

When the assistant commissioner of reclamation (William E. Warne) addressed the Chicago conference in 1944, he told of things being done on the big reservoir projects to benefit wildlife. But he knew what was on everyone's mind, and commendably he also dealt with the silt question. The situation in Lake Mead was his well-chosen example.

Before the building of Boulder Dam (1936, now Hoover Dam), irrigators on the lower Colorado River were spending $1.4 million annually to remove silt from their canals and ditches. At that time the estimated annual deposit of silt on the river's delta was 100,000 acre-feet, or 330 tons per minute.

> The entrapment of silt at Boulder Dam, as you can see, materially benefits water users downstream . . . At an average rate of silt deposition of 100,000 acre-feet annually, more than 300 years would elapse before the reservoir could be filled . . . however, additional reservoirs will be created which will serve to halt the silt before it reaches Lake Mead. Already the Bureau of Reclamation has made extensive field investigations looking to a dam at Bridge Canyon [Grand Canyon], 200 miles upstream from Boulder, and other sites are being studied in connection with a comprehensive plan for the full use of the waters of the Colorado. Any forecast as how rapidly the water storage capacity of Boulder Dam will be reduced by silt deposits is contingent on how rapidly the upstream developments take place.[10]

Thus, one big water project begets another. The figure seems generally accepted that approximately 50,000 reservoirs have been built on rivers on the nation, and most of the best sites are in use. But where does the process stop? How long are these reservoirs going to last? Raw data are available on many impoundments, for people qualified to interpret them, although most such reports seem to be fairly old (e.g., Eakin and Brown 1939, Soil Conservation Service 1950, Dendy and Champion 1969). About the most that a non-professional can get from them is evidence that some of the dams will be producing water and power for a matter of centuries, while others will have terminated their service in a much shorter time. In his USDA bulletin on *The Control of Reservoir Silting*, Carl B. Brown (1944) summarized estimates

> . . . that as a result of silting alone 21 percent of the Nation's water-supply reservoirs will have a useful life of less than 50 years, another 25 percent will last 50 to 100 years, whereas only 54 percent will provide enough storage to suffice for present requirements (not the estimated future needs) 100 years hence.

Brown thought that irrigation and recreation reservoirs will be depleted at "similar, if not somewhat faster rates" and flood control impoundments could last much longer.

"Useful life" is an arguable point, yet (contrary to practice) the idea should be represented in all plans for new reservoirs. I suggest that specifications should reveal at what point in time the new lake will have lost half its storage capacity. That statistic should be calculable and reasonably precise. "Half life" would be a good name for it. Surely obsolescence is an important consideration in amortizing the cost of anything.

* * *

[10]The principal feature of those upstream developments is Glen Canyon Dam at Page, Arizona. The silt that formerly went down the Colorado River through the Grand Canyon is now settling to the bottom of Lake Powell. Lake Mead has had its reprieve.

The congress has always included many members—though often outnumbered—whose concern for the public interest or something more practical led them to oppose the most flagrantly irresponsible water projects. Citizen conservation groups and national leaders have endlessly editorialized (e.g., Carter 1967, Reisner 1978) or mounted aggressive campaigns (viz. Garrison Diversion) over what they regarded as shameless violations of the public trust. Perhaps as a result, we have been spared some major errors, both environmentally and economically.

The Colorado River stills flows, somewhat denatured but unimpeded, through Grand Canyon National Park. Those waters will never reach the ocean—their expiring trickle will soak into the desert down Mexico way. But in the world-famous gorge they are allowed to perform a part of their ancient function, despite the great plans for Bridge Canyon and Marble Canyon Gorge dams.

As another notable escape, Alaska's Yukon flats are still one of the major waterfowl producing wetlands on the continent. At the meeting in 1963, the redoubtable Gabrielson (appropriately identified in his obituary as "the archetype of conservation statesmen") said that the proposed "Rampart Dam is synonymous with resources destruction." Evidently the planners gave little thought to the blocking of salmon migrations on the Yukon, to the flooding of 10 thousand square miles (25,900 km^2) of wetlands that produce a million ducks and geese a year, to the destruction of habitat for moose and other wildlife—resources for which Alaska is famous (see Leopold and Leonard 1966). Gabe remarked further that "A very determined effort is being made to speed up the studies and rush its authorization through Congress, and conservationists everywhere had better look into the proposal and learn the facts that are involved." They did look, they learned, and Rampart did not qualify.

Among the satisfaction that conservationists dwell upon is the cross-Florida barge canal, which was authorized by Congress during the war to create a new route for traffic across the northern part of the state. Supposedly it was to short-circuit the longer way around, which was exposed to U-boat patrol. However, after the war the pressures were kept up, and by 1971 a beautiful river was becoming a canal, and the half-billion-dollar project was a third completed. But the diligent opposition of state and national citizens finally had its effect in Washington. The Corps of Engineers—which by that time was beginning to change its spots on environmental matters[11]—restudied the project and recommended against its completion. President Nixon called off the dredges, and no work has been done since then. In all realism, Congress should have deauthorized the project, but that final move has not been made.

No one should be so naive as to think anything in the big-water field has been finally decided until the last cubic yard of concrete is poured. The spark of many a public-works Gargantua still glows in the punk of bureaucratic archives. At the 12th conference Charles Jackson (1947) told of the 13 flood-control and power dams that had been proposed for the Potomac River. It took the leadership of Virginia congressman A. Willis Robertson and an uprising of adamant Potomoc defenders in three states and the D.C. to abate the menace. But Jackson recognized that "this

[11]Changes in the leadership of the Corps and its environmental awareness were evident and widely commended by conservationists (see Reetz and Pierce 1976, Bratton 1981).

does not mean the Corps of Engineers will give up on the project. They will simply wait for a more auspicious opportunity."

The true proportions of what we have missed—or perhaps not yet experienced—may have been exposed to view by Senator Kuchel (1965) of California at the 30th conference. He told of a grand design by which water "requirements" of the future might be met:

> The Senate Committee on Public Works now has under study proposals for the development of a plan to collect surplus water in the Arctic and, through a system of canals, tunnels and rivers, distribute it to water-scarce areas in Canada, the Western United States and Northern Mexico. In addition, this project, estimated to cost $100 billion, would provide a waterway from Vancouver, British Columbia, on the Pacific, to Duluth, Minnesota, on Lake Superior. The diverse channels would deliver water to the northern plains from Alberta to South Dakota, and increase the flow through the Great Lakes-St. Lawrence System.

Possibly such thinking raises a fundamental question of how we are to tell the difference between a resource shortage and just too many people. What if a million more people want to move to Arizona? Do we allow available water to set a limit? Not if the business community can help it. A million people—more customers, land development, housing starts, tax base, representation in Congress, manifest destiny—what are we waiting for? The accepted strategy is to attract the people and then worry about resources.

Something on that order is behind the Central Arizona Project (CAP), a world-class boondoggle authorized in 1968 with a capital investment price tag (updated) of $3.5 billion (Postel 1984). It is already well along. The Natural Resources Defense Council published a thumb-nail description (Reisner 1978). In addition to "four giant dams and a far-flung desert irrigation empire of pumps, storage reservoirs, aqueducts, and canals . . .

> The project features an aqueduct which will bring water from the Colorado River (whose water is already overallocated, but no matter) into central Arizona, using up, in the process of doing so, enough electricity to heat, cool, and light a city of 875,000 people. Its chief beneficiary will be agribusiness, which consumes ninety percent of Arizona's water and returns three percent of the state's income.

After a penetrating analysis of all aspects of the project, University of Montana economist Thomas M. Power (1978) concluded that, over 50 years

> . . . the project will cost the U.S. taypayer more than $5.4 billion in subsidies while yielding no positive net return to the nation. Its benefit-cost ratio is less than 0.35 to 1.0, not the 1.6 to 1.0 as claimed by the Bureau of Reclamation. It may well only return a few cents of each dollar invested in it.

Even as a gift to Arizonans, the CAP is an illusory benefit. Many irrigators will not be able to afford facilities necessary to use the water, and costs to municipal and industrial users (who will have priority after an initial phase) will be high ". . . CAP will cost Arizonans more than $5.1 billion."

In its present economic configuration, much of the arid Southwest survives on fossil water and on the assumption that at the expiration of borrowed time someone else's water will be available to supply their need. The previously mentioned cropping program of the Texas panhandle—dependent on the continuing drawdown of the Ogalalla aquifer—is a good example.

The "one-year rotation" of irrigated cotton, corn, and sorghum leaves the soil disturbed and largely unprotected the year round. As a result, smothering dust storms are a taken-for-granted feature of winter weather. The natural vegetation of this region was a grass-shrub savanna, which is suggestive of the kind of grazing economy that would be durable for the future if properly managed.

The Chamber of Commerce attitude has been that this is a political problem, that the world's future need for food will require that a river (or even Great Lakes water) will be piped in from the north to perpetuate the whole operation. The present regional economy is a top-heavy investment dependent on the continued wasteful expenditure of soil and water riches of the Pleistocene.[12]

This harkens back to another statement in Senator Kuchel's (1965) presentation. We probably can agree with him that "the solutions to these vast and vital undertakings are not merely the amount of concrete poured and the number of turbines installed but rather, it is the quality of ideas generated from a breadth of vision and from dedication to the American dream."

It is timely to recognize that any continuation of water developments on their historic scale will mean a wholesale mutilation of the natural hydrology of the continent. The merits of that natural system have been evident to many, including the members of Congress, who saw a need for the study and development of policy. They created the President's Water Resources Policy Commission, who reported (Cooke et al. 1950) in three massive volumes. Leland Olds (1951), a member of that commission spoke at the 16th conference. In discussing the natural dynamics of river basins, he asked an elemental question about man and his interventions:

> Has he, along with all other forms of life, been adapting his ways to the unity of river basins? Or has he tended more and more to divorce himself from this unity, seeking rather to make the water and land resources subservient to human will, destroying the balance of the grand collectivism which is the basin in pursuit of quick individual gain, so ultimately wearing and wasting away the very base of civilization?

With reference to wildlife, he said of the Commision's recommendations "that commercial fishing, sports fishing, wildlife conservation, and recreation opportunity should be considered as among the primary objectives throughout the planning of water resources programs, that they should be evaluated fully in all decisions to construct water resources projects . . . Congressional legislation and appropriations should be directed at both protection and improvement of these values."[13]

When ancient canyons are blocked with dams and then filled with silt, the changes are forever, they cannot be undone. The transitory nature of reservoir benefits seems to guarantee that many of our investments will stop drawing interest within a century. In which case there will be more problems to solve and less to work with in solving them. How far ahead do we plan? This episode of the American dream could end in a rude awakening.

[12]Somewhat contrary to expectation, late reports show some reduction of irrigated acreage (Postel 1984). It could be a sign of weakening in the boomtime outlook.

[13]Constructive policy making has been embodied in numerous legislative acts. Another formal effort in this direction was the creation in 1968 of the National Water Commission, which reported in 1973. The document of more than 500 pages was summarized in more useful form for general distribution (Luce et al. 1973). A principle advocated by the Commission was that in water resources planning there should be two major objectives, economic efficiency and environmental quality (see Fairchild 1976, Hanke 1976, Whipple 1976).

In these times of growing fiscal emergency and deep stirrings of taxpayer unrest, the congressional enthusiasm for building dams and giving away water and power (see Luce et al. 1973) seems to have lost some of its impetus. Possibly Central Arizona and that just-completed 3-billion-dollar atrocity of the South, the Tennessee-Tombigbee barge waterway, have been too successful.

With help from the Office of Management and Budget, a debate has developed over how projects should be selected and over the idea that beneficiaries (state and local) should pay a major share of the costs and even market value for what they receive (Dawson 1983). At the 1983 conference, the former executive director (Caulfield) of the Water Resources Council, quoting an earlier paper, stated that the "Federal water resources program is politically dying, if not already dead." He pointed out that since 1975 "no omnibus rivers and harbors authorizations for the Army Corps of Engineers (formerly a two-year occurrence) have been enacted and (with a few exceptions) no new authorizations for the Bureau of Reclamation have been made."

To anyone optimistically inclined, it has appeared that the Congress might be undergoing a change of heart— that is, until late in the 1984 session. Then, in the House of Representatives and also in the Sentate, bills were hastily assembled that included 300 new projects—pork in the barrel for everyone—about 18 million dollars worth. The National Wildlife Federation editorialized in *The Leader* (August 1984) that

> If funded, these projects could constitute the biggest wave of water resources development since the New Deal and would mark the first time in eight years that Congress has enacted an omnibus water projects bill.

It was too late to resolve differences and get action in 1984. However, the bills are being brought up again in the 1985 session. Every citizen knows that the nation's economic integrity hangs in the balance. Every member of Congress knows where money could be saved. Whether anything basic in the water resources field has changed will soon be evident.

* * *

As of 1985, one of the most significant things we can say of our public lands is that they are still public. Long before the first wildlife conference, Congress had recognized that certain national properties should be held in trust and managed for the good of all.

The Forest Service Organic Administration Act was passed in 1897. The public forests (now 188 million acres [76 million ha]) were to be preserved as watersheds and as productive timberlands. However, at first as a matter of practice, and later under multiple-use mandates (McArdle 1953), they became grazing lands, wildlife habitat, recreation areas, and samples of the primitive.

The National Park Service was made a legal entity under its "organic" act in 1916. The Nation's unique natural wonders were to be held unimpaired for the future as scenic memorabilia, as great possessions that could not endure in private ownership, as a pleasuring ground for the people. Today the system includes about 80 million acres (32.4 million ha) in 335 units of all categories, which recorded 244 million visitors in 1983.

The Bureau of Land Management, created in 1946 from the USDI General Land

Office and the Grazing Service, took custody of the 450 million acres (182.1 million ha) of remaining public domain lands (now National Resources Lands), originally regarded as disposable. Although dominated by grazing, other uses of its lands gained recognition, and BLM acquired long-overdue management and administrative authorities under the Federal Land Policy and Management Act of 1976.

At the 48th conference, Governor Ed Herschler (1983) of Wyoming noted that the Taylor Grazing Act of 1934"for the first time, brought active federal management to the millions of acres of public domain lands that hadn't already been set aside and managed as forests, parks, and wildlife reserves. It also marked the end of the federal policy of disposal and the beginning of a policy of retention and management."

Retention has not gone uncontested. In the late 1940s a drive was mounted by western grazing permitees on the national forests to take over (by transfer to the states) those lands on a gift basis—similar designs on BLM lands date back into the 1920s. The stockmen's aggressive enterprise was one of the preoccupations of Bernard DeVoto (1947) in his "Easy Chair" editorials. It failed, but in the 1970s it emerged again on a broader scale as the "sagebrush rebellion."

Of that passage in public-land history (still not defunct), a Colorado governor (Lamm and McCarthy 1982) said,

> In one sense, it is a legal war against the federal government, its objective nothing less than the formal cession of the public lands to the states in which they lie. In another sense, it is . . . a political crusade mixed with hard talk and backcountry demagoguery designed to force Washington into improved public-lands management.

With components of image, tradition, avarice, and big-government bungling, it is evident that the revolt is not a simple matter to be satisfied by a single feasible concession. The transfer of lands is not feasible, but on the need for management improvements anyone can agree.

The national wildlife refuges, like the parks and forests, were initially assembled piecemeal through various withdrawals and acts (Greenwalt 1978). The first refuge was in Alaska, the Afognak Forest and Fish Culture Reserve, established by President Harrison in 1892 (Williamson 1984). Land acquisition for waterfowl refuges was specifically authorized by the Migratory Bird Conservation Act of 1921 and shored up financially by the Migratory Bird Hunting Stamp Act five years later. Bean (1983) summarized:

> Until 1966, there was no single law governing the administration of the many federal refuges. In fact, there were numerous administrative units, known variously as "game ranges." "wildlife ranges," "wildlife management areas, " "wildlife production areas," "waterfowl production areas," and "wildlife refuges," all under the jurisdiction of the Fish and Wildlife Service, or, in a few cases, under the joint jurisdiction of the Fish and Wildlife Service and the Bureau of Land Management . . .

These areas (now 420 units aggregating 90 million acres [36.4 million ha]), representing a variety of legalized management purposes and standards, were brought together by the National Wildlife Refuge Administration Act of 1966. An amendment in 1975 directed that all units of the system be administered by the Fish and Wildlife Service.

In the legal foundation for refuge management, an important burden of decision is left with the Secretary of the Interior, who 'may permit the use of any area within the System for any purpose, including but not limited to hunting, fishing, public recreation and accommodation and access whenever he determines that such uses are compatible with the major purposes for which such areas were established.

The dominant function of federal refuges is to furnish habitat for waterfowl, endangered species, and other wildlife (Leopold et al. 1968, Fish and Wildlife Service 1976b), but it is not the exclusive use. How much hunting, trapping, fishing, and boating is consistent with the original purpose may be an area of disagreement between federal and state administrators. How much grazing, haying, and similar activities are compatible is not usually a concern of refuge land-use permitees, and any managerial attempt at limitation is likely to become an issue in the office of the congressional representative in whose district the offense occurs.

Such problems are rife on the refuges—a persistent source of mismanagement and inefficiency. The provisions of law are, for the most part, clear enough. How they are interpreted or ignored by individual members of the congress in their response to claims of self-interested constituents often is a law unto itself.

The National Wildlife Refuge System is in need of a more explicit charge that standardizes policy, responsibility, and authority throughout the system. We are awaiting another "organic" act. More broadly, in the pattern of the Forest Service, the National Park Service, and BLM, the act should be at bureau level. It should cover the Fish and Wildlife Service in all its functions (see Reed and Drabelle 1984).

* * *

A standing principle operates in Congress to which the members are unusually faithful. The presumably unwritten law has left its mark on the public lands. It is the prevailing policy that any member should have the last word on whatever goes on in his state or district.

Abusive practices in the refuge system are in a pattern well known on other public properties. The constituent-congressman connection has accounted for much of the historic overgrazing and even illegal activities on the national forests. Although heavy grazing is still prevalent, that situation has been conspicuously improved in certain areas. Inquiries about such improvements usually reveal that some forest supervisor risked a transfer or worse to get a job done.

In the national parks, prolonged occupation and incompatible activities by inholders have had the same kind of protection. The longstanding failure by Congress to make adequate provision for blocking-in federal ownership produced continuing management problems and permitted costly escalation of land prices when purchases finally were made. This is another area where improvement is occurring, at least as far as the intent of Congress is concerned. In the three years from 1982 to 1984, appropriations for parkland acquisition totaled more than $332 million, a respectable sum if the administration had allowed the National Park Service to spend it, which they did not (Callison 1984). A congressional report suggested that this might be an "illegal impoundment of funds."

In his remarks introducing the conference programs, Dr. Gabrielson frequently called attention to the activities of special interests. At the 18th meeting (1953) he noted again the recurring attacks on the public lands:

> Regardless of the name of the President or the names of the men who are members of the cabinet, and regardless of their party affiliation, those who want something

> for nothing are always at work. Recently, this capital has had an influx of such individuals, including the political-minded livestock men who seek to get a strangle hold on the public lands equal to that which they have on most of the state-owned lands in the West; miners who want special privileges beyond those now accorded to them by law; and individuals who, in promoting various projects of their own, seek to invade the wildlife refuges; to destroy the national forests; or defile the national parks and monuments. These areas which have been set aside for the public use and enjoyment are always a temptation to gentry of this type. They are here, bringing pressure not only on the new administrators but on their congressmen and senators.

Gabe understood well the ways of government. He knew that the members of our national law-making body respond to demands of the people, and that many of the people think only on themselves. In the conservation idiom of our time, no one ever said so much in so few words as when Pogo declared, "We have met the enemy and he is us."

Special interests have far-reaching influence on the process of establishing national parks. As a case in point, in 1937 a choice area in the Sonoran Desert of southern Arizona was set aside as Organpipe Cactus National Monument. There on the Mexican border, the resource of interest was the strikingly beautiful vegetation. A complicating problem was that a family of ranchers, with no title of any kind, was running cattle on the area. A distinguished Arizona senator decided that the cattle came first; he was a member of the Interior Committee and of the Appropriations Committee. The National Park Service tried to get some kind of control by issuing a permit for 1000 cattle, but that is as far as they could go.

It took 35 years to free Organpipe from the blight of heavy grazing; it finally happened after the last of the ranching family had passed on. When a local bank foreclosed the holdings, they rounded up 1500 cattle and 300 burros. The monument has now qualified for national park status and has been recognized as a biosphere reserve. The corrals and fences have been removed, and the vegetation is showing signs of recovery.

Some people say, have patience and eventually we will get the job done. But one wonders, is that the way to do it? It may be later than they think—which suggests an example.

Long after many intelligent third-graders had learned that we needed a redwoods national park, our representatives finally gave in to public pressure and got the job done, after a fashion. It cost a billion dollars by the time they had bought-off the vested interests. That was more than we paid for all the rest of the National Park System. In his paper at the 30th conference, Senator Kuchel (1965) attested to the magnificence of those ancient trees:

> Last year I read in *National Geographic* an intriguing and romantic article. It told of the discovery in the State of California of the world's oldest living thing [sic]—a giant Redwood rising 367 feet toward the sky. That monarch and its neighbors must be preserved and shall be preserved.

In assembling redwood leftovers for the park, the congressional planners did indeed preserve, for a time at least, the trees on Redwood Creek. But during the dragged-out arguments, they allowed the forest on steep slopes above the creek to be butchered off. Whether the world's tallest trees can continue to survive under the new burden of heavy siltation remains to be seen. After getting the land, the National Park Service embarked on an all-out effort to stabilize the watershed.

An environmental type that was highly significant in early America is little represented in our National Park System: the grasslands. Long ago, we should have made provision for at least two such parks, one in the tallgrass prairies (Platt 1983), and one in the great plains. The one in the West should be a fenced range of a million acres (405,000 ha), complete with buffalo and wolves. It could be like nothing the people have seen on this continent (Allen 1977).

That would mean doing something of transcending significance in the West—excluding livestock from a small unit of our grazing country. Are we then to back away and say we cannot afford it? So far, that is our position.

The lands and waters we hold in common are the national estate. The irreplaceable wilderness we have set aside is a cultural, historical, and biological treasure house that will grow in value with each passing year (Hines 1953, Burns 1983, Schwegman 1983). The National Park Service has custody of our only fully protected (i.e., not open to hunting) wilderness. That total protection is needed for some kinds of research on wild communities. And such research is essential if we are to manage efficiently in the great majority of lands, both public and private, that must be our production areas for material wealth.

The scientific value of primitive areas has been slighted in our assembly and management of the wilderness system. The park service and other agencies with wilderness responsibilities need to recognize their public obligation to make these lands and waters (any areas, for that matter) available for many kinds of research. Which will require an ironclad system-wide policy of cooperation that is made known to all units in the field. This is at present a realm of local option and wayward performance.

There is a special need among members of the congress and among citizens at large for an understanding that reserved natural areas are much more than sites for one-alone recreation. They are the most tangible link we have with our irretrievable past. Without them we will become estranged from the social and ecological roots of our culture. We cannot fully know where we are without a knowledge of where we have been.

Amid the great surge of development in the West (Lamm and McCarthy 1982) and elsewhere, threats to the integrity of our public lands are emerging on every side. This is a particular hazard to what we expect to accomplish in the national parks (National Park Service 1980). Securing the necessary level of protection and provident management in these national properties will require a share of the eternal vigilance that we recognize as the price of freedom. It will involve continuing reexamination and innovation.

As a practical move in that direction, in 1970 the Public Land Law Review Commission made its report to the President and to Congress, after six years of study and deliberation. One of their recommendations (number 131) was that "The Forest Service should be merged with the Department of the Interior into a new department of natural resources" (Public Land Law Review Commission 1970, Pyles 1970). This idea is still viable and needs further study by the congress. It could be one of the important moves in our next 50 years.

* * *

In the long record of these meetings, changes in the titles and functions of state administrative agencies have reflected broadening citizen ideas of public responsibilities in the natural resources field. Such departmental titles as *Fish and Game* have commonly changed to *Wildlife*, and *Conservation* has sometimes become *Natural Resources*. In the new semantics, even *Environment* is getting into it. A major preoccupation with propagation and stocking in the early handling of game and fish problems has largely given way to habitat management. Gains have likewise been made in the replacement of political influences with merit systems and in applying the scientific approach to whatever needs to be done. This can be stated with confidence, not because things are so surpassingly good today—if anything is certain, it is the survival of political finagling—but because originally the state of conservation affairs was so bad.

At the second wildlife conference, E. Sydney Stephens (1937) described a development in Missouri that has achieved historic status. He told how, after 30 years of frustration over political blundering, conservationists had taken action. By way of a public referendum, the state constitution was amended to provide for a non-partisan, non-paid commission with staggered terms of six years.

> The commission is vested with the control, management, restoration, conservation and regulation of the birds, fish, game, forestry and all wildlife resources of the state. The power to regulate is thus taken from the legislature and vested in the commission. This means that the new agency has the power to fix open and closed seasons and bag limits, to set up the various divisions and activities required to carry out its function.

At the time he helped bring about this sensational achievement, Stephens was president of the state's Restoration and Conservation Federation—more recently the Missouri Wildlife Federation. Later, as chairman of the new conservation department, he gave a paper at the general session of the 11th conference (1946) appraising progress in wildlife administration in the nation.[14] Applying a series of standards for rating state wildlife agencies, he concluded that, "the departments of 12 states are less than 25 per cent efficient, and 30 rank below 50 per cent; and only 5 have a 'passing' grade of 60 or better." Of the 12 states ranking under 25 percent efficient, he said they simply wasted the money paid by sportsmen. "They should be painlessly but promptly put to death. The next 18 might be given a stay of execution on their promise to reform."

Many state administrators have had occasion to envy the position of the Missouri director and commission in having full discretionary authority over regulations granted to them by the state constitution. Of course, the legislature can enact laws delegating such responsibility to the commission (see MacKenzie 1937), but this does not always get done. Meddling in such details by committees or influential individuals is commonplace and gives rise to throw-backs in management that the public, as well as administrators and their technical help, must live with (Pender 1943). The historic record in many states is replete with examples in which the findings of wildlife staffs were over-ridden by actions of pressure groups who got what they wanted by invoking "democracy" in the legislature. Issues so handled have frequently been in the controversial fields of bounties and predator control, artificial stocking of fish and game birds, winter feeding of wildlife, and hunting regulations on overpopulated deer.

Because legislators are sensitive about their prerogative of having the last word on

[14]See also the opening remarks of Gabrielson at the 14th conference (1949).

anything, the Missouri plan remains (to my best knowledge) unique in the nation. However, the past half century has seen important administrative progress in all states. This is commonly helped along by the activities of well-informed citizen organizations. Great good was accomplished by the federal aid to wildlife and fisheries laws in 1937 and 1950. These provided that in order to be eligible for Pittman-Robertson and Dingell-Johnson funding the states must have their own laws forbidding the diversion of game and fish license moneys to non-conservation purposes (Day 1940).

Numerous other avenues exist for growth and improvement. The participation of state administrators in activities of the International Association of Fish and Wildlife Agencies and the Western Association of Fish and Wildlife Agencies has done much to shake out tendencies toward provincialism, especially where the turnover of personnel is frequent. The pooling of ideas and interests in the creation of model laws and regulations of various kinds has been widely useful. Significant also is the practice—usually by the governor—of arranging for an "outside" review and evaluation of the natural resources department and its functions. The Wildlife Management Institute has performed this service more than 50 times. As another effort toward policy guidance, in 1972 the Institute appointed a committee to draft a new North American Wildlife Policy, which was reported on at the 38th conference (Allen 1972, Allen et al. 1973, Leonard 1973). This was an update on the report by the Leopold committee in 1930.

Anyone even remotely interested in outdoor affairs during the past decade must be aware of the growing interest in many aspects of wildlife protection and management among the general public. One expression of this interest has been that in the federal government and in nearly all states some kind of "nongame" wildlife program is either established or on the way (see Jackson 1982, Lyons 1982). For many purposes (such as conference programs and state administration), endangered species and urban wildlife are included in the nongame category. Three of the recent North American conferences have included technical sessions on nongame wildlife (1974, 1978, 1980), and in 1981 a special session was held on urban problems. Since the early 1970s, a general proliferation of publications has been evident on the needs of non-hunted birds and mammals and on the non-consumptive uses of all species (Kellert 1976, Fazio and Belli 1977, Shaw 1977, Witter and Shaw 1979, Bury et al. 1980, Kellert and Westervelt 1982).

The expanded activities of states, which are necessary to satisfy new demands, are supported in various ways (Wildlife Management Institute 1975, Unkel 1983, Whitehead 1983, Wolf 1983), including federal funding now available under the Fish and Wildlife Conservation Act (the "nongame act") of 1980 (see Bean 1983). It seems of particular interest that in finding the solution to a fiscal dilemma of long standing, conservationists in Missouri have again set a standard. Just 41 years after the famous Stephens paper, another director of conservation told the 43rd conference how the operation was organized and carried out (Noren 1978).

Plagued by a shortage of money for all purposes, including the establishment of a new nongame wildlife program, they set about a systematic study of needs and funding possibilities that spanned nearly a decade. It involved a review by hired consultants, and the energetic participation of the Commission, departmental employees, the Missouri Wildlife Federation, and a St. Louis businessman and his wife. A public meeting was held, and a Citizens Committee for Conservation was formed to promote the new program, which was dubbed "Design for Conservation." Its aim was an amendment to the state constitution that would add one-eighth of one percent to the state sales tax. This tax was expected to yield some $20 million, which would be earmarked to about double the existing budget of the Department of Conservation.

The massive drive for public support was beset by complications, opposition, and setbacks, but the new tax referendum finally appeared on the ballot of 2 November 1976. It was approved by some 30,000 votes. In a news release, the Wildlife Management Institute remarked, "All Missourians deserve much credit for supporting their Department of Conservation, which remains a national leader in resource management."

Carl Noren's report to the nongame wildlife session of the 43rd conference has major value in his detailed account of what can be accomplished through sustained devotion to a cause, persistence in the face of discouragement, and the cooperation of leadership. It also exemplifies how many state affiliates of the National Wildlife Federation are functioning in helping to decide the outcome of important issues.[15]

When, in 1945, Carl Shoemaker identified soil erosion as our major "conservation" problem, he was referring to the human environment and the status of a basic resource. This was likewise the view of Lester Brown in his summation of resource problems in 1984. He selected world-wide soil erosion as a subject for special treatment. Essentially, the status of this land-use issue has not changed, except for the worse.

When we shift our purview to the wider range of human ecology and include the entire gamut of social and economic variables, then population becomes the most-critical component of the welfare equation. I have noted that in recent discussions of the question of human numbers, population is sometimes identified as the "multiplier" of environmental problems, which is a realistic concept (e.g., Downs 1973).

It is fairly certain that Shoemaker was well-informed on these matters. In alluding to difficulties in the tropics, he was drawing on the work of William Vogt, conservation director of the Pan American Union, who had carried out extensive surveys of wildlife, land, and people problems in Latin America (Lloyd and Vogt 1946). In 1948, Vogt published his best-selling book, *Road to Survival,* an unusually forthright exposition of human relationships to resources and living standards. One appreciative reviewer called it "A stunning book, which every citizen should read aloud to his congressman." Despite such accolades, the author's advocacy of population control through the reduction of birth rates produced indignant reactions in the public press—often expressions of religious or economic conviction.

That new concepts in the field of human demography were getting around became evident in 1954 with the holding in Rome of the United Nations sponsored Conference on World Population. However, in this country there was little evidence of any definitive public policy. In 1959 President Eisenhower clearly enunciated his own position on such matters. He said of the much-discussed question of birth control. "This government has not, and will not . . . as long as I am here, have a positive

[15]It should be a part of this record that in 1984 the Missouri electorate approved another constitutional amendment that responded to drastic cuts in federal and state funds for state parks and erosion control. This one provides for a one-tenth of one percent sales tax increase for four years unless extended in another election. It should raise about $30.5 million annually. Missouri has the second-highest rate of soil erosion in the nation (WMI Outdoor News Bull., 30 Nov. 1984).

political doctrine in its program that has to do with birth control. That's not our business'' (Miller 1964).

Other prominent world figures did not share the president's orientation toward population. In 1963, in a lecture given at the University of Washington, Julian Huxley issued a judgment that is widely shared today: ''The world population problem is to my mind the most important and the most serious of all the problems now besetting the human species. The problem of avoiding nuclear war is more immediate, but that of overpopulation is, in the long run, more serious and more difficult to deal with . . .''

In another of the commentaries that Gabrielson recorded in these transactions (1965), he talked about the increase in population and what it means to the good life we cherish:

> As consumers of resources and occupiers of space, people are one of the most serious threats to their own future welfare in this country and in countries around the world. Their threat lies in a virtually unimpeded population expansion and the accompanying demands for living room, for food, and for endless other human needs and desires.

Later, he went on to say, ''Everyone involved in resources management should be aware of this serious problem [high fertility rates] because successful husbandry of our resources encompasses as much the factors of demand as it does of supply.''

Work on many aspects of the continuing increase in human beings was going forward in councils of the world, in academia, and in the U.S. State Department. Many members of Congress were becoming interested in population-related problems. In July 1969 Richard Nixon sent the first presidential message on population growth to the Congress. He requested support for action by the Secretary of State and the Agency for International Development ''to give population and family planning high priority for attention, personnel, research and funding among our several aid programs'' (Kieffer 1973).

There was further evidence that a substantial U.S. program had been gaining ground. In a speech before the U.N. assembly in 1965, President Lyndon B. Johnson issued a call for concerted action:

> Let us in all our lands . . . including this land . . . face forthrightly the multiplying problems of our multiplying populations and seek the answers to this most profound challenge to the future of all the world. Let us act on the fact that five dollars invested in population control is worth one hundred dollars invested in economic growth.

That year the National Research Council issued its report, *The Growth of U.S. Population*, and in 1966 the Interior Department Yearbook Number 2 was entitled, *The Population Challenge*. By 1969 ''the U.S. Government was the principal source of funding for family planning programs throughout the world. Yet three years later, in 1972, President Nixon, like President Eisenhower, rejected the recommendations of the carefully selected Commission on Population Growth and the American Future, for legalized abortion and contraceptive services to minors'' (Piotrow 1973).

In writing the foreword of a book on the population crisis (Piotrow 1973), our U.S. Ambassador to the U.N. stated,

> When I moved to the United Nations in 1971 . . . I found that the population problem was high on the international agenda, though lacking some of the urgency

> the matter deserves. The General Assembly had designated 1974 as the World Population Year with a major conference of governments scheduled . . . It is quite clear that one of the major challenges of the 1970s, the Second United Nations Development Decade, will be to curb the world's fertility . . . Success in the population field, under United Nations leadership, may, in turn, determine whether we can resolve successfully the other great questions of peace, prosperity, and individual rights that face the world.

The ambassador, George H. Bush, Jr., obviously understood the basic problems of mankind. Such understanding also was manifested on the part of certain state officials. In California a manifesto from the governor's office stated in part:

> Our country and state have a special obligation to work toward the stabilization of our own populations so as to credibly lead other parts of the world toward population stabilization.
>
> I, therefore, would urge the citizens of California to join in the observance of October 14, 1974 as World Population Day and to take this opportunity to reflect on the necessity of population stabilization to the welfare of all the peoples of the world.
>
> Ronald Reagan
> Governor

The most recent World Population Congress was held in Mexico City last August (see Bull 1984). The head of the American delegation assured the assembly that the support of the United States for "population strategies based on voluntary family planning" would continue. In 1984 this would constitute 44 percent of the population assistance provided by developed countries of the world.

It was stated, however, that the policy of the United States required a "sharper focus," that this country concurred in the address of welcome by the President of Mexico, which placed the population problem in context: "Our planet, inhabited today by 4.8 billion human beings, has the natural resources, production capacity and different administrative and political skills it needs to fully meet the basic needs of its future population." The American statement added that the growth of population, in itself, is neither good nor bad. "People, after all, are producers as well as consumers."

The American statement (Buckley 1984) also made it clear that the contribution of funds by this nation was not totally unencumbered:

> . . . the U.S. will no longer contribute to separate non-governmental organizations which perform or actively promote abortion as a method of family planning in other nations; and . . . before the U.S. will contribute funds to the United Nations Fund for Population activities, it will insist that no part of its contribution be used for abortion and will also first require concrete assurances that the UNFPA is not engaged in, or does not provide funding for abortion or coercive family planning programs.

So swings the pendulum. Aside from our patently useful funding, it is probable that American technical help has been of major value to responsible leadership in the Third World. It has become widely evident in overpopulated tropical nations that their progress in economic and social programs is being foreclosed by the spread of poverty and land degradation. They have need of further aid (see Yinger et al.

1983). Attitudes toward the control of human numbers are changing, and these are not likely to be seriously confused by aberrations in our own policies.

In the wildlife and natural resources conferences, relatively few papers have dealt specifically with the problems of human densities (see Davis 1953, Vogt 1961) although the subject is mentioned here and there. When E. R. Kalmbach summarized the 23rd conference in 1958, he noted the paucity of such contributions and commented that "In only three of the 1,777 papers presented during the 29 years encompassed by this review, has the author stated that something might have to be done about it [i.e., population control]."

Since that time, the record is somewhat better, perhaps reflecting the broadening of natural resources coverage (e.g., Vogt 1961, Allen 1969, Downs 1973, Peterson 1975). As of 1983, in a dozen European countries the birth rate had declined to, or below, the death rate, and zero population growth had been attained. In other industrialized nations a reduction of fertility rates is under way. However, on a worldwide basis 35 percent of human beings are less than 15 years of age—implying a huge potential for further increases. An awe-inspiring job remains to be done, and a minimal contribution that might be expected of the U.S. Congress is the creation of a population policy for our own government (see Mann 1980).

To conceptualize the present condition of mankind, we are in a mode of holding what we can of environmental diversity (see Nature Conservancy 1975, Council on Environmental Quality 1980, 1981, Wolf 1985) and our resource base while we get over a population "hump" that will pose the gravest social and economic difficulties *Homo sapiens* has faced in 40,000 years. As judged by what it would be possible for present knowledge and technology to do for a manageable population in creating the good life for all people, I estimate that we are overpopulated by 100 percent in the United States and by at least 400 percent in the world at large.

* * *

Our orderly utilization of wildlife by sustainable methods is subject to various constraints that natural resources administrators commonly identify as "people" problems. One such game and fish administrator described two extremes of public attitude. He especially deplored the doings of a school of thought, as he termed it.,

> . . . which, like the poor we have with us always, who, if we should judge from their practice, believe they have a right to kill without regard to the future supply or for the next generation.

On the other hand, he observed that

> There has developed in recent years a considerable class of sentimentalists who . . . preach the doctrine that it is morally wrong and inhumane to kill any wild game bird or animal at any time.

It would not be surprising to see such comment in a newspaper anywhere in the country. At one pole of the public polarization, we have the character once known as a game hog, now more commonly identified as the slob hunter. At the other extreme is the highly visible reaction of those who foster the anti-hunting cult. However, contrary to common impressions, these niches in our outdoor society are not a recent development. The statements I cite were made by commissioner I. T. Quinn of Alabama, and they appear on the first page of the second volume of game conference transactions, which was published in 1929.

Today the extremes of attitude are still with us, more conspicuous than ever. Although these twain shall never meet, it is possible that, in some degree, they have a common origin. Both have responded to the pressures generated by that extra hundred million citizens and to the fact that an increasing proportion of the population is concentrated in metropolitan centers isolated from the natural scene.

It is especially true of those most-populous areas that each fall large numbers of inexperienced hunters go afield not knowing what they want or what to expect. They have done little homework, and they confront a growing complexity of regulations. They encounter posted lands and waters in what they thought was a free country. Few of them ever heard of a hunting ethic, and they have little contact with the kind of peers who accept that ethic as a part of the game. Which means keeping the sport morally respectable and biologically sound.

Among them are the slobs—not all from the city, but probably a major part. Out beyond the suburbs their work is evident to everyone, most notably the shot-up signs and the trash where they parked their cars. What the "hunters" did not do they get credit for. At least a few of them did worse things, well known to farmers and enforcement officers. A few is all it takes, but we do not really know how many there are.

It may be that some of us, as an outgrowth of frustration, are accepting anti-social behavior as an inevitable reality of the times, which could be a serious error. The influence of the slobs is far-reaching. It is hardly to be doubted that their activities play into the hands of those who would abolish all hunting, trapping, and even fishing.

Caught in the middle between those outer limits of attitude—irresponsible gunnery and vandalism on the one hand and anti-everything on the other—are the rank and file of hunters, a substantial portion of whom could justifiably be called sportsmen. Most of them are not just hunters or fishermen. They may be found in any group of people making enjoyable use of wild scenes and creatures (see Peterle 1961, Klein 1973).

Also between those extremes—and most significant of all—is the great body of the uncommitted public. A majority of them participate in one or more outdoor pastimes, and their casual, "non-consumptive" uses should never be underestimated (Shaw and King 1980). Wildlife professionals have long recognized that the preponderant value of free-living animals and their habitats is the one we call esthetic. This was discussed by the chief of the Canadian Wildlife Service at the 16th conference (Lewis 1951). He noted the almost universal appreciation of natural beauty, and he appraised what it means to the individual:

> Aesthetic and recreational values are primarily concerned with living a life . . . They upbuild the persons who assimilate them . . . In the long run, they are essential to the sound development of society. In comparison with economic values they take no second place.

Users of the out-of-doors have increased out of proportion to the increase in population. In the 25 years after the first national survey of fishing and hunting (in 1955), the population of the United States increased by 34 percent. In the same period, fishermen increased by 101 percent and hunters by 42 percent. "In 1980, 79.7 million individuals observed, photographed, or fed wildlife at home" (Fish and Wildlife Service and Bureau of the Census 1982). That would equal about half of the adult population.

City-life estrangement from the natural world probably contributes to the pacifist trend among outdoor users, and certainly to the tender sentiments of those who develop the anti-death passion. Many deprived urbanites have never seen the inside of a chicken, much less blood on the snow.

Among biological illiterates, representations of the unsophisticated press (no reflection on pro outdoor writers) are taken at face value. Anyone who kills anything or who is in the field with a gun is likely to be dubbed, in all simplicity, "a hunter." The news media miss no opportunity to feature outrages committed against endangered species, such as the shooting of a condor or a whooping crane, by you-know-who.

Topping it all off, the state may prescribe a liberalized hunting kill of overpopulated deer. The purpose may be to cope with crop damage or to reduce starvation on a depleted winter range. But there it is, always more killing. The high productive capacity of well-situated animal populations, the compensations that are part of the annual cycle of numbers—these are not evident to most people. State biologists call what they are doing *management,* and so another dirty word gets into the anti-hunting lexicon.

Public objection to hunting and allied pastimes probably finds its most refined expression in the anti-death movement. Evidently a guiding principle is that no creature should be allowed to die by violence in public. Peaceful, out-of-sight mortality involving such factors as starvation, disease, or the destruction of habitat appears to be acceptable. No price is too high to "save" an animal if money can be raised—the classical example being the hoisting of overpopulated burros out of the Grand Canyon by helicopter at $1000 each (Allen et al. 1981; see also Carothers et al. 1976, Behan 1978, Wagner 1983).

The ultimate development of the anti-death movement—organizations and individuals who have, quite literally, made a financially successful career of it—was described by Goodrich (1979) at the 44th conference. As evidenced by studies of the Wildlife Legislative Fund of America, some $30 to $50 million is being collected yearly "for campaigns to stop hunting, trapping and fishing and to close down wildlife management." An effective program is being mounted in schools, complete with teacher seminars and the widespread distribution of "educational" materials.

In an earlier paper, Kellert (1978) reported on a study of the characteristics of various categories of hunters and anti-hunters in a nationwide sample. Of the latter group he concluded that

> Demographically, anti-hunters included a disproportionately large number of females and were significantly more likely to reside in large urban areas. Additionally, anti-hunters reported far less experience raising animals and very few fathers engaged in farm-related occupations. Surprisingly, anti-hunters reported no greater behavioral involvement with animals or the out-of-doors, with the exception of owning pets for companionship reasons . . . [they] had among the lowest knowledge-of-animals scores of any group studied.

In the national sample, 29 percent of the respondents expressed a strong objection to sport hunting. This cohort of public opinion undoubtedly represents the source of funding for the hard-driving zealots who would drastically change the longstanding wildlife use and management programs of the nation. Their combined efforts are likely to be a significant political force in times ahead. They should not be taken lightly.

* * *

Nearly all interpretations of people doings have a speculative side. Attempts at synthesis would be more satisfying if we had a better basis of solid information. During the 1970s it became evident that such a data base was being developed, most notably by Kellert and his students at Yale (1976, 1978, 1980, Kellert and Westervelt 1982). It is customary to blame the social scientist for not taking more interest in important problems of aberrant behavior or public attitudes. But social phenomena are part of a greater context. We may be trying to understand a heel, a finger, or an eyebrow without knowing what the whole body is about.

When we look closely at the besetting issues of today, they quickly broaden out into what, more properly, should be called human ecology. This intermingle of causes and effects has components ramifying into environmental biology, population dynamics, sociology, human behavior, economics, living standards—divisions and subdivisions without end.

The field is interdisciplinary, and the disciplinarians tend to space themselves out, maintain their specialties, and stick to manageable details. When something big and important happens, each of them interprets it as a function of his own terms of reference. We fail to teach students to think conceptually and then are not wise enough to wish we had (Yambert 1934, Hoopes 1982). The farther a young person goes into advanced training, the more he or she specializes. The field of interest may be some important supply item in the resource base. Or it might be demographics, where learning may include little concern for environmental influences. Economic theory seems to develop with the assumption of unlimited resources, unending demand, and growth forever. When someone does reflect on such an abstraction as earthly carrying capacity, amenities like wildlife and outdoor recreation seldom figure into it. Quality of life assumes a "bread-alone" orientation.[16]

Some of these tendencies were bothering Samuel Dana (1951), dean of natural resources at the University of Michigan, when he gave his paper at the 16th wildlife conference. As he expressed it,

> Last week I attended a conference on science, technology and world resources at Northwestern University. For two full days and three evenings, leaders in the physical, biological and social sciences discussed man's ability to feed, clothe, house, transport, and entertain the present and future population of the world. With the exception of fish for food and other products, I do not recall a single mention of wildlife. Although there was an occasional dissenting voice,most of the discussion apparently assumed that an indefinite increase in population is inevitable and probably desirable. Some of the more optimistic—or were they really pessimistic?—looked forward to the time when technology will practically eliminate present checks on the number of people this planet will support. When that day comes, if it ever does, wildlife will still be a part of our culture, but certainly a very different part. The wildlife manager may have the task of preserving specimens not only of the trumpeter swan and the grizzly bear but of the English sparrow and the cottontail rabbit in zoological parks. He may have to provide sport for the fisherman in aquaria and for the hunter in shooting galleries.

Dana's paper was six pages long. As a reflection of the intense interest in this subject, the discussion was more than eight pages of fine print—the most I have seen in my perusal of the transactions.

[16]For an ecologically realistic treatment of the world food problem, see Pimentel et al. 1975.

In the pursuit of exact science, we break the big unknowns down into manageable parts, and this is a reliable and productive way to develop facts. But facts are interrelated, and unless someone pulls them together the dynamics of the whole get lost. A main trouble in dealing with ecological issues is that we underestimate them. The ecosystems that support all living things are the most complex entities we know anything about in the universe. A famous astronomer, Harlow Shapley (1967), whose interests did not stop with astronomy, was properly respectful of the limitless mysteries of the organic world.

> Life and the living of it is a desperately complicated business. The full analysis of the interior of a butterfly larva is vastly more difficult than the analysis of the interior of the remote star Polaris.

It is little wonder that we are baffled and tend to oversimplify in self defense. We have only begun to understand natural systems, but we can have faith that among the threads of interdependence—operating in time through cycles of change—an original order does exist. It is an order that works, proved by the survival of plants and animals that are still here.

Man too was spawned of the organic world. When he lived as a member of a life community, he received the same environmental "services" as other creatures. His food supply was there to be used, his numbers were controlled, his pollution products were all degradable. That plan of living was hard on the individual, but it preserved the early hominid for respectably long time periods.

Superimposed upon our biological adaptations, we now are trying to understand the culture that supposedly makes us human. In early stoneage stages it got a relatively slow start. But as one thing built on another, it gained a logarithmic momentum. It developed the scientific method and sailed away into the era of modern technology.

Today, armed with all the devices of mechanical ingenuity, we are re-doing the earth. We add confusion to complexity. Our "developments" are a welter of discordant conditions that we sometimes dignify as a system. The biosphere has become a patchwork of disturbance communities maintained as unsightly back alleys of the human citadel. The occupation forces do not know what was there before or what is likely to come after. A look at what man hath wrought suggests that we got into the construction business without benefit of blueprints.

As a biological organism, the human being has lost his place in nature, his community context. Since we began to control longevity we have traded off the control of human numbers. The modern technology that supposedly could liberate us has turned against the environment. To our credit, sometimes in the stillness of the night, we try to remember that no species survives without a productive habitat. An intelligent organism ought to be able to explain where it is headed. But we the people have not yet found out.

* * *

As we look back on these fifty years, we must believe in all prudence, with Stewart Udall (1964), that "The time has come when men must choose what kind of permanent relationship they want to have with their land and her creatures."

On this planet today a billion people are fairly well off and at least half a billion are hungry. Between these economic opposites are more than three billion who work hard with the likely prospect of getting into one class or the other. Most of them have little control over how it will be.

We have had impressive successes in converting the biosphere to our immediate use. An open question about many of the great achievements is how long they will last. Some will come off as poor investments, or they may have side effects that no one could foresee. In general, it appears that our craftsmanship has outperformed our design.

The innovations of science have made it possible to dig always deeper into the earth's deposit of natural wealth. People for whom there is no tomorrow are engaged in an exploitive overkill that cannot be sustained. The controls of simpler times no longer limit our excesses, and we are caught between the millstones of mechanical genius and ecological indifference.

Our record of conservation legislation is testimony that foresight, wisdom, and even courage have sometimes gone into the lawmaking process. We have much of the legal underpinning of a durable natural resources program—the duck stamp, the Pittman-Robertson act, the endangered species law, and many others. It is unfinished business, but it is a firm foundation.

In the conduct of public affairs, our nation needs the guidance of responsible policy; lawmakers on yonder hill understand that. Often they have made good policy, but sometimes as individuals they forget the wording. No doubt the creation of policy does require the amalgamation of minds and interests—deep and shallow, for now and forever, with and without commitment. In the presence of headlong "progress," our hazard is that we should delay too long, bemused with the art of compromise. Foresight and timing are a part of good leadership. It is little credit to anyone when we finally arrive among the redwoods, minus our shirts, and then have to look for the big trees.

This government, of the people, will be about what the people decide it should be. It we make improper demands on our representatives, then improper things will sometimes be done. Minorities have a way of imposing their claims on the uninvolved majority. The great body politic have their accounting on judgment day—the 15th of April—but the bills are not itemized; they must sign blank checks for more of the same. Their best defense against partisan abuse is in citizen orgainzations who make a specialty of the knowledge and leadership that all of us need.

I tried to write a summary of these articles of exploration. But I found that a summary of a summary does not mean much. These transactions are a record of progress, and they also tell how sometimes the faith of our fathers did not pan out. I doubt that we have much basis for prediction. I would offer you fool's gold with smug optimism, and there is no point in spreading despair. As of 1985 a great deal of our future history is uneducated guesswork.

We have the knowledge, and even the means, of keeping out of a lot of trouble. I am not sure we have the will. If there is a sum of truth in what we know, it may be the reality that we proprietors of Earth are responsible for our future, and the future will yield according to what we are willing to invest in it.

A few months from now we start a new half century. I cannot guess whether there will be another six-foot shelf of books for people of the future to dig into. But we will leave our record for anyone to see. It will be written on the land, in the rivers, and in the sky. The people who care will read it, and they will know how well we did.

Literature Cited

Addy, C. E. 1964. Atlantic flyway. Pages 167-184 *in* J. P. Linduska, ed. Waterfowl tomorrow, U.S. Fish and Wildl. Service, Washington DC.

Allen, D. L. 1969. Population, resources, and the great complexity. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 34:450-461.

_____. 1972. The need for a new North American wildlife policy. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 37:46-54.

_____. 1977. A proposal: Great Plains National Park. National Parks and Conserv. Mag. 51(8):4-9.

_____(chairman) et al. 1973. Report of the Committee on North American Wildlife Policy. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 38:152-181.

_____, L. Erickson, E. Raymond Hall, and W. M. Shirra. 1981. A review and recommendations on animal problems and related management needs in units of the National Park System. USDI, National Park System Adv. Bd., Rep. to Sec. of the Interior. 18pp. (Unpublished).

Allen G. W. 1964. Estuarine destruction... A monument to progress. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 29:324-331.

American Farmland Trust. 1984. Soil conservation in America. Washington, DC. 133pp.

Anderson, A. 1950. Shall we have salmon, or dams, or both? Trans. N. Amer. Wildl. Conf. 15:449-454.

Anderson, J. M. 1953. Duck clubs furnish living space. Trans. N. Amer. Wildl. Conf. 18:122-129.

_____, and F. M. Kozlik. 1964. Private duck clubs. Pages 519-526 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, DC.

Anon. 1936. General Wildlife Federation formed. Amer. Wildl. 25(1):3, 14-15.

Atwood, S. S. et al. 1970. Land use and wildlife resources. National Acad. Sci., Washington, DC. 262pp.

Baker, J. G. 1966. The industrial status of lead shot substitutes. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 31:97-103.

Ball, R. C. 1952. Farm pond management in Michigan. Trans. N. Amer. Wildl. Conf. 17:221-225.

Bean, M. J. 1983. The evolution of national wildlife law. Praeger, NY., 449pp.

Behan, R. W. 1978. Political dynamics of wildlife management: the Grand Canyon burros. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:424-433.

Bellrose, F. C. 1951. Effects of ingested lead shot upon waterfowl populations. Trans. N. Amer. Wildl. Conf. 16:125-135.

_____. 1959. Lead poisoning as a mortality factor in waterfowl populations. Illinois Natur. Hist. Survey Bull. 27(3):235-288.

_____. 1964. Spent shot and lead poisoning. Pages 479-485 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, DC.

Bennett, G. W. 1945. Overfishing in a small artificial lake. Onized Lake near Alton, Illinois. Illinois Natur. Hist. Survey 23(3):373-406.

Bennett, H. H. 1939. Soil conservation. McGraw-Hill, NY. 193pp.

_____. 1946. Wildlife gains through soil conservation. Trans. N. Amer. Wildl. Conf. 11:42-49.

Bodovitz, J. E. 1967. San Francisco Bay. Trans. N. Amer. Wildl. Conf. 32:120-126.

Bolen, E. G. and F. S. Guthery. 1982. Playas, irrigation, and wildlife in west Texas. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:528-541.

Bollman, F. H. 1972. Anadromous fish management in the Columbia River: an economic appraisal. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 37:122-135.

Boyle, R. H. 1969. The Hudson River. W. W. Norton, NY. 304pp.

Bratton, J. K. 1981. Effectiveness of the Corps' resource management efforts. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:21-26.

Breaux, J. B. 1982. Outlook for fish and wildlife in the 97th Congress. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:9-16.

Bricker, O. P. 1981. Toxic substances in the Chesapeake Bay estuary. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:250-258.

Brown, C. B. 1944. The control of reservoir silting. USDA, Misc. Publ. 521. 166pp.
Brown, L. R. et al. 1984. State of the world 1984. Worldwatch Inst. Rept. W. W. Norton, NY. 252pp.
_____, and E. C. Wolf. 1984. Soil erosion: quiet crisis in the world economy. Worldwatch Paper 60. Worldwatch Inst., Washington, DC. 49pp.
Bryan, P., and C. M. Tarzwell. 1941. A preliminary report on the census of commercial fishing in TVA impoundments. Trans. N. Amer. Wildl. Conf. 6:265-272.
Brynaert, K. E. 1983. The need for new initiatives in wetland management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:292-293.
Buckley, J. 1984. U.S. Government plenary statement at the International Conference on Population. Mexico City, 8 August 1984. 8pp.
Bull, B. 1984. Voodoo demography. What population problem? Amicus J. 6(1):36-40.
Burns, R. M. 1983. Natural area selection and management: U.S. Forest Service programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:497-503.
Burwell, R. W., and L. G. Sugden. 1964. Potholes—going, going...Pages 369-380 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, DC.
Bury, R. B., H. W. Campbell, and N. J. Scott, Jr. 1980. Role and importance of nongame wildlife. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:197-207.
Cain, S. A. 1966. Coordination of fish and wildlife values with water resources development goals. 2nd. Ann. Amer. Water Resources Assoc. Conf. 11pp.
_____. 1967. Estuaries: our most endangered natural habitats. Symp. Marsh & Estuary Manage. 10pp.
Callison, C. 1984. Hamstringing the national parks. Amicus J. 6(1):5-7.
Carothers, S. W., M. E. Stitt, and R. R. Johnson. 1976. Feral asses on public lands: an analysis of biotic impact, legal considerations and management alternatives. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:396-406.
Carroll, J., J. Duffield, L. Fischer, S. H. Hanke, R. H. Haveman, C. Howe, W. O'Neil, T. H. Power, V. K. Smith. 1979. Benefits or costs II. National Audubon Soc., National Wildl. Fed., Washington, DC. 46pp.
Carter, L. J. 1967. Dams and wild rivers: looking beyond the pork barrel. Science 158(3798):233-242.
Caulfield, H. P. Jr. 1983. Historical perspectives on water management policies and procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:15-22.
Cicchetti, C. J., R. K. Davis, S. H. Hanke, R. H. Haveman, J. L. Knetsch. 1972. Benefits or costs? An assessment of the Water Resources Council's proposed principles and standards. Johns Hopkins Univ., Dep. Geog. & Environ. Engineering, Baltimore. 18pp.
Clark, T. L. 1983. Waterfowl management plans: views of the International Association of Fish and Wildlife Agencies. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:289-291.
Clepper, H. 1975. Crusade for conversation. Amer. Forestry Assoc., Washington, DC. 92pp.
Cooke, M. L. et al. 1950. A water policy for the American people. President's Water Resources Policy Comm. Rep. Vol. 1. 445pp.
_____. 1950. Ten rivers in America's future. President's Water Resources Policy Comm. Rep. Vol. 2. 793pp.
_____. 1950. Water resources law. President's Water Resources Policy Comm. Rep. Vol. 3. 777pp.
Cooper, G. P. 1948. Fish stocking policies in Michigan. Trans. N. Amer. Wildl. Conf. 13:187-193.
Council on Environmental Quality. 1979. Ecology and living resources: coastal ecology and shellfish. Pages 435-474 *in* Environmental quality 1979. 10th Ann. Rep. Washington, DC.
_____. 1980. Ecological and living resources—biological diversity. Pages 31-80 *in* Environmental quality 1980. 11th Ann. Rep. Washington, DC.
_____and Department of State. 1981. Global future: time to act. Rep. to the President on Global Resources, environment and population. Washington, DC. 242pp.
Cronin, L. E. 1967. The condition of the Chesapeake Bay. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 32:137-150.
_____. 1981. The Chesapeake Bay. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:223-229.

Dana, S. T. 1951. Wildlife in today's economy: social aspects. Trans. N. Amer. Wildl. Conf. 16:27-41.
Darling, J. N. 1936. Remarks. Trans. N. Amer. Wildl. Conf. 1:16-34.
_____. 1937. Remarks. Trans. N. Amer. Wildl. Conf. 2:208-213.
Davidson, J. B. 1952. Restoration of Illinois wet lands with the aid of P-R. Trans. N. Amer. Wildl. Conf. 17:237.
Davis, K. 1953. Future population trends and their significance. Trans. N. Amer. Wildl. Conf. 18:8-21.
Davison, V. E. 1949. Bobwhites on the rise. Chas. Scribner's Sons, NY. 150pp.
Dawson, R. K. 1983. Current initiatives in water management policies and procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:23-27.
Day, A. M. 1940. How goes the Pittman-Robertson Act? Trans. N. Amer. Wildl. Conf. 5:36-40.
DeBates, L. W. 1967. The role of small wetland preservation in comprehensive prairie pothole region planning. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 32:325-331.
DeMoss, T. B., D. A. Flemer, C. J. Strobel, and D. Wilding. 1981. Trends in water quality for Chesapeake Bay relative to improved management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:230-249.
Dendy, F. E., and W. A. Champion. 1969. Summary of reservoir sediment deposition surveys made in the United States through 1965. USDA, Agr. Research Service, Misc. Publ. 1143. 64pp.
DeQuine, J. F. 1952. A brief progress report on management of the St. Johns River and Lake Okeechobee, and several other large Florida waters. Trans. N. Amer. Wildl. Conf. 17:234-236.
DeVoto, B. 1947. Sacred cows and public lands. Harper's Mag. 197(1178):44-55.
Downs, H. 1973. The impact of population growth on resources and the environment. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 38:37-41.
Dushinske, R. L. 1953. Drainage and subsidy payments. Trans. N. Amer. Wildl. Conf. 18:73-80.
Eakin, H. M., and C. B. Brown. 1939. Silting of reservoirs. USDA, Tech. Bull. 524. 168pp.
Edminster, F. C., Jr. 1947. The ruffed grouse. Macmillan, NY. 385pp.
_____. 1964. Farm ponds and waterfowl. Pages 399-407 *in* J. P. Linduska, ed. Waterfowl tomorrow, U.S. Fish and Wildl. Service, Washington, DC.
Eisenlohr, W. C., and C. E. Sloan. 1968. Generalized hydrology of prairie potholes on the Coteau du Missouri, North Dakota. U.S. Geol. Survey Circ. 558. 12pp.
Erickson, R. E., R. L. Linder, and K. W. Harmon. 1979. Stream channelization (P.L. 83-566) increased wetland losses in the Dakotas. Wildl. Soc. Bull. 7(2):71-78.
Eschmeyer, R. W. 1942. The catch, abundance, and migration of game fishes in Norris Reservoir, Tennessee, 1940. Tennessee Acad. Sci. Proc. 17(1):90-115.
_____. 1944. Harvesting the fish crop. Trans. N. Amer. Wildl. Conf. 9:202-211.
_____. 1945. The Norris Lake fishing experiment. Tennessee Dep. Conserv., Div. Fish and Game Bull. 31pp.
_____. 1949. Recent advances in fresh-water fishery management. Trans. N. Amer. Wildl. Conf. 14:207-224.
_____. 1950. Fish and fishing in TVA impoundments. Tennessee Dep. Conserv. Bull. 28pp.
_____, and C. M. Tarzwell. 1940. An analysis of fishing in the TVA impoundments during 1939. Trans. N. Amer. Wildl. Conf. 5:217-244.
Eschmeyer, R.W., D. E. Manges, and O. F. Haslbauer, 1946. Spring fishing on several TVA storage reservoirs, 1945. Tennessee Acad. Sci. 21(1):78-88.
Fairchild, W. D. 1976. Balancing economic development and environmental quality through the Water Resources Council's principles and standards. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:136-141.
Fazio, J. R., and L. A. Belli, 1977. Characteristics of nonconsumptive wildlife users in Idaho, Trans. N. Amer. Wildl. and Natur. Resour. Conf. 42:117-128.
Fish and Wildlife Service. 1976a. Use of steel shot for hunting waterfowl in the United States. Final Environ. Statement. USDI, Washington, D.C. 276pp.
_____. 1976b. Operation of the National Wildlife Refuge System. Final Impact Statement. USDI. Fish and Wildl. Service, Washington, D.C.

______. 1984. 50 years of achievement. The cooperative research unit program in fisheries and wildlife, 1935-1985. USDI, Fish and Wildl. Service, Washington, D.C.
______and Bureau of the Census. 1982. National survey of fishing, hunting, and wildlife-associated recreation. USDI, U.S. Dep. of Commerce, Washington, D.C. 156pp.
Fleming, W. J., and D. R. Clark, Jr. 1983. Organochlorine pesticides and PCB's: a continuing problem for the 1980s. Trans. N. Amer. Wildl. and Natur. Resour.. Conf. 48:186-199.
Forsythe, S. W., and S.W. Gard. 1980. Status of bottomland hardwoods along the lower Mississippi River. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:333-340.
Frayer, W. E., T. J. Monahan, D. C. Bowden, and F. A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States. Colorado State Univ., Dep. Forestry & Wood Sciences, Fort Collins. 31pp.
Fredrickson, L. H. 1980. Management of lowland hardwood wetlands for wildlife: problems and potential. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:376-386.
Gabrielson, I. N. 1943. Wildlife refuges. Macmillan, N.Y. 257pp.
______. 1949. Formal opening. Trans. N. Amer. Wildl. Conf. 14:5-8.
______. 1953. Formal opening. Trans. N. Amer. Wildl. Conf. 18:3-5.
______. 1954. Formal opening. Trans. N. Amer. Wildl. Conf. 19:1-5.
______. 1960. Formal opening. Trans. N. Amer. Wildl. Conf. 25:1-6.
______. 1963. The job ahead. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 28:18-27.
______. 1965. First things first. Trans. N. Amer. Wild and Natur. Resour. Conf. 30:4-13.
Garrison Diversion Unit Commission. 1984. Final report. Washington, D.C. 59pp.
Gavin, A. 1953. Agriculture reaches northward in Canada. Trans. N. Amer. Wildl. Conf. 18:118-121.
______. 1964. Ducks Unlimited. Pages 545-553 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
Gee M. A. 1942. Success of planting legal-sized trout in the Southwest. Trans. N. Amer. Wildl. Conf. 7:238-244.
Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Trans. N. Amer. Wild. and Natur. Resour. Conf. 47:441-452.
Glover, F. A. 1964. Tundra to tropics. Pages 23-35 *in* J. P. Linduska, ed. Waterfowl tomorrow. Fish and Wildl. Service, Washington, D.C.
Goodrich, J. W. 1979. Political assault on wildlife management: is there a defense? Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44: 326-336.
Gottschalk, J. S. 1981. A concept of management for the Chesapeake Bay. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:311-317.
Graham, E. H. 1944. Natural principles of land use. Oxford Univ. Press, N.Y. 274pp.
______. 1947. The land and wildlife. Oxford Univ. Press, N.Y. 232pp.
Graham, F., Jr. 1971. Man's dominion. M. Evans, N.Y. 339pp.
Geene, C. W. 1942. New York State's fish yield and suggestions for increasing fresh-water yields in wartime. Trans. N. Amer. Wildl. Conf. 7:417-423.
Greenwalt, L. A. 1978. The National Wildlife Refuge System. Pages 399-412 *in* H. P. Brokaw, ed. Wildlife and America. Council on Environ. Quality, Washington, D.C.
Grinnell, G. B. 1894. Lead poisoning. Forest & Stream 42(6):117-118.
______. 1901. American duck shooting. Willis McDonald, N.Y. 627pp.
Guthery, F. S., J. M. Pates, and F. A. Stormer. 1982. Characterization of playas of the north-central Llano Estacado in Texas. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:516-527.
Hair, J. D. 1983. Cleaning up the Chesapeake: a test of political resolve. The Leader (Nat. Wildl. Fed.) 4(12):9.
Hancock, R., and R. C. Barkley. 1980. The Cache River Basin, Arkansas: tragedy and opportunity. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:422-427.
Hanke, S. H. 1976. Options for financing water development projects. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:142-152.
Harmon, K. W. 1969. North Dakota's water bank proposal. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 34:323-331.
Hawes, H. B. 1935. Fish and game, now or never. D. Appleton-Century, N.Y. 332pp.
Hazzard, A. S. 1937. Results of stream and lake improvement in Michigan. Trans. N. Amer. Wildl. Conf. 2:620-624.

Henderson, F. R., et al. 1984. Guidelines for increasing wildlife on farms and ranches. Great Plains Agr. Council, Wildl. Resources Comm. and Coop. Ext. Service, Kansas State Univ., Manhatten.
Hernandez Corzo, R. 1965. Waterfowl conservation in Mexico. Trans. N. Amer. Wildl. Conf. 13:260-265.
Herschler, E. 1983. Retention of federal (public) lands. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:10-14.
Hickey, J. J. 1955. Is there scientific basis for flyway management? Trans. N. Amer. Wildl. Conf. 20:126-150.
Hines, L. G. 1953. The myth of idle resources: a reconsideration of the concept of nonuse in conservation Trans. N. Amer. Wildl. Conf. 18:28-35.
Holden, C. 1984. Day of reckoning for the Garrison Diversion project. Science 225(4665):904-906.
Holloway, A. D., and T. K. Chamberlain. 1942. Trout management and stocking results in the national forests of the southern Appalachians. Trans. N. Amer. Wildl. Conf. 7:245-249.
Holt, E. G. 1934. Erosion control and game development. Proc. Amer. Game Conf. 20:177-181.
______. 1935. The Soil Erosion Service and wildlife. Proc. Amer. Game Conf. 21:319-325.
______. 1936. Soil conservation means wildlife conservation. Trans. N. Amer. Wildl. Conf. 1:239-243.
______. 1937. Soil and wildlife conservation, a report of progress. Trans. N. Amer. Wildl. Conf. 2:78-82.
Hoopes, D. T. 1982. New directions in career preparation: the campus connection. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:187-193.
Hope, C. R. 1952. High dams—low dams—watershed planning. Trans. N. Amer. Wildl. Conf. 17:55-61.
Hornaday, W. T. 1931. Thirty years war for wild life. Chas. Scribner's Sons, N.Y. 292pp.
Horton, T. 1984. The people's bay. Amicus. J. 6(1):12-19.
Horwitz, E. L. 1978. Our nation's wetlands. Interagency Task Force Rep., Council on Environ. Quality, Washington, D.C. 70pp.
Hoxie, K. 1985. Compromise struck on Garrison Diversion Unit. The Leader (Nat. Wildl. Fed.) 6(1):1, 10.
Hubbs, C. L., and R. W. Eschmeyer. 1937. Providing shelter, food and spawning facilities for game fisheries of our inland lakes. Trans. N. Amer. Wildl. Conf. 2:613-619.
Hubbs, C. L., and R. W. Eschmeyer. 1938. The improvement of lakes for fishing. Michigan Institute for Fisheries Research Bull. 2. 233pp.
Hunt, G. S. 1960. Lead poisoning among ducks wintering on the Detroit River. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 25:162-170.
______, and H. E. Ewing. 1953. Industrial pollution and Michigan waterfowl. Trans. N. Amer. Wildl. Conf. 18:360-368.
Hunter, G. W., III, L. M. Thorpe, and D. E. Grosvenor. 1940. An attempt to evaluate the effect of stream improvement in Connecticut. Trans. N. Amer. Wildl. Conf. 5:276-291.
Huxley, J. 1963. The world population problem. Pages 43-48 *in* The human crisis, by Julian Huxley. Univ. Washington Press, Seattle.
Jackson, C. E. 1947. More public knowledge—less high dams. Trans. N. Amer. Wildl. Conf. 12:89-101.
Jackson, J. J. 1982. Public support for nongame and endangered wildlife management: which way is it going? Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:432-440.
Jenkins, R. E. 1978. Habitat preservation by private organizations. Pages 413-427 *in* H. P. Brokaw, ed. Wildlife and America. Council on Environ. Quality, Washington, D.C.
Jensen, G. H. , and J. E. Chattin. 1964. Western production areas. Pages 79-88 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
Jordan, J. S., and F. C. Bellrose. 1950. Shot alloys and lead poisoning in waterfowl. Trans. N. Amer. Wildl. Conf. 15:155-170.
Kalmbach, E. R. 1958. Conservation in an expanding economy: an appraisal of the 23d North American Wildlife Conference. Trans. N. Amer. Wildl. Conf. 23:585-606.
Kellert, S. R. 1976. Perceptions of animals in American society. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:533-546.

_____. 1978. Attitudes and characteristics of hunters and anti-hunters. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:412-423.
_____. 1980. Americans' attitudes and knowledge of animals. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:111-124.
_____, and M. O. Westervelt. 1982. Historical trends in American animal use and perception. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:649-664.
Kieffer, J. A. 1973. U.S. population assistance to the developing nations. *In* How many people? Foreign Policy Assoc., Headline Series 218:75-87.
Klein, D. R. 1973. The ethics of hunting and the anti-hunting movement. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 38:256-267.
Korte, P. A., and L. H. Fredrickson. 1977. Loss of Missouri's lowland hardwood forests. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 42:31-41.
Krapu, G. L., et al. 1982a. The Platt River ecology study. Spec. Sci. Rep. USDI, N. Prairie Wildl. Research Ctr., Jamestown, N.D. 187pp.
_____, K. J. Reinecke, and C. R. Frith. 1982b. Sandhill cranes and the Platte River. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:542-552.
Krumholz, L. A. 1950. New fish stocking policies for Indiana ponds. Trans. N. Amer. Wildl. Conf. 15:251-270.
Kuchel, T. H. 1965. Resources of people. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 30:13-23.
Ladd, W. N., Jr. 1978. The future U.S. Fish and Wildlife Service migratory waterfowl habitat acquisition program. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:226-234.
Lagler, K. F. 1941. Predatory animals and game fish. Amer. Wildl. 30(2):87-90.
_____. 1944. Problems of competition and predation. Trans. N. Amer. Wildl. Conf. 9:212-229.
Lamm, R. D., and M. McCarthy. 1982. The angry West. Houghton Mifflin, Boston. 344pp.
Langlois, T. H. 1944. The role of legal restrictions in fish management. Trans. N. Amer. Wildl. Conf. 9:197-202.
LaRose, M. N. 1969. Engineering limitations on water transfers. Saskatoon Wetlands Seminar. Canadian Wildl. Service Rep. 6:16-20.
Lendt, D. L. 1984. 50 years of achievement. The cooperative research unit program in fisheries and wildlife, 1935-1985. USDI, Fish and Wildl. Service, Washington, D.C.
Leonard, J. W. 1973. Remarks of the session chairman. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 38:151-152.
Leopold, Aldo (chairman), et al. 1930. Report to the American Game Conference on American Game Policy. Proc. Amer. Game Conf. 17:284-309.
_____. 1931. Game survey of the North Central States. Madison, Wis. 299pp.
_____. 1933 Game management. Chas. Scribner's Sons, N.Y. 481pp.
Leopold, A. Starker. 1964. Mexico and migratory waterfowl conservation. Pages 729-736 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
_____, and J. W. Leonard. 1966. Effects of the proposed Rampart Dam on wildlife and fisheries. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 31:454-459.
Leopold, A. Starker, C. Cottam, I. McT. Cowan, and T. L. Kimball. 1968. The National Wildlife Refuge System—report of the advisory committee on wildlife management appointed by Interior Secretary Stewart L. Udall. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 33:30-53.
Lewis, H. F. 1951. Wildlife in today's economy: aesthetic and recreational values of wildlife. Trans. N. Amer. Wildl. Conf. 16:13-16.
Lloyd, H. 1929. Water and water-fowl. Trans N. Amer. Wildl. Conf. 16:122-128.
_____, and William Vogt. 1946. Pan-American conservation. Trans. N. Amer. Wildl. Conf. 11:5-10.
Lodge, R. W. 1969. Agricultural use of wetlands. Saskatoon Wetlands Seminar. Canadian Wildl. Service Rep. 6:11-15.
Luce, C. F., et al. 1973. New directions in U.S. water policy. National Water Comm., Summary and Conclusions from Final Rep. 197pp.
Lyons, J. R. 1982. Nonconsumptive wildlife-associated recreation in the U.S.: identifying the other constituency. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:677-685.

MacDonald, P.O., W. E. Frayer, and J. K. Clauser. 1979. Documentation, chronology, and future projections of bottomland hardwood habitat losses in the lower Mississippi alluvial plain. USDI, Fish and Wildl. Service, 2 vol.
MacKenzie, H. W. 1937. Discretionary powers in wildlife administration. Trans. N. Amer. Wildl. Conf. 2:33-38.
MacLennan, R. 1983. Provincial view of waterfowl management plans. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:287-288.
Mair, W. W. 1953. Ducks and grain. Trans. N. Amer. Wildl. Conf. 18:111-117.
Males, L. L. 1960. Upstream flood prevention. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 25:56-58.
Mann, D. 1980. Urgently needed now; a national policy to reduce U.S. population. Negative Population Growth, N.Y. 54pp.
Marsh, G. P. 1864. Man and nature. Chas. Scribner, N.Y. 560pp.
Massman, W. H. 1964. The fishes—a neglected aspect of estuarine research. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 29:337-352.
McArdle, R. E. 1953. Multiple use—multiple benefits. Trans. N. Amer. Wildl. Conf. 18:53-72.
McClosky, W. 1984. Hard times hit the bay. National Wildl. 22(5):6-14.
McLaughlin, C. T. 1983. Approaches for resolving Mid-America's farmland problems. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:28-31.
Meehan, O. L. 1948. Fish stocking—to what purpose? Trans. N. Amer. Wildl. Conf. 13:193-198.
Miller, M. C., ed. 1964. Focus on world population. *In* Intercom, a world affairs handbook. Foreign Policy Assoc. 6(1):13-72.
Moyle, J. B. 1949. Fish-population concepts and management of Minnesota lakes for sport fishing. Trans. N. Amer. Wildl. Conf. 14:283-294.
Munro, D. A. 1964. Survival of the species in Canada. Pages 537-544 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
Murphy, G. I. 1950. The closed season in warm-water fish management. Trans. N. Amer. Wildl. Conf. 15:235-251.
Myers, O. 1984. NWF calls for more steel zones. FWS steel-shot proposal inadequate. The Leader (Nat. Wildl. Fed.) 5(11):1-2.
National Audubon Society. 1984. National Audubon Society's campaign to stop the Garrison Diversion Unit. Nat. Audubon Soc., N.Y. 18pp.
National Park Service. 1980. State of the parks—1980. Rep. to Congress. USDI, National Park Service, Washington, D.C. 57pp.
Nature Conservancy. 1975. The preservation of natural diversity: a survey and recommendations. Final Rep. to U.S. Dep. of the Interior. Nature Conservancy. Arlington, Va. 212pp.
Needham, P. R. 1939. Natural propagation versus artificial propagation in relation to angling. Trans. N. Amer. Wildl. Conf. 4:326-331.
______. 1950. Artificial propagation of game fishes—looking forward. Trans. N. Amer. Wildl. Conf. 15:270-279.
______. 1959. New horizons in stocking hatchery trout. Trans. N. Amer. Wildl. Conf. 24:395-407.
Noren, C. 1978. Additional funds for resource management. Trans. N. Amer. Wildl. Conf. 43:42-52.
Office of Technology Assessment. 1984. Wetlands: their use and regulation. U.S. Congress, Office of Tech. Assess., Washington D.C. 208pp.
Ohlendorf, H. M. 1981. The Chesapeake Bay's birds and organochlorine pollutants. Trans. N. Amer. Wildl. Conf. 46:259-270.
Olds, L. 1951. Water Resources. Trans. N. Amer. Wildl. Conf. 16:44-52.
Orth, R. J., and K. A. Moore. 1981. Submerged aquatic vegetation of the Chesapeake Bay: past, present and future. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:271-283.
Pattee, O. H., and S. K. Hennes. 1983. Bald eagles and waterfowl: the lead shot connection. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:230-237.
Pearson, T. G. 1937. Adventures in bird protection. D. Appleton-Century, N.Y. 459pp.

Pender, J. D. 1943. Ill-advised legislation affecting game management. Trans. N. Amer. Wildl. Conf. 8:346-350.

Perry, M. C., R. E. Munro, and G. M. Haramis. 1981. Twenty-five year trends in diving duck populations in Chesapeake Bay. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:298-310.

Peterle, T. J. 1961. The hunter—who is he? Trans. N. Amer. Wildl. and Natur. Resour. Conf. 26:254-266.

Peterlik, P. 1984. Are we moving closer to a lead shot ban? Outdoor Amer. 49(4):16-19, 33.

Peterson, C. C., and C. R. Madsen. 1981. Property tax credits to preserve wetlands and native prairie. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:125-129.

Peterson E. 1952. Marsh drainage and waterfowl. Trans. N. Amer. Wildl. Conf. 17:123-131.

______. 1953. Big dam foolishness. Trans. N. Amer. Wildl. Conf. 18:93-103.

Peterson, R. W. 1975. How the damn thing works: population, resources, and quality of life. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 40:6-26.

Phillips, C. G. 1975. Migratory waterfowl management opportunities provided by the water bank program. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 40:294-299.

Pimental, D., W. Dritschilo, J. Krummel, and J. Kutzman. 1975. Energy and land constraints in food protein production. Science 190:754-762.

Pinchot, G. 1947. Breaking new ground. Harcourt, Brace, N.Y. 522pp.

Piotrow, P. T. 1973. World population crisis. Praeger, N.Y. 276pp.

Platt, D. R. 1983. Preservation of the tallgrass prairie: opportunities for action. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:551-556.

Postel, S. 1984. Water: rethinking management in an age of scarcity. Worldwatch Pap. 62. Worldwatch Institute, Washington, D.C. 65pp.

Power, T.M. 1978. An economic analysis of the Central Arizona project, Bureau of Reclamation. CAP Publications, Phoenix, Az. 45pp.

Pritchard, D. W. 1951. The physical hydrography of estuaries and some applications to ecological problems. Trans. N. Amer. Wildl. Conf. 16:368-376.

Prosser, N. S. 1984. The Sport Fishing Institute program: how it works. Canadian Wildl. Fed., Ann. Meeting, Saskatoon, Saskatchewan, 14-16 June. 7pp.

Public Land Law Review Commission. 1970. One third of the nation's land. Rep. to President and Congress. 342pp.

Pyles, H. K. 1970. What's ahead for our public lands? National Resources Council of Amer., Washington, D.C. 343pp.

Quinn, I. T. 1929. Address of the chairman. Proc. Amer. Game Conf. 16:1-2.

Reed, N. P., and D. Drabelle. 1984. The United States Fish and Wildlife Service. Westview Press, Boulder, Co. 163pp.

Reetz, G. A., and D. A. Pierce. 1976. Flood control and wildlife preservation in Los Angeles water projects. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:177-185.

Reid, K. A. 1944. Broad public values inherent in land and water. Trans. N. Amer. Wildl. Conf. 9:78-86.

Reiger, J. F. 1975. American sportsmen and the origins of conservation. Winchester Press, N.Y. 316pp.

Reisner, M. 1978. Water projects. Natur. Resources Defense Council, Newsletter 7(4):1-10, 15-24.

Rosene, W. 1969. The bobwhite quail, its life and management. Rutgers Univ. Press, New Brunswick, N.J. 418pp.

Rothschild, B. J., P. W. Jones, and J. S. Wilson. 1981. Trends in Chesapeake Bay fisheries. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:284-298.

Salter, R. M. 1953. Wildlife and our soil conservation objectives. Trans. N. Amer. Wildl. Conf. 18:81-91.

Sanders, A. F., III, and D. M. Soileau. 1980. Atchafalaya Basin, Louisiana: wetland conservation alternatives. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:413-421.

Saunders, G. B. 1964. South of the border. Pages 253-262 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.

Schneberger, E. 1948. Natural propagation of fishes. Trans. N. Amer. Wildl. Conf. 13:198-205.

Schrader, T. A. 1955. Waterfowl and the potholes of the North Central States. Agric. Yearbook. USDA, Washington, D.C. Pp. 596-604.

Schwegman, J. E. 1983. State natural area programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 58:491-494.
Sears, P. B. 1935. Deserts on the march. Univ. Oklahoma Press, Norman. 231pp.
Shannon, W. T. 1965. Private clubs and the waterfowl resource. Trans. N. Amer. Wildl. Conf. 30:255-259.
Shapley, H. 1967. Beyond the observatory. Chas. Scribner's Sons, N.Y. 223pp.
Shaw, S. P., and W. F. Crissey. 1955. Wetlands and the management of waterfowl. Agric. Yearbook. USDA, Washington, D.C. Pp. 604-614.
Shaw, S. P., and C. G. Fredine. 1956. Wetlands of the United States. Circ. 39. USDI, Fish and Wildl. Service, Washington, D.C. 67pp.
Shaw, W. W. 1977. A survey of hunting opponents. Wildl. Soc. Bull. 5(1):19-24.
_____, and D. A. King. 1980. Wildlife management and nonhunting wildlife enthusiasts. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:219-225.
Shetter, D. S. 1939. Success of plantings of fingerling trout in Michigan waters as demonstrated by marking experiments and creel census. Trans. N. Amer. Wildl. Conf. 4:318-325.
Shoemaker, C. D. 1945. National and international conservation problems. Trans. N. Amer. Wildl. Conf. 2:359.
Silcox, F. A. 1936. Remarks of the chairman. Trans. N. Amer. Wildl. Conf. 1:1-5.
Skud, B. E., and W. B. Wilson. 1960. Role of estuarine water in Gulf fisheries. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 25:320-326.
Smith, A. G., J. H. Stoudt, and J. B. Gollop. 1964. Prairie potholes and marshes. Pages 39-50 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
Smith, E. V. and H. S. Swingle. 1943. Results of further experiments on the stocking of fish ponds. Trans. N. Amer. Wildl. Conf. 8:168-173.
Soil Conservation Service. 1950. Annotated bibliography on sedimentation. USDA, SCS, Sedimentation Bull. 2. 351pp.
Solman, V. E. F., J. P. Currier, and W. C. Cable. 1952. Why have fish hatcheries in Canada's national parks? Trans. N. Amer. Wildl. Conf. 17:234.
Sparhawk, W. N. 1949. The history of forestry in America. USDA Yearbook, USDA, Washington, D.C. Pp. 702-714.
Sparrowe, R. D. 1982. Influence of cooperative wildlife and fishery units on graduate education and professional employment. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:219-230.
Spencer, J. 1981. Soybean boom, hardwood bust. Amer. Forests 87(2):22-25, 49-52.
Steen, M. O. 1947. Wake up, America! Trans. N. Amer. Wildl. Conf. 12:40-44.
Stephens, E. S. 1937. Missouri's new wildlife set-up. Trans. N. Amer. Wildl. Conf. 2:20-25
_____. 1946. Where are we, and what time is it? Trans. N. Amer. Wildl. Conf. 11:21-27.
Stevens, J. C. 1936. The silt problem. Amer. Soc. Civil Eng. Trans. 101:207-288.
Stoddard, H. L. 1931. The bobwhite quail; its habits, preservation, and increase. Chas. Scribner's Sons, N.Y. 559pp.
Stroud, R. H. 1952. Management of warm-water fish populations in Massachusetts' lakes, ponds, and reservoirs. Trans. N. Amer. Wildl. Conf. 17:214-220.
Swingle, H. S. 1945. Improvement of fishing in old ponds. Trans. N. Amer. Wildl. Conf. 10:299-308.
_____. 1949. Some recent developments in pond management. Trans. N. Amer. Wildl. Conf. 14:295-310.
_____. 1956. Determination of balance in farm fish ponds. Trans. N. Amer. Wildl. Conf. 21:298-318.
_____, and E. V. Smith. 1939. Increasing fish production in ponds. Trans. N. Amer. Wildl. Conf. 4:332-338.
Swingle, H. S., and E. V. Smith. 1940. Experiments on the stocking of fish ponds. Trans. N. Amer. Wildl. Conf. 5:267-276.
Swingle, H. S., and E. V. Smith. 1942. Management of farm fish ponds. Alabama Polytechnic Inst., Agr. Expt. Sta. Bull. 254. 23pp.
Sykes, J. E. 1967. The role of research in the preservation of estuaries. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 32:150-160.
Tarzwell, C. M. 1936a. Lake and stream improvement in Michigan. Trans. N. Amer. Wildl. Conf. 1:429-434.

______. 1936b. Experimental evidence on the value of trout stream improvement in Michigan. Amer. Fisheries Soc. Trans. 66:177-187.
______. 1938. An evaluation of the methods and results of stream improvement in the Southwest. Trans. N. Amer. Wildl. Conf. 3:339-364.
______. 1941. A second season of creel census on four Tennessee Valley reservoirs. Trans. N. Amer. Wildl. Conf. 6:202-221.
Tetreault, B. 1983. Waterfowl management plans: a Canadian perspective and implementation plans. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:283-286.
Thorpe, L. M. 1942. Application of fishery survey data to heavily fished lakes. Trans. N. Amer. Wildl. Conf. 7:436-442.
Tiner, R. W., Jr. 1984. Wetlands of the United States: Current status and recent trends. USDI, Fish and Wildl. Service, Washington, D.C. 59pp.
Trefethen, J. B. 1961. Crusade for wildlife. Stackpole, Harrisburg, Pennsylvania and Boone & Crockett Club, N.Y. 377pp.
______. 1975. An American crusade for wildlife. Winchester Press, N.Y. and Boone & Crockett Club, N.Y. 409pp.
Udall, S. L. 1964. Foreword. P.vi *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish and Wildl. Service, Washington, D.C.
Unkel, W. C. 1983. Public financing of fish and wildlife conservation: the California experience. Trans. N. Amer. and Natur. Resour. Conf. 48:149-154.
U. S. Department of the Interior. 1970. River of life. Environ. Rep., Cons. Yearbook Series 6, Washington, D.C. 96pp.
Van Dersal, W. R. 1938. Native woody plants in the United States: their erosion control and wildlife values. USDA, Misc. Publ. 303. 362pp.
______. 1943. The American land. Oxford Univ. Press, N.Y. 215pp.
Van Oosten, J. 1944. Factors affecting the growth of fish. Trans. N. Amer. Wildl. Conf. 9:177-183.
Vogt, W. 1948. Road to survival. Wm. Sloan Assoc., N.Y. 335pp.
______. 1961. The management of human populations. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 26:4-18.
Wagner, F. H. 1983. Status of wild horse and burro management on public rangelands. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:116-133.
Walford, L. 1967. Problems of conservation in the Atlantic estuarine zone. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 32:161-164.
Warne, W. E. 1944. Reclamation protects wildlife interests. Trans. N. Amer. Wildl. Conf. 9:124-131.
Wetmore, A. 1919. Lead poisoning in waterfowl. USDA Bull. 793. 12pp.
Whipple, W., Jr. 1976. Environmental objectives and water quality control programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:153-162.
Whitehead, C. J. 1983. State fish and wildlife agency responses to funding challenges. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:139-148.
Whitesell, D. E. 1976. Providing habitat for migratory birds through private efforts. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:513-517.
______. 1983. New dimensions in Ducks Unlimited's waterfowl programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:273-278.
Wiebe, A. H. 1942. The rough fish problem in TVA waters. Trans. N. Amer. Wildl. Conf. 7:410-416.
Wildlife Management Institute. 1975. Current investments, projected needs, and potential sources of income for nongame fish and wildlife programs in the United States. Wildl. Manage. Inst., Washington, D.C. 77pp.
Wildlife Society (The). 1985. A review of the Garrison Diversion Unit Commission December 20, 1984, Final Report. Water Projects Committee, N. Dakota Chapt. 7pp.
Williams, D. A. 1958. Today's opportunities for conservation in agricultural development. Trans. N. Amer. Wildl. Conf. 23:5-14.
Williamson, L. L. 1984. Wildlife refuges under assault. Outdoor Amer. 49(4):10-15.
Witter, D. J., and W. W. Shaw. 1979. Beliefs of birders, hunters, and wildlife professionals about wildlife management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44:298-305.

Wolf, E. C. 1985. Conserving biological diversity. *In* State of the world 1985. Lester R. Brown et al. Worldwatch Inst. Rep. W. W. Norton, N.Y. 301pp.
Wolf, T. J. 1983. Wyoming's wildlife trust fund. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:155-158.
Womach, J. 1977. National evaluation of the water bank program. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 42:246-254.
Yambert, P. A. 1934. Is there a niche for the generalist? Trans. N. Amer. Wildl. Conf. 29:494-503.
Yinger, N., R. Osborn, D. Salkever, and I. Sirageldin. 1983. Third world family planning programs: measuring the costs. Population Bull. 38(1):1-36.

Current Public Perceptions, Attitudes, and Desires on Natural Resources Management

Louis Harris
Chairman
Louis Harris and Associates, Inc.
New York, New York

Perhaps the most remarkable fact about environmental issues is that the establishment consistently both underestimates the seriousness of pollution problems *and* the depth of feeling of the public about cleaning up the mess. Somehow, the establishment in this country at nearly any given point in time is convinced that maybe environmental problems will become less severe or will somehow get better and go away. They also act an unfortunately large number of times in a manner that suggests that somehow conviction about matters environmental on the part of the public are a passing fancy which will soon be forgotten. Except for Senator Stafford, most of the establishment leadership spends 20 years clawing their way to the top—only to be 20 years out of date.

Well, just within the past fortnight, our firm has completed another update on basic public attitudes toward environmental matters that I am privileged to report to you here today. First, the common assumption is that the top priority of the country is to stimulate economic growth. Indeed, keeping the economy growing and prosperous is a top priority. But, then, often the next step is to add, when environmental matters come up, that a clean-up should take place *only* when in consonance with economic growth. But bluntly, if the choice is between growth and a clean up, then the clean up must take a back seat. Well, I can report to you categorically that by 63-33 percent, a solid majority of the American people reject that view.

Indeed, over the past year, we have asked samples of over 10,000 individuals how they feel about strict enforcement of the Clean Air and Clean Water acts. By 85-8 percent it is no contest: over an 8-1 majority favors strict enforcement of the existing statutes. And, I might add, want them reenacted again, with a substantial 66 percent who favor making the renewal of those acts even *tougher* and *more* strict than the originals passed over ten years ago.

Again, when we asked about just how serious a whole spate of environmental problems are today, in field work concluded just a week ago, here is what we found. Air pollution by coal-burning electric power plants: a serious problem by 70-26 percent. Pollution by radioactive wastes from nuclear power plants: a serious problem by 79-18 percent. Acid rain pollution: a serious problem by 76-18 percent, up sharply from a comparable 60-18 percent who felt the same back in 1981. Incidentally, the number aware of acid rain has gone up from 30 percent in 1980 to a nearly unanimous 94 percent today. But more about acid rain and its clean up in a moment. A substantial 88-11 percent majority nationwide is convinced that the problem of contaminated drinking water is a serious problem. And, finally, a nearly unanimous 93-5 percent majority believes that the problem of disposal of hazardous wastes is a serious problem.

These are staggering numbers by any standards. In a society where the victor of an election needs no more than one vote over the 50 percent mark to achieve power, these percentages indicate a virtual no contest. Environmental concerns win hands down.

Now let me report some late findings on the subject of acid rain. That subject, of course, was a matter discussed by the President of the United States and the Prime Minister of Canada just yesterday [March 17, 1985] when they met in Quebec City. They agreed to a joint study of the problem. That's become a familiar story whenever acid rain is discussed. Let's study it some more. Let's look into it more. Let's analyze its ramifications and dimensions more. Some would read that as meaning: maybe it will go away.

Yet, as far as the American people are concerned—and, indeed, the Canadian people are even more aroused on this subject than our own—there is a growing sense that the matter of acid rain has been contemplated, discussed, studied, and tossed back and forth, to put it bluntly, enough. It's about time to *do* something about acid rain, as it is about time to *do* more about toxic waste dumps, and to *do more* about keeping the environment from continuing to be fouled.

On acid rain. Over eight in every ten people are convinced that the sources of acid rain are emissions from plants and factories that burn coal, plants and factories that burn oil, chemical plants, and emissions from cars and trucks that burn gasoline and diesel fuel. What is more, sizable majorities are also convinced by now that acid rain is rapidly increasing the toxic content of lakes and rivers, crippling wildlife, threatening water supplies, and endangering agriculture and the raising of livestock. What is more, there is now a sense that acid rain is affecting every section of the country, with the South now coming up rapidly as a prime affected area equal to the Northeast.

The question that seems to have been debated interminably about acid rain is just who should shoulder the substantial costs of cleaning it up. Over six in ten are prepared to put the burden on all those individuals and corporations who use fuels that contribute to the acid rain problem, including oils, natural gas, and gasoline. This means, in effect, anyone who burns such fuel that results in acid rain should participate in the cost of cleaning it up. But there is a more specific focus: a big 72-22 percent majority of the American people single out the shareowners of investor-owned electric utilities as the proper target for bearing most of the costs of cleaning up acid rain. Indeed, close to three in every four Americans today would like to see Congress pass legislation that placed the responsibility and liability clearly on the shoulders of such generators of acid rain. The question, of course, is immediately asked if people who are so willing to see companies, such as electric utilities, socked with much of the cost of cleaning up acid rain would also be willing to see their own bills raised. Indeed, we have asked that and people on average are willing to pay close to $70 a year, if the costs of cleaning up acid rain are passed on to them at least in part. And, despite the leveling out of inflation in recent years, believe me, most people are not in a mood to pay more for nearly anything these days. But they are willing to pay more, if need be, to do something about acid rain.

While on the subject of acid rain, let me deal with yet another issue. It has been said repeatedly that one of the real problems in coming up with amelioratives for acid rain are the sharp splits that exist by region on this issue. So let us take just one key result on the study we completed just this past week: having shareholders of investor-owned electric utilities pay for the clean up of acid rain. In the West, a 67-30 percent majority would consider such a solution eminently fair and reasonable.

In the South an almost identical 68-26 percent majority feels that way. In the Midwest a higher 75-20 percent majority supports such a solution, and in the East a higher 77-20 percent majority feels that way. Now it is true that a higher majority in the East feels strongly about putting the burden on electric utilities for paying for acid rain than is the case in the West. But in the West, over a two to one majority supports exactly what a three to one majority in the East advocates. So those who would claim that acid rain is a regional issue, dividing the country sharply, conjuring up a nation divided within itself as in the case of slavery in the mid-nineteenth century, simply do not appear to have a leg to stand on.

Even in Congress, where we have repeatedly polled members on acid rain, a seven to one majority wants to tighten sulfur dioxide standards for new plants, a six to one majority wants laws passed requiring existing plants to meet stricter sulfur dioxide emission standards and by six to one to require scrubbers for existing plants.

Yet the public itself is also of the view that precious little has been getting done. The President is given marks of 61-33 percent negative on his handling of environmental clean up matters. One in every two people are prepared to say the Reagan record in environmental matters has been an outright failure, though a substantial 41 percent are hopeful that the second term Reagan will be better than the first.

But the ratings given other major parts of the establishment on how they have handled environmental matters have been scarcely better. Congress comes up with marks of no better then 58-40 percent negative, state and local governments with negative marks of 63-32 percent negative. And industry with a rating that is 68-27 percent negative.

Let me conclude by saying that, in many ways, our polling on environmental matters has been almost a strange and even eerie experience over the past several years. We find, for example, on racial matters that the pendulum tends to swing back and forth between those who are conscience stricken over the country not having done enough and a sense that change is moving too rapidly. Or we have found that the entire question of economic growth can go up or down by as much as 30 points depending on the period we ask about it as a national priority. We have found that support for increasing defense spending has dropped from 71 percent in 1980 to no more than 9 percent today. In many areas, we have found that change can take place with some rapidity.

But in the environmental area, the dynamic of change in recent years has always been in one direction: the American people get tougher and tougher and more adamant and more shocked about the state of environmental clean up. And they are literally furious that there has been so much perceived foot-dragging on the part of those with the power to get things done. Thus, the majorities in any sound poll conducted on this subject are simply huge and staggering. They parallel nothing less than belief in free elections, in the right to free speech, the right to worship, and the right to private ownership of property. If any of these were believed to be in dire peril, you would hear about it in a hurry.

Yet, somehow, the cries and demand of the populace to their leaders on environmental matters fall on relatively deaf ears. The word somehow does not quite get through.

Well, let me say it is my view that the critical mass has been reached on this subject in terms of public opinion, and the day of reckoning is about to be at hand. I would not be at all surprised to see environmental matters become a critical balance of power issue in the 1986 elections. We are a post industrial society now, which is just coming to the point of calculating the sizable costs of putting our house in order as a consequence of a long period of straight out industrial growth. To put it bluntly, we are unwilling to tolerate a silicon valley, for example, to be victimized by toxic wastes as a cost of developing a high technology industry. We are demanding right now by big margins to require industry to develop high tech, but to do it in a pollution-free setting.

Basically, what people are asking and pleading and demanding out there is that there be a new wave of commitment by those who purport to speak for the people, who speak the words that they care about the quality of the human experience. The challenge is to the leadership to catch up with the governed. To catch up now, not later, before it is too late.

Status of Programs and Future Directions for Maintaining Air and Water Quality

The Honorable Robert T. Stafford
Chairman, Environment and Public Works Committee
U.S. Senate
Washington, D.C.

I am pleased to have the opportunity to meet with you today to join in your discussions of this Nation's resources and to share in your concerns over threats to our environment. My assignment is to share with you my view of the legislative activity in the 99th Congress regarding initiatives that deal with natural resources, health, and environmental well-being.

It is always hazardous to attempt to predict future legislative actions, and that hazard may have been increased by our slow start in the Senate; by the tremendous pressures created by the budget deficit; and by the impacts upon the Congress created by international forces ranging from terrorist activities to deaths in the Kremlin to foreign trade. But, if you will permit me to limit my crystal ball gazing to legislation that falls within the jurisdiction of the Senate Committee on Environment and Public Works, I will give it a try.

It is important to examine what we are doing and where we are trying to go. We have choices to make and challenges to face. The choices are more limited than they were thirty years ago. That means the challenges are greater. If we are to have a livable environment in the future, we must all understand how much we will have to depend upon each other to achieve that goal. Clearly, we must have the best efforts and the concerned involvement of scientists from industry, medicine, and our colleges and universities. We must also attract the attention of workers, managers, union leaders, business owners, bureaucrats, politicians, farmers, hunters, fishermen, and both public and private interest groups. Are there goals common to such varied interests in our quest?

Surely there are. And, surely the most basic of the goals are these:

- Safe and adequate supplies of water and food.
- Air quality that enhances, rather than diminishes, life.
- Disposal systems for liquid and solid hazardous wastes that perform adequately.
- And healthy housing and workplaces.

In the United States, our own and previous generations have made substantial gains in the effort to achieve those basic goals. We must clearly protect those gains already recorded. And, we must understand that we and our children and their children face environmental hazards far greater than those of the past.

Before we examine the prospects for the legislative future on these fronts, it may be instructive to review the immediate past. For the last four years, I have been the chairman of the Senate Committee on Environment and Public Works. And, for each of those years, our committee has been involved in the task of seeking the proper federal response to national environmental threats. At the beginning of 1983, we announced the environmental agenda for our committee. I predicted that the committee would produce for Senate consideration—in this order—legislation to reauthorize the Resource Conservation and Recovery Act (RCRA); the Clean Water Act; the Clean Air Act, and the chemical Superfund Act.

I am proud of the fact that the Committee on Environment and Public Works did, indeed, produce that legislation during the 98th Congress. And, we threw in reauthorization of the Safe Drinking Water Act for good measure. That was the good news.

The bad news was that the Senate found time to act only on the Resource Conservation and Recovery Act and that the other environmental bills died when the 98th Congress expired. Which means we shall have to try again this year.

Although only one of our priority bills was enacted and signed into law last year, the consoling fact is that it was the most important of the bills on the list. And, on the whole, the Congress did a good job in the legislation. Reauthorization of the Resource Conservation and Recovery Act will mean better protection for all Americans against the hazards of chemical poisons. The new law will be the beginning of the end of land disposal of most poisonous chemicals—certainly of those in liquid form. Certain wastes will be banned entirely from landfills.

Underground tanks used to store petroleum and other hazardous substances will be regulated under the new law. And, the Environmental Protection Agency will begin regulation of so-called "small generators" of at least 100 kilograms (220 pounds) of hazardous wastes each month. This law, designed to track and to regulate hazardous wastes from "cradle to grave," has as its primary purpose the prevention of future dangerous spills of these chemicals. The goal of the law is to ensure proper handling and disposal of dangerous chemicals and to prevent future Love Canals.

The final version of the bill that was enacted into law was a blend of the Senate and House versions and represented a major gain in the effort to protect our environment and public health. It surely represents a major effort to protect one of our most valuable natural treasures—our groundwater—that we are beginning to contaminate to dangerous levels.

Despite our early gains in slowing—even reversing—the rate of the pollution of our surface waters, we are beginning to become aware of our inability to maintain our early progress in protecting the integrity of our surface waters, and it is a major concern. On that basis, we had better be even more concerned about the dangers to our groundwaters. Every state in the nation—including my own environmentally conscious state of Vermont—has experienced some level of groundwater contamination.

Even though specialists estimate that less than one percent of the nation's groundwater supply is polluted, we cannot be sure the contamination is not greater. And, in those instances where groundwater contamination has been detected, it has been found that those concentrations are much higher than those generally found in surface waters. Also, while we seem to have been able to find a way to clean our polluted surface waters, there has been no assurance so far we will be able to do the same with our groundwaters.

It is clear that our best course is to protect the quality of our groundwater, rather than to depend upon our ability to clean it up after we have contaminated it. One of the best ways to achieve that goal is through passage by the Congress of legislation that was approved by the Senate Committee on Environment and Public works in the last session. The Senate version of the Clean Water Act of 1984, for instance, included a provision to begin a national program designed to regulate and to control so-called "nonpoint" sources of water pollution—the kind of sources that threaten both our surface water and groundwater supplies.

''Nonpoint'' source pollution includes that generated by agricultural activities; urban storm water runoff; mining runoff; silverculture; the products of individual wastewater systems we call septic tanks, and atmospheric deposition, to name the most common. Those most interested in wildlife management are well aware of the hazards generated by ''nonpoint'' pollution, particularly in those parts of the country where chemicals are used heavily in farming operations, such as the San Joaquin Valley in California.

Our committee produced a sound proposal to begin the long journey to eventual control of ''nonpoint'' source pollution in this Nation, but the Senate did not consider the proposal because of opposition from a handful of senators and a cool response from the Administration. The Senate shall have another opportunity to consider the legislation this year.

Another source of ''nonpoint'' pollution is atmospheric deposition. That includes, of course, acid rain—which threatens our lakes and rivers and streams and forests and crops, and adds to health hazards created by all sulfur emissions.

Our committee produced a series of amendments to the Clean Air Act that included an acid rain control provision that would have reduced the sulfur emissions that cause acid deposition by about 40 percent in 31 eastern states in the next decade. It is my intention to urge our committee to act again on acid rain legislation in this session of the Congress. Here again, floor action last year was blocked by Administration opponents who were joined by a handful of members of the Senate.

Leakage from underground storage tanks and seepage from inadequate and illegal hazardous waste sites continue to pollute our environment—including surface water and groundwater. The chemical Superfund law is this Nation's major weapon in the battle against that danger. Here again, our committee reported legislation in the last session of the Congress that was not considered on the floor because of Administration opposition.

As you know, we have already renewed the effort to extend and expand the Superfund law. Let me review the bidding at this point:

Since I became chairman, the Senate Committee on Environment and Public Works has spent up to four years gathering evidence and testimony and considering appropriate action to take regarding the Clean Air Act, the Clean Water Act, and Superfund. The members of the committee were nearly unanimous in approving the legislation developed in the committee. Only one or two members voted against each of the final bills. Reorganization of the Senate has reduced the size of the committee and some members have left. But, all 15 members of this year's committee served on the committee last year. Thus, in most cases, I anticipate that the committee will be prepared to act quickly—and without extensive new hearings—to renew its approval of the legislation.

It would be my hope that the committee will follow our early agenda and report bills to the Senate that substantially reflect the agreements we reached in the past. Indeed, I anticipate the committee will report remaining environmental bills in this order this year:

- Clean Water Act.
- Safe Drinking Water Act.
- Clean Air Act.

We have already reported an improved version of the chemical Superfund law. The law is extended for another five years under the terms of our bill; the funding is increased to $7.5 billion from the current level of $1.6 billion for five years, and we have improved enforcement and reporting.

I have received assurances that the Finance Committee will begin to work on the fund-raising section of Superfund next month, with a tentative goal of completing that work early in May.

Indeed, our committee has tentatively earmarked the week of May 13th to the 17th for floor action on Superfund—and Clean Water and Safe Drinking Water. That's ambitious, but our committee will be ready if the Senate is.

Senator John Chafee of Rhode Island, who is chairman of our major environmental subcommittee, has scheduled hearings on the Clean Water Act for March 26th, 27th and 28th, and a markup on the bill has been scheduled for April 4th. I anticipate that a strong environmental bill will emerge from both the Chafee Subcommittee and the full committee and that the bill will be ready for action on the Senate floor in May.

In the past I have joined Senator Chafee in stressing that we were opposed to any efforts to weaken the Clean Water Act, and we particularly stressed our opposition to any proposals to change Section 404 of that act. However, because of some unexpected interpretations of Section 404 requirements by the Corps of Engineers—most recently in the New York City Westway Affair—Senator Chafee is considering some oversight hearings on Section 404 to see whether we may need to strengthen those provisions of the law.

I anticipate that Senator Chafee will also soon introduce a bill to reauthorize the Endangered Species Act for another five years or so, without any changes. It is most likely I will join him to sponsor that legislation.

Senator Durenberger of Minnesota, who is chairman of the committee's other environmental subcommittee, can be expected to renew his efforts to produce an improved version of the Safe Drinking Water Act. Our committee reported a reauthorization of that act last year, but there again the Senate was prevented from action by the opposition of only a few members.

I remain committed to the need for action to reduce the sulfur pollution that causes acid rain. But, political reality forces me to tell you that the future and timetable for Senate action on acid rain control legislation depends on many factors. Among them are the results of the meetings concluding today in Quebec City between President Reagan and Canadian Prime Minister Brian Mulroney. As you know, the Canadian government has announced its plan to reduce sulfur and nitrogen oxide emissions by up to 50 percent in Eastern Canada over the next nine years.

I have appealed to President Reagan to drop his Administration's opposition to acid rain control legislation in this country. And, surely the President's future policy on acid rain will have some impact on the prospects for Senate action on our bill.

The House of Representatives has been unable to generate any acid rain control legislation so far, and, of course, House action is important also.

We in the Senate Committee on Environment and Public Works will make our decision on acid rain control legislation and other aspects of the Clean Air Act as developments occur in the months ahead.

In short, I have already shared with my fellow committee members the proposal to act early in this session of the Congress on Superfund, Clean Water, Safe Drinking Water, and Clean Air—in that order. Such a schedule contemplates action in the Senate this spring or early summer on Superfund, the Clean Water Act, and the Safe Drinking Water Act, and just a bit later on the Clean Air Act. And, we will be prepared to move forward on the Endangered Species Act and any changes deemed necessary in Section 404 of the Clean Water Act along the way.

That's an ambitious schedule, particularly in view of our lack of success with an equally ambitious schedule in the last session of the Congress. But, we have already met our committee timetable on Superfund and we are well on schedule on Clean Water. And, while ambitious, that schedule is achievable—because some things have changed since last year.

On Superfund, last year's Administration opposition to any action has been dropped. The Administration has recommended that Superfund be reauthorized for five years and that the size of the fund be increased. Disagreements remain over details, but not in the need for action. There will be action by the Congress this session.

Additionally, members of our committee have worked for four years on the Clean Air Act reauthorization and for two years on reauthorization of the Clean Water Act. Those are complex and interesting measures, but not so complex that they require another two years of study. And, surely not so interesting as to attract dedicated attendance of members at another long round of hearings and markups.

There is no question in my mind that Americans want strong environmental legislation and that they want action against the spreading dangers of poisonous chemicals.

The Resource Conservation and Recovery Act was approved in the Senate last year by a roll-call vote of 93 to 0, even though those who sought to delay Senate floor action argued that it was "too controversial" to be given floor time near the end of the session. I fully anticipate that Superfund and the Clean Water, Clean Air, Safe Drinking Water and Endangered Species Acts will command comparable majorities when they are presented to the Senate floor for vote. The votes of approval may not be unanimous, but they will be overwhelming.

Americans understand that man-made toxic chemicals present the greatest threat to their health and to the environment now and for the rest of the twentieth century. Americans also understand that acid rain can no longer be tolerated, even while some scientists caution that there is more to learn about the subject, just as we have more to learn about poisonous chemicals and their consequences.

But, the stakes in these debates are enormous. Continued failure to act on these environmental fronts threatens the health of millions of Americans and places entire regions of our nation at risk. Also at risk is the economic well-being of farmers, foresters, fishermen, and others who depend upon an unpolluted environment for their incomes.

Managers of our wildlife and other natural resources and the sportsmen and businessmen who benefit from that management have come to realize how great the risk is to their universe. Refusal to act because there is a level of uncertainty can be as unwise and foolish as acting too hastily on the basis of too little information.

There are many times when it would be irresponsible for a scientist to ignore uncertainty, but equally irresponsible for a public official to give that uncertainty too much weight in deciding public policy. It is my view that we are in one of those occasions in our deliberations over the issue of acid rain—and probably also in our deliberations regarding control and cleanup of toxic chemicals.

Because of that circumstance, it is important that we learn how to accommodate environmental requirements even where the costs are uncomfortable and the benefits are distant. The protection of our environment often requires investment based on suspicion and speculation. If we always wait for absolute knowledge, it will likely be too late to avert disaster.

In dealing with pollution, waiting for absolute knowledge can be as dangerous as operating in ignorance—particularly when the pollution is hazardous to life and health. We are off to a late start in dealing with chemical waste sites and with other releases of chemical poisons into the environment. We cannot permit our groundwater to become polluted as we permitted our surface waters and air to become polluted. We cannot permit our wetlands to be used as cesspools for runoff or discharge waters that contain heavy metals and other toxic substances. We must continue to gather knowledge and information regarding pollution and its consequences. But, we must also be prepared to act on the basis of what we already know.

It is no secret that I am prepared to act. And, I am confident that the overwhelming majority of the members of the Senate Committee on Environment and Public Works is ready to demonstrate that those members are once again ready to act. We shall give the full Senate and the Congress the opportunity to do the same. I know full well that it takes two Houses of the Congress and a President to enact legislation into law, but I and my colleagues on the Senate Committee on Environment and Public Works have already started the process.

Legislative Needs to Improve Management of Natural Resources

The Honorable John B. Breaux
Chairman, Subcommittee on Fisheries and Wildlife Conservation and the Environment
U.S. House of Representatives
Washington, DC

I want to thank the Wildlife Management Institute for allowing me the opportunity to address the 50th annual meeting of the North American Wildlife and Natural Resources Conference. Although the topic of my speech is "Legislative Needs to Improve Management of Natural Resources," I would like to take this time to share some thoughts with you on a broader topic, namely where we are in our cooperative efforts in wildlife management.

Several days ago I was in a meeting with a high official from the Office of Management and Budget (OMB). As you can imagine, we were talking about the attempt by OMB to ripoff the new funds that will be going to the states as a result of the passage of the Wallop-Breaux legislation. In that discussion, which was sometimes heated, I told the OMB official that what we in the fish and wildlife community have developed over the years is a very successful partnership involving the Federal Government, state fish and wildlife agencies, and, most importantly, the private citizen, whether that person is a hunter, a fisherman, or someone who simply enjoys watching wildlife.

I asked this official to compare the Fish and Wildlife Service budget with other agencies of about similar size and to compare how much of the overall agency budget comes from user fees. With full funding of Wallop-Breaux, more than one-third of the budget will come from user fees. This partnership, like most good partnerships, involves what amounts to a contract. Part of that contract is that, no matter how bad the times are, we do not divert these user fees to other purposes. We should recall that the Duck Stamp and the Pittman-Robertson program were both established in the midst of the Great Depression. That is why it is absolutely essential that we protect the integrity of the funding mechanisms that were established for the Duck Stamp, the Pittman-Robertson program, and the Wallop-Breaux program. Senator Wallop and I have told the President, Dave Stockman and our fellow members that we intend that the Wallop-Breaux program must be properly funded, and with your help, it will be.

The conversation with OMB started me thinking about this remarkable partnership for conservation that has developed over the past 50 years. It is remarkable, in part, because of the efforts put forth by the partners.

In the Federal Government, the Fish and Wildlife Service has moved from being a small arm of the Department of Agriculture to an agency that manages more land than the National Park Service and which carries out myriad other responsibilities involving research, monitoring toxic substances, endangered species, and wetland regulation responsibilities as well as those for migratory waterfowl. The states, too, have responded. They have dedicated all of their license receipts to wildlife management and used their grants under Pittman-Robertson to carry out wildlife management programs that, in many cases, have resulted in more deer, more turkeys, and more wildlife than in those by-gone years when we had less than half the population we have now. Today, 32 states have instituted tax check-off or other programs to benefit nongame and endangered wildlife. This growing emphasis on all wildlife is most encouraging.

Private organizations have played a great role as well. Ducks Unlimited has protected and developed millions of acres of waterfowl breeding habitat in Canada, and, recently, has begun to restore and improve breeding areas in the U.S. The Nature Conservancy has not only catalogued rare and endangered ecosystems, they have raised money to go out and buy them. In fact, through the Mellon Foundation, they have a revolving fund of $50 million to acquire important pieces of habitat. We should not forget the sporting arms manufacturers and the fishing tackle manufacturers who have supported excise taxes on their products. We should also not forget the conservation groups, like the National Wildlife Federation and the National Audubon Society and many others who have educated people and lobbied hard for a place for wildlife in the law, in the budget, and on the land.

This partnership is also remarkable because of the rare degree of trust that has developed among the participants. What group would willingly come forward offering to pay higher prices for their sports equipment? Hunters and fishermen have done that. In Louisiana, when we asked hunters if they were willing to pay more for their duck stamps, an astounding 80 percent said yes, if others would pay their share of the conservation costs as well. Recreational fishermen overwhelmingly supported the Wallop-Breaux legislation, even though it means higher tackle prices for them.

The legislation that we consider in the future must continue to flow out of our partnership for conservation. As you know, we have reintroduced the Emergency Wetlands Resources Act. This legislation would once again call on hunters to make a sacrifice by raising the price of the Duck Stamp over a five year period from its current level of $7.50 to $15. It would also require entrance fees at some National Wildlife Refuges with the proceeds going into the Migratory Bird Conservation Fund. Current Duck Stamps would serve as an entry permit. This provision would allow nonhunters to participate in the wetland acquisition program that has been in existence for over 50 years. Finally, the legislation would authorize up to $75 million per year for state and federal wetland acquisition programs. This federal share reflects the federal responsibility for protecting the migratory bird resource and would encourage state wetland acquisition programs.

We should also begin the process of developing a sound base for funding nongame programs. Unfortunately, it will be difficult to develop an excise tax program similar to the one we have for Wallop-Breaux and Pittman-Robertson. To be fair, there must be a solid connection between the item taxed and the program. Taxing binoculars, for example, for nongame programs would hardly be fair to the millions of people who use binoculars for sporting events and other purposes. We will be holding hearings on the nongame program and looking at the various possibilities for funding. What is particularly encouraging in this area is the recent moves by the states to develop their own sources of funding. Incidentally, one of our budget initiatives this year will be to increase the amount of money available to the states under Section 6 of the Endangered Species Act. I believe adequate funding is essential if we are to make the states full partners under the Act. Because of the state match, it is also the most economical for the Federal government to bring about the recovery of endangered species.

We will also be moving forward with legislation to establish a National Fish Hatchery System and to make sense out of our current fish hatchery policy. For too long, hatcheries have been constructed by the whim of the appropriations committees and shut down by the caprice of the Office of Management and Budget. We need to develop a rational policy that sorts out federal hatchery functions, mitigation responsibilities, state responsibilities, and those hatchery activities which are more appropriately supported by the private sector. We are working with the Fish and Wildlife Service, the National Marine Fisheries Service, the states, and the various interest groups on this legislation, which we hope will end the uncertainties of our current hatchery policy.

We must also move on legislation to encourage private conservation measures. Last year I introduced legislation to provide tax incentives for conservation. Although I have not reintroduced that legislation this year, I plan to offer it for consideration when Congress begins to address tax reform issues later this year. I am also working with Congressman Webb Franklin of Mississippi on his legislation to allow debt-ridden farmers to give conservation easements on marginal land, including wetlands, in exchange for a reduction of their debt. I believe we must develop these innovative approaches to conservation if we are going to conserve wildlife on private land. Without private cooperation, we face a future where wildlife is restricted to enclaves protected by state and federal agencies.

If we are to be successful in legislation, and in conserving natural resources, we must work together. For fifty years, there has been a partnership for conservation. Working together, those who went before us, and those of us in this room, have accomplished a great deal. The refuge system, the wildlife restoration programs, programs to protect endangered species and nongame, and most recently, Wallop-Breaux, would not have been possible without the united efforts of the conservationists in this room and those who preceded us. Now it is time to move forward.

I propose a new partnership for conservation. Like the old one, it should bring out the best efforts of all of the partners. Wildlife managers, conservationists, and state and federal agencies should continue to move ahead, forging new and innovative solutions to conservation problems. We should also reach out to other groups, particularly private landowners and agricultural interests, to encourage wildlife conservation in conjunction with other activities.

We must encourage industry to develop innovative ways to accommodate wildlife. I am particularly encouraged by the efforts being made by Tenneco and the Fish and Wildlife Service to establish mitigation banks that protect valuable marshlands. There need to be more attempts at innovative solutions to some of our resource problems. Another example of a creative approach is in the rigs-to-reefs program that has been pioneered by Tenneco and which we have encouraged in our recently passed artificial reefs legislation. Finally, we need to encourage those who are nonhunters and nonfishermen to join in constructive efforts to conserve fish and wildlife.

In this partnership, as in all partnerships, there will be quarrels. On most issues, we need to recognize that the interests that bring us together are much greater than the issues that divide us. Some problems, and these are few, need legislative solutions. Other problems are better settled with a bottle of bourbon and a few heated discussions among ourselves. I feel this is particularly true of some of the issues that tend to divide state and federal wildlife managers. We have all worked hard to provide more resources to both state and federal agencies. Let's pull together rather than pull apart.

Finally, I want to say a word to the people in this room, people who have dedicated their lives to wildlife conservation. As a hunter, I know that you are the people that make my sport possible by maintaining healthy populations of wildlife. I salute you for this and for your role in conserving the natural heritage of this country.

I think you know that scientific management has no greater supporter than John Breaux. I would caution you, however, that wildlife management is an art and a science, not a dogma. We need to use it to develop methods for conserving wildlife in different habitats and in different ways, not as a shield to protect existing management practices or theories. We must use our tools to move ahead, not to tie us to the past. Remember, our predecessors who came to Washington 50 years ago were not looking back, they were looking forward.

Forest Decline and Acid Deposition: Quandary for Natural Resources Management

Robert L. Burgess
Professor and Chairman
Department of Environmental and Forest Biology
SUNY College of Environmental Science and Forestry
Syracuse, New York 13210

Acid rain is a current catchword in the vocabulary of many Americans, a pejorative phrase to much of the media, a polemic term to coal companies, utilities, industrialists, politicians, and our Canadian neighbors, and perhaps the dominant politico-socio-economic problem in much of northwestern Europe. Yet the problem is not new, having been initially recognized by Robert Angus Smith, a British chemist, 133 years ago (Smith 1852). Smith essentially found a gradient of rainfall chemistry in and around the industrial city of Manchester, and demonstrated that rainfall in the city contained sulfuric acid, while that falling on rural fields did not. More recently, of course, acid rain (acid precipitation, acidic deposition) has become a widely documented phenomenon, and thousands of studies have been completed that address this question in many parts of the world (Garfield 1985).

I will discuss acidic deposition in the most general terms, concentrate on what we know or what we think we know about forest decline, both in eastern North America and in western Europe, suggest some basic redirection in national and international research thrusts, and give my view on why the total problem presents a quandary for natural resources management.

Permit me to emphasize, right at the start, that I believe that acidic deposition is a harmful environmental phenomenon. We cannot continue to insult aquatic and terrestrial ecosystems with precipitation of pH 4.0 without expecting change to occur. I believe that legislative or administrative controls of some sort are essential, but given the enormous economic costs involved, prudence must be exercised, and we may not be able to trade incipient national bankruptcy for continued forest productivity and a high quality sport fishery in the lakes of the Adirondacks. But this is Hobson's choice. Just because the baby seems to suffer no immediate ill effects from ingestion of a few micrograms of lead, we do not permit our children to be raised in a lead-saturated environment.

I further believe that evidence of deleterious effects of acidic deposition on temperate zone lakes is substantial and conclusive (National Research Council 1984). We do not need to wait for comparable evidence for forests to appear before the nation realizes that something must be done. However, at the present time, the available data do not make a strong case for terrestrial ecosystem damage, a point I will develop later.

Since the initial identification of the increasing acidity of precipitation both in Europe and in North America, a great many studies have been published on the effects of acid rain on a wide variety of ecosystems, soils, and fabricated structures. Ecologically, attention has focused on lakes, forests, and agricultural systems. Studies of acidic deposition range from analyses of long-term monitoring data, to empirical surveys, to experimental plots or microcosms using acid rainfall simulators, to sophisticated computer modeling techniques. These models employ mathematical equations to describe atmospheric processes, pollutant emission, transport, and transformation, plume dispersion, particulate fall velocities, aerosol behavior, canopy interception, biotic adsorption and absorption, and residence times in soils.

Knowledge of the actual and potential effects of acidic deposition on forest ecosystems is vital, given the vast economic, hydrologic, and biological importance of forested lands. For example, New York State alone has over seven million hectares classified as forest, about 60 percent of the total land area of the state (Brooks 1981). In 1970, over 1.3 million people in New York were employed in timber or timber-related industries (Ferguson and Mayer 1970). Forests are a source of employment, wood products, recreation, and wildlife, and their continued vitality is essential as they directly influence the character of air, water, soil, and aesthetic resources.

The effects of acidic deposition on ecological systems are expected to be manifold and complex (Cowling and Linthurst 1981, Evans 1982, D. W. Johnson et al. 1982, Johnson and Siccama 1983a, b). Direct and indirect effects of acidic deposition on vegetation may include damage to leaf surfaces and tissues, disturbance of normal metabolism and growth processes, alteration of leaching or exudation by leaves and roots, interference with reproductive and regenerative processes (Evans 1984), increased susceptibility to environmental stresses such as drought, alteration of symbiotic relationships, changes in microbial activity and decomposition rates, and interference with host-parasite or pathogen interactions (Smith et al. 1984). Further potential effects of acidic deposition on forest ecosystems may include accelerated rates of leaching of base cations, including plant nutrients, from the soil and associated interference with nutrient cycling (D. W. Johnson et al. 1983, Likens and Bormann 1974, McFee et al. 1976, Mollitor and Raynal 1982, Norton 1976, Voigt 1979), increasing levels of trace metals and greater solubility of aluminum in the soil, perhaps to toxic levels (Cronan and Schofield 1979, Ulrich et al. 1980), and fertilizer effects from the deposition of nitrogen and sulfur-containing substances (Altshuller and Linthurst 1984, CAST 1984, Irving and Miller 1981).

Researchers studying the effects of acidic deposition on natural ecosystems are faced with a serious dilemma. Standard cause-and-effect experimental design requires that one subject area be exposed to the "treatment" in question while another is left unexposed. The effects of the treatment are ascertained by comparing the treated area with the unexposed, control area. For the comparison to be valid, the control area and the treated area must differ only with respect to the treatment; that is, all other factors must be kept equivalent. Herein lies the major problem encountered in studies on the effects of acidic deposition on forest growth and productivity. Vast geographic areas receive acidic deposition but there are no unexposed control areas which can be used for comparisons. Some studies have compared geographically separated forests which could be inferred to receive different amounts of acidic deposition (Abrahamsen et al. 1977, Cogbill 1977). However, so many other environmental features vary between these areas that valid comparisons cannot readily be made concerning the effects of acidic deposition.

Experimental studies establishing dose-response relationships for acidic deposition and plant growth and development are often instructive in assessing potential sensitivity of plants to acidification. However, extrapolating such results as a means of interpreting response of the plants under natural field conditions is a serious problem (Evans 1982, Raynal et al. 1982a, b). Finally, serious disagreements among scientists seeking to evaluate current evidence concerning the effects of acidic deposition on natural ecosystems are exemplified in the following contrasting, even contradictory, statements which appeared in back-to-back feature articles in the journal, *Environmental Science and Technology*:

> There are growing indications that widespread dieback and decline of forests in both Europe and North America are caused by short- and long-range transport of air pollutants (Tomlinson 1983)

and,

> Available evidence does not show a clear cause and effect relationship between acid deposition and forest decline and dieback in the U.S. (Johnson and Siccama 1983a).

In a recent critical analysis of published literature on acidic deposition and forest ecosystems (Burgess 1984), a number of salient points emerged. These are:

1. There has been significant "dieback" of red spruce in the northeastern United States in the past 25 years. The direct, or most probable, cause has not been identified, although most hypotheses involve combinations of drought, air pollutants, and acidic deposition (Scott et al. 1984). Effects of insects, pathogens, soil conditions, exposure, winter injury, and abnormal weather patterns have been postulated as potentially contributory. Similar "declines" have been reported for maple, birch, ash, and oak since the 1930s, all of which show strong relationships with drought conditions. Periodic regional drought is strongly implicated in recent alleged red spruce "dieback," and for selected cases involving other tree species as well. From currently available information, it is not possible to determine whether periods of moisture stress are solely responsible for dieback, act as triggering mechanisms for abiotic or biotic decline, or are simply an easily identifiable factor in a much larger and much more complex syndrome (see Friedland et al. 1984).
2. Alleged impacts of acidic position on forests generally include one or more of the following eight mechanisms, processes, or events:
   a. Simultaneous mortality of all age classes of trees.
   b. Reduction in seed germination and/or seedling establishment.
   c. Reduced productivity/vitality of living trees.
   d. Accelerated leaching of nutrient cations from soils.
   e. Mobilization of aluminum in soil solution, leading to aluminum "toxicity."
   f. Acceleration of natural soil acidification processes.
   g. Accumulation of heavy metals in soils.
   h. Injury to fine root hairs of trees and/or "physiological drought."

   None of these can be individually, unequivocally, or directly tied to the apparent "dieback" of red spruce and other species in northeastern North America. There is evidence that each is operative in certain places, on certain soils, and with certain species, but none are known to be exclusively responsible. Based on knowledge of multi-factor ecological relationships, it is probable that several (or all) of the above may have contributed, or are contributing to the red spruce dieback.

3. There is no identifiable "threshold" concentration of acidic deposition below which we can state that forest ecosystem damage does not occur. It is difficult, if not impossible, to determine sensitivities of individual species to the combination of pollutants in the various forms in which acidic deposition occurs. There are no sensitivity standards for natural ecosystems. Furthermore, pollutant/canopy interactions influence deposition at individual sites in individual forest types.

That a threshold concentration of acidic deposition exists, below which forest damage does not occur, is not a satisfactory concept for several reasons. First, while establishing threshold damage levels for gaseous pollutants based on vegetation dose-response studies may seem practical, evaluating the simultaneous impacts of gaseous, aerosol, particulate, and dissolved substances on plants is problematic. There have been few experimental studies to determine the sensitivity of individual plant species to combinations of pollutants in the various forms in which acidic deposition occurs. Thus, there is little basis for establishing sensitivity standards for natural ecosystems.

Second, the variability of pollutant loadings has not been fully recognized because pollutant concentration-vegetation canopy interactions must be considered. Acidic deposition loadings under contrasting adjacent forest types may differ significantly. For example, Mollitor and Raynal (1983) found that annual net wet deposition of sulfate in bulk precipitation in the central Adirondack Mountains measured about 26 kg ha^{-1}, while sulfate deposition beneath a hardwood canopy was 30 kg $ha^{-1}yr^{-1}$ and beneath a conifer canopy, about 50 kg $ha^{-1}yr^{-1}$. Clearly, the nature of vegetation at any site influences the atmospheric inputs to the location. Thus, the relationship between atmospheric pollutant concentrations and atmospheric deposition is not straightforward.

Third, the no-damage threshold concentration concept is not compatible with the strong likelihood that many atmospheric deposition effects are chronic and cumulative rather than acute and episodic. For example, potential effects on vegetation associated with nutrient leaching or metal toxicity may develop over many years as soils and plants are exposed to both natural and anthropogenically-induced system changes.

These complications mean that the establishment of threshold concentrations of atmospheric deposition which are not to be exceeded without forest damage is difficult. The implication of such standards is that deposition below the threshold will be "safe" and that deposition above the threshold will be damaging. It is quite possible that some terrestrial ecosystems may be adversely influenced by *any* significant anthropogenic atmospheric deposition inputs while others may be unaffected by rather heavy loadings.

Based on an evaluation of potential damage to certain aquatic habitats, Canadian members of the joint U.S.-Canada study of transboundary air pollution proposed that deposition of sulfate in precipitation be reduced to less than 20 kg ha^{-1} yr^{-1} to protect sensitive aquatic ecosystems. Their counterparts in the United States did not endorse this proposal but concluded that there is no evidence that chemical or biological effects occur in regions receiving less than 20 kg $ha^{-1}yr^{-1}$ of wet sulfate. While this value of sulfate deposition may be viewed as a general threshold level, it should be clear that this standard has been associated with aquatic ecosystem damage, and may or may not be applicable to terrestrial ecosystems.

Trees may respond to the deposition of acidic substances in ways dependent on the genetic characteristics of the species, the sensitivity of individual developmental stages, the timing, duration, frequency, and severity of deposition events, and the nature of meteorological and microenvironmental conditions (Cowling 1978, 1982). Thus, a complete assessment of the influences of acidic deposition on tree species must include a consideration of phenology, the changes in life cycle stages as affected by environment and season. Seed germination and seedling emergence and establishment are phases potentially susceptible to acidic deposition (Abrahamsen et al. 1976, Fernandez 1983, Lee and Weber 1980, Raynal et al. 1982a, b). Mature and reproductive phases of growth also may be sensitive to acidic deposition (Haines et al. 1980, Likens 1976, Cowling 1978, Jacobson 1980, 1983, Evans 1982). However, there is no documentation of differences in the sensitivity of vegetation to acidic deposition from natural field studies.

To circumvent the lack of available control forests for comparative studies, dendroecological techniques have been employed to assess acidic deposition effects (Abrahamson et al. 1977, Cogbill 1977). Using the historical records of tree growth embodied in annual growth rings, growth of the tree prior to acidic deposition influence can be compared to that of recent decades to determine possible changes in growth trends associated with changing atmospheric chemistry. After variation due to climatic factors and age is removed, a trend of decreased growth can be interpreted as evidence of the possible impact of acidic deposition (Jonsson 1976).

Available dendroecological studies were conducted in natural stands or plantations where the lack of historical data on stand development, incomplete characterization of soils, and lack of detailed atmospheric deposition data seriously restricted the ability to attribute non-climatically induced growth decline to acidic deposition. Several, but not all, of the studies clearly show a decline in tree growth in a variety of tree species common in the eastern United States (e.g., Johnson et al. 1981). Due in large part to limitations in the methodology and the lack of comprehensive data on soils and stand history, it is impossible to determine if these growth declines are related directly, indirectly, or are unrelated to acidic deposition (Puckett 1982, Roman and Raynal 1980).

Experiments with simulated acid rain and various plant species have generated models which suggest a cause and effect relationship between acid inputs and plant health. Extensive monitoring of both wet and dry deposition demonstrates a possible cause looking for an effect, but complex forest ecosystems are replete with effects for which the causes are unknown. Some hypothesize that acid deposition is a direct or indirect cause of some of the deterioration and mortality seen in northeastern forests. The large step from hypothesis to demonstration requires special care not to confuse the many interacting factors. Decline is a long term deterioration, often ending in death, caused by a combination of specifically ordered but interchangeable stress factors (Manion 1981). The deterioration of red spruce in North America, often cited as an acidic deposition problem, provides a good illustration of the semantic confusion surrounding decline, disease, and injury.

The available evidence for forest decline is substantial and rather unequivocal. Trees are dying, growth rates are slowing, areas are converted to other uses, and consequently, overall productivity is down in many regions of the eastern United States. This generalized decline constitutes an identifiable and measurable effect, but tells us little or nothing of the probable multifactor cause. Over the past decade, hundreds of investigators, working for a score of funding agencies, have spent millions of dollars and published thousands of papers and reports on "The effect of acid rain on . . ." For terrestrial ecosystems, the results are still equivocal and lack the convincing data that approach "proof." Aquatic systems, on the other hand, show well-documented effects of acidic deposition, both through changing water chemistry and impacts on the biotic community.

There is good reason why forests and lakes do not show similar effects. First of all, a five-year old fish is an old fish, while a 100-year old spruce is just approaching middle age. In other words, the turnover times of the dominant populations differ by orders of magnitude. We cannot deal with long-lived tree species within the life span of individual investigators. Evidential data come comparatively easy in aquatic ecosystems, and only with great difficulty in most forests.

Secondly, most work has focused on tree species, those forest dominants of primary economic importance. Yet tree species, in most forest ecosystems, constitute no more than about 10 percent of the vascular flora, and an even smaller fraction of the total plant species. Yet the number of studies on algae, fungi, mosses, or understory herbs is incredibly small, even though many potential effects could be expected to first show in populations of these components. Tracking an herb population on the forest floor for a decade might tell us more than continuing to focus our energies on a selected set of economically important tree species.

Several federal and state agencies are beginning to adopt programs addressing forest decline. By focusing on a known effect, it may be possible to work toward identification of a most probable cause or set of causes. This approach has a long history in epidemiology, illustrated by the following example. For over thirty years, public health scientists have analyzed thousands of records in Tennessee, searching for effects of long-term, chronic, low-level radioactive releases from operations at Oak Ridge. The search has been fruitless, trying to pinpoint effects resulting from a known "cause." Conversely, in the 1950s epidemiologists took an identified effect, cancer of the lungs, and worked backward to a most probable cause, leading, of course, to the Surgeon General's pronouncement that smoking constitutes a major hazard to our health. If we can attack the forest decline syndrome on a broad front, we may be able to document causes that have thus far been elusive. And history may record this as a major conceptual breakthrough in the ways that ecological science can be brought to bear on the problems of modern society.

All of the concern surrounding acidic deposition and its effects presents a quandary for natural resource management, where politics, economics, and science must interrelate for the common good. I recognize several areas where problems have arisen in the past, and will probably continue to plague decision makers in the future.

First, political expediency dictates that both scientists and managers pay attention to "hot topics." Researchers quickly learn in what arenas funding is available, be they couched in terms of "new research thrusts" or "national needs." While science application is always a high priority activity, scientists seldom have much to say concerning either the areas of need or the methodologies to be employed. Instead, governmental processes generate budgets, and often dollars are programmed based on what will be approved, and not necessarily on what may be really needed.

In turn, this leads to changing foci of research. There are probably thousands of scientists who have changed individual and long-term emphases in their research programs to become involved with acid rain. This is all well and good, and badly needed. But who can measure the research results that were not obtained because of the magnitude of the shift? What might we now know of fish and wildlife populations, behavior, ecological relationships, or chemical communication had the practicing research community been able to continue its original thrust? We may never know, but the blizzard of acid rain literature must mean that many areas of important resource research are either neglected or have been totally shelved.

Finally, focus on acid rain has resulted in the redirection of limited available funds and a dilution of available manpower in critical areas. For many agencies, both federal and state, land acquisition has ground to a halt. Technical personnel are shifted from resource management functions into positions of peripheral research responsibility. People once involved in songbird surveys or track and pellet counts are now servicing atmospheric sampling devices, changing strip charts, and checking on computer interfaces.

Resource managers may be faced with decisions every day that go unrecognized as resulting from these pressures. Do we continue to stock fish in lakes where natural populations have disappeared? How do we manage game birds and large mammals in obviously declining forests? And what do we do with dying timber? Harvest quickly? Let it recycle? Clearcut and replant, not really knowing whether the new seedlings will make it.?

These are questions of immense importance and they need the careful consideration of not only the resource managers and scientists, but the politicians, economists, engineers, and the general public, too (Alison 1984). Acidic deposition is a global threat, but we must deal with it rationally and objectively if we are to effectively manage both our global resources and our global economy. To this end, I encourage all participants to get informed, weigh data and conclusions, and utilize the wisdom of our individual and collective experience to insure that our priceless heritage of natural resources is still here for our great-grandchildren.

Literature Cited

Abrahamsen, G., K. Bjor, R. Horntvedt, and B. Tveite. 1976. Effects of acid precipitation on coniferous forest. *In* F. H. Braekke, ed. Impact of acid precipitation on forest and fresh water ecosystems in Norway. Research Report to SNSF-Project.

Abrahamsen, G., R. Horntvedt, and B. Tveite. 1977. Impact of acid precipitation on coniferous forest ecosystems. Water, Air, and Soil Pollut. 5:57-73.

Alison, R. M., 1984. Wildlife—a chilling tale. Ontario Out-of Doors, Nov/Dec:9-11.

Altshuller, A. P., and R. A. Linthurst, eds. 1984. The acidic deposition phenomenon and its effects. Critical assessment review papers, Vol. II: Effects Sciences. EPA-600/8-83-016BF. U.S. Environmental Protection Agency, Washington, D.C. liv +690pp.

Brooks, P. R. 1981. The forest resources of New York. A summary assessment. New York State Department of Environmental Conservation, Albany. 140pp.

Burgess, R. L., ed. 1984. Effects of acidic deposition on forest ecosystems in the northeastern United States: An evaluation of current evidence. ESF 84-016. SUNY Coll. Env. Sci. and For., Syracuse, N.Y. 108pp. plus appendices.

CAST (Council for Agricultural Science and Technology). 1984. Acid precipitation in relation to agriculture, forestry, and aquatic biology. Report No. 100. Council for Agricultural Science and Technology, Ames, Iowa. 31pp.

Cogbill, C. V. 1977. The effect of acid precipitation on tree growth in eastern North America. Water, Air, and Soil Pollut. 8:89-93.

Cowling, E. B. 1978. Effects of acid precipitation and atmospheric deposition on terrestrial vegetation. Pages 47-63. *in* J. N. Galloway, E. B. Cowling, E. Gorham and W. W.

McFee, eds. A national program for assessing the problem of atmospheric deposition (acid rain). A report to the Council on Environmental Quality, Fort Collins, CO.
_____. 1982. An historical resume of progress in scientific and public understanding of acid precipitation and its biological consequences. *In* F. M. D'Itri, ed. Acid precipitation: effects on ecological systems. Ann Arbor Science, Ann Arbor, MI. 506pp.
_____, and R. A. Linthurst. 1981. The acid precipitation phenomenon and its ecological consequences. BioScience 31:649-654.
Cronan, C. S., and C. L. Schofield. 1979. Aluminum leaching response to acid precipitation effects on high elevation watersheds in the northeast. Science 204:304-306.
Evans, L. S. 1982. Biological effects of acidity in precipitation on vegetation: a review. Environ. Exper. Bot. 22:155-170.
_____. 1984. Botanical aspects of acidic precipitation. Bot Rev. 50(4):449-490.
Ferguson, R. H., and C. E. Mayer. 1970. The timber resources of New York. Res. Bull. NE-20. USDA For. Serv., Upper Darby, PA. 193pp.
Fernandez, I. J. 1983. Acidic deposition and its effects on forest productivity—a review of the present state of knowledge, research activities, and information needs—second progress report. Technical Bull. No. 392. National Council of the Paper Industry for Air and Stream Improvement, Inc., N.Y. 180pp.
Friedland, A. J., R. A. Gregory, L. Karenlampi, and A. H. Johnson. 1984. Winter damage to foliage as a factor in red spruce decline. Can. J. For. Res. 14:963-965.
Garfield, E. 1985. Acid Rain. Part I. What is it and what does it do? Current Contents 16(9): 3-12. Part 2. Public issues and proposed solutions. Current Contents 16(10):3-11.
Haines, B., M. Stefani, and F. Hendrix. 1980. Acid rain: threshold of leaf damage in eight species from southern Appalachian forest succession. Water, Air, and Soil Pollut. 14:403-407.
Irving, P. M., and J. E. Miller. 1981. Productivity of field-grown soybeans exposed to acid rain and sulfur dioxide alone and in combination. J. Environ. Qual. 10(4):473-478.
Jacobson, J. S. 1980. The influence of rainfall composition on the yield and quality of agricultural crops. Pages 41-46. *in* D. Drablos and A. Tollan, eds. Ecological impact of acid precipitation. The Norwegian Interdisciplinary Res. Prog: Acid precipitation-effects on forest and fish, Oslo-As, Norway.
_____. 1983. Ecological effects of acid rain. J. Air Pollut. Control Assoc. 33(11):1031.
Johnson, A. H., and T. G. Siccama. 1983a. Acid deposition and forest decline. Environ. Sci. Tech. 17:294-306.
Johnson, A. H., and T. G. Siccama. 1983b. Spruce decline in the northern Appalachians: evaluating acid deposition as a possible cause. Proceedings of the Annual Meeting of the Tech. Assn. of the Pulp and Paper Industry. Pp. 301-310.
Johnson, A. H., T. G. Siccama, D. Wang, R. S. Turner, and T. H. Barringer. 1981. Recent changes in patterns of tree growth rates in the New Jersey pinelands: a possible effect of acid rain. J. Environ. Qual. 10:427-430.
Johnson, D. W., J. Turner, and J. M. Kelly. 1982. The effects of acid rain on forest nutrient status. Water Resour. Res. 18:449-461.
Johnson, D. W., H. van Miegroet, D. W. Cole, and D. D. Richter. 1983. Contributions of acid deposition and natural processes to cation leaching from forest soils: a review. J. Air Pollut. Control Assoc. 33(11):1036-1041.
Jonsson, B. 1976. Soil acidification by atmospheric pollution and forest growth. Pages 837-842 *in* L. S. Dochinger and T. A. Seliga, eds. Proc. First International Symposium on Acid Precipitation and the Forest Ecosystem. Gen. Tech. Rep. NE-23. USDA For. Serv., Upper Darby, PA.
Lee, J. J., and D. W. Weber. 1980. The effect of simulated acid rain on seedling emergence and growth of eleven woody species. For. Sci. 25:393-398.
Likens, G. E. 1976. Acid precipitation. Chem. Engineering News 54:29-44.
_____, and F. H. Bormann, 1974. Acid rain: a serious environmental problem. Science 184:1176-1179.
Manion, P. D. 1981. Tree disease concepts. Prentice Hall Inc., Englewood Cliffs, NJ. 399pp.
McFee, W. W., J. M. Kelly, and R. H. Beck. 1976. Acid precipitation effects on soil pH and base saturation of exchange sites. Water, Air, and Soil Pollut. 7:401-408.
Mollitor, A. W., and D. J. Raynal. 1982. Acid precipitation and ionic movement in Adirondack forest soils. Soil Sci. Soc. Amer. J. 46:137-141.

Mollitor, A. W., and D. J. Raynal. 1983. Atmospheric deposition and ionic input in Adirondack forests. J. Air Pollut. Control Assoc. 33(11):1032-1035.

National Research Council. 1984. Acid deposition: Processes of lake acidification. National Academy Press, Washington, D.C.

Norton, S. A. 1976. Changes in chemical processes in soils caused by acid precipitation. Pages 711-724 *in* L. S. Dochinger and T. A. Seliga, eds. Proc. First International Symposium on Acid Precipitation and the Forest Ecosystem. Gen Tech. Report NE-23. USDA For. Serv., Upper Darby, PA.

Puckett, L. J. 1982. Acid rain, air pollution, and tree growth in southeastern New York. J. Environ. Qual. 11:376-381.

Raynal, D. J., J. R. Roman, and W. M. Eichenlaub. 1982a. Response of tree seedlings to acid precipitation. I. Effects of substrate acidity on seed germination. Environ. Exp. Bot. 22:377-384.

Raynal, D. J., J. R. Roman, and W. M. Eichenlaub. 1982b. Response of tree seedlings to acid precipitation. II. Effect of simulated acidified canopy throughfall on sugar maple seedling growth. Environ. Exp. Bot. 22:385-392.

Roman, J. R., and D. J. Raynal. 1980. Effects of acid precipitation on vegetation. Pages 4-1 to 4-63 *in* Raynal, D. J., A. L. Leaf, P. D. Manion and C.J.K. Wang, eds. Actual and potential effects of acid precipitation on a forest ecosystem in the Adirondack Mountains. NYS-ERDA Report 80-28. Albany, N.Y.

Scott, J. T., T. G. Siccama, A. H. Johnson, and A. R. Breisch. 1984. Decline of red spruce in the Adirondacks, New York. Bull. Torrey Bot. Club 111(4):438-444.

Smith, R. A. 1852. On the air and rain of Manchester. Manchester Literary Phil. Soc., Ser. 2, 10:207-217.

Smith, W. H., G. Geballe, and J. Fuhrer. 1984. Effects of acidic deposition on forest vegetation: Interaction with insect and microbial agents of stress. Pages 33-50 *in* R. A. Linthurst, ed. Direct and indirect effects of acidic deposition on vegetation. Acid Precipitation Series—Volume 5. Butterworth Publ., Boston.

Tomlinson, G. H. 1983. Air pollutants and forest decline. Environ. Sci. Tech. 17:246-256.

Ulrich, B., R. Mayer, and P. K. Khanna. 1980. Chemical changes due to acid precipitation in a loess-derived soil in central Europe. Soil Sci. 130:193-199.

Voigt, G. K. 1979. Acid precipitation, forest ecosystems and intensive harvesting. Pages 33-48 *in* Impact of intensive harvesting on forest nutrient cycling. SUNY College of Environmental Science and Forestry, Syracuse, N.Y.

Outdoor Recreation Skills and Education: Responsibilities, Ethics, Successful and Needed Programs

Chairman:
FRANCIS (BUD) E. EYMAN
Assistant Superintendent
Outdoor Skills Education
Missouri Department of Conservation
Jefferson City, Missouri

Cochairman:
EDWARD L. KOZICKY
Executive Vice-President
North American Association of Hunter Safety Coordinators
Godfrey, Illinois

Outdoor Recreation Skills Education Introduction

F. E. "Bud" Eyman
Missouri Department of Conservation
Jefferson City, Missouri 65102

We are particularly grateful to have this opportunity to discuss a subject that to many in the field of education is the wave of the future: Known by many titles—outdoor education, outdoor skills education, conservation education, environmental education, or what have you. To many, outdoor skills education is one of the most valuable tools presently available for fish and game agencies when attempting to address today's many complex problems facing our agencies.

The management of fish and wildlife becomes increasingly more complex as competition for use of our natural resources increases. The good old days of the 1930s and 1940s, when hunters and fishermen were actively involved in the conservation movement and had the out-of-doors virtually to themselves, are like the dinosaur or passenger pigeon—gone forever. Education programs of yesteryear were basic, academic and sterile—oriented to the classroom, and in many cases to the one-room schoolhouse.

They were proscriptive (shalt not) and prescriptive (thou shalt) in nature. In those early days, perceptive leaders of the time recognized the need for such programs as hunter and aquatic education and a positive approach to the ethical use of our fish and wildlife resources. Aldo Leopold wrote in his *A Sand County Almanac* of the need to "Establish the seeds of a Conservation Land Ethic."

The outdoor recreation boom of the 1960s and 1970s, which is still strong today, created a rush to the out-of-doors that has virtually become a nightmare for today's fish and game agencies. The legendary primeval forest that poets so often speak of—at one time the exclusive domain of the hunter—is today crisscrossed with hiking trails and laced with campsites. The once secluded mountain lake or stream so dear to yesterday's fishermen is today's playground for the new breed of outdoors person.

It is at this point that one might make the observation "that the number of abusers is directly proportionate to the number of users." Competition for today's natural resource use is without question having a traumatic impact on state and provincial wildlife agencies, not to mention the long term effect which promises to levy even more acute problems for fish and game managers of the future.

Some state and provincial fish and game agencies are presently gearing up to address tomorrow's problems. Hunter Education programming has been broadened to include trapper education; while other agencies have developed programs to address snowmobile, and boating problems. Survival, advanced species-oriented seminars and other kindred areas of interest have found a place in state and provincial programming, and soon to come is aquatic education under the expanded Dingell-Johnson funding.

Research tells us that approximately 20 percent of our constituents are hunters, trappers or fishermen and approximately another 20 percent are openly sympathetic to their cause. On the other hand, however, approximately 60 percent of our constituents have interests that lie in entirely different directions.

Outdoor skills educational programming appeals to this major segment of our population. What better way to address our natural resources needs of today and tomorrow than by planting the seed of a sound conservation ethic in the youth of our nation. What better way to ensure both political and financial support from all groups—birdwatchers, hikers, campers, hunters, fishermen, and trappers—than through sound recreational skills education programs.

The NRA and History of Hunter Education in North America

Gary L. Anderson, James M. Norine, and Thomas C. Lankenau,
National Rifle Association of America, Washington, D.C.

The history of hunter education in North America is relatively brief, but this movement has already had a profound impact on making hunting a safer and more enjoyable sport. The first formal hunter education course was not initiated until 1949, although its origins can be traced to the first inhabitants of the continent. Hunting was a way of life, a means of existence and a part of the culture. Hunting skills and knowledge were passed along from father to son. Hunting was depicted in art, religious ceremonies, and language.

With the colonizaion of North America by Europeans, the hunter-gatherer society was replaced by agriculture, animal husbandry, and finally industry. Hunting was no longer a necessity for survival but a means of supplementing domestic meat production. Hunting became a sport; hunters became sportsmen.

These modern sportsmen were unlike their hunter-ancestors. They pursued game animals primarily for recreation. Hunting knowledge and skills were still passed down from father to son, but safety practices were often not included in this training. Likewise, hunters' skills and knowledge were less developed because many were from urban backgrounds and open fields were less available to practice the skills of hunting. As the number of sport hunters increased, their actions, attitudes, and safety were causing concern among hunters and non-hunters.

As early as the 1906 International Association of Fish and Wildlife Agencies meeting, Charles Joslyn of Michigan, denounced the unsportsmanlike conduct of some hunters who killed hundreds of ducks daily without apparent concern for the future of waterfowl and hunting. In 1928, Seth Gordon, as Conservation Director for the Izaak Walton League of America, published a code of outdoor ethics stressing safety and respect for other people, wildlife, and property rights. In 1946 the state of Kentucky initiated a firearms safety course at its conservation camp. These concerns and actions planted the seeds for hunter education in North America.

At the Tenth North American Wildlife Conference in 1945, former National Rifle Association (NRA) Executive Director, C. B. Lister, cited the need for specific, reliable information on hunting accidents and the circumstances surrounding them. Michigan, Minnesota, Pennsylvania, and New Jersey had systems for collecting data but none of them sought the same information. It was obvious that some national organization had to tabulate the known facts about hunting accidents that occurred throughout the United States and Canada.

In 1946, the NRA undertook this task, which culminated in the adoption of the Uniform Hunter Casualty Report Form. It was not until 1950, at the first Hunting Accident Clinic, that NRA was designated the collecting agency of the reports. Also in that year the International Association of Fish and Wildlife Agencies approved the NRA form, and 43 states and 5 Canadian provinces expressed a willingness to cooperate. A second meeting of the Hunter Accident Clinic was called in 1953. Using the experience gained from the first two years with the Uniform Hunter

Casualty Report Form, the NRA simplified the form to facilitate its completion by field agents and to present the information in a more readily usable form.

New York was the first state to enact a law requiring firearm safety instruction. From 1938 to 1949 there had been over 1,700 hunting accidents, including 239 fatalities. In the late 1940s the New York State Conservation Department attempted to develop a program aimed at reducing hunting accidents, and in 1949 the legislature decided to formalize that program. They passed a law requiring all persons under the age of 17 who had not previously held a hunting license to attend a brief course from a State Game Protector before being issued a hunting license. The Conservation Department however had no formal course, prepared materials, or trained instructors, and the number of applicants for training was so great that the Game Protectors alone could not provide the courses.

To resolve this problem, the Conservation Department requested assistance from the National Rifle Association which was operating an organized youth marksmanship training program, with published materials, certified volunteer instructors, and qualification programs, which evolved from the Winchester Junior Rifle Corps that NRA took over in 1927. Using information from the hunting accident reports and the assistance of the American Association for Health, Physical Education and Recreation, the National Rifle Association developed a four-hour training course, which was first taught in New York in 1950. NRA marksmanship instructors taught the first hunter safety classes and certified the first hunter safety instructors. The core of the NRA course was knowledge of firearms and the safe use and handling of firearms in the field. Other subjects included game identification, game laws, map and compass skills, and hunter/landowner relations.

After 1950, the NRA Hunter Safety Training Program evolved from the materials developed for the New York program. NRA staff trained and certified volunteer instructors, provided materials and maintained statistical records for state programs. The use of volunteer instructors, many of whom began as certified NRA marksmanship instructors, established a tradition that has been a vital key to the growth of hunter education. New Hampshire adopted the program in 1953, California in 1954, and seven more states joined in 1955. By 1958, over 30,000 instructors had been appointed and nearly 600,000 students had received training in 25 states and one Canadian province.

Because of the growing need for variations in state programs and the growing administrative burden of keeping records for a national program, it became apparent that the NRA could not continue the direct administration of every state hunter safety program. In addition, state laws made it increasingly necessary to screen instructor applicants closely. A cooperative plan was thus developed in 1957 by NRA and states and provinces to coordinate insructor and student training. The NRA returned much of the responsibility for clerical work to the states along with adminisrative control of hunter safety programs.

Under the cooperative plan, the NRA furnished student and instructor packets, with states providing supplemental materials such as game laws, and the states now issued certification cards. The states compiled monthly reports on the number of students certified and instructors appointed. This data was used by the NRA to compile monthly and yearly national reports.

In 1957, the NRA Student and Instructor Hunter Safety Manuals were revised and supplemental manuals on bowhunting, vision, field care of game, first aid, survival, and black powder shooting were developed. As states and provinces began certifying their own instructors, the NRA concentrated more on promoting hunter education programs, publishing training manuals and assisting states in developing support materials.

The NRA also sponsored an annual hunter education award. In 1955 the Executive Committee of the International Association of Fish and Wildlife Agencies requested the NRA to initiate a program to reward states and provinces who had the best safety program. The NRA developed such a program and the award was presented annually from 1957 to 1978. From 1979 to present the NRA has recognized the top program through its own awards program.

Between 1958 and the late 1970s, the hunter education movement in North America underwent a gradual transition that featured better organized programs, dramatic expansion to new states, development of different training materials, and emergence of a major federal government role in hunter education. The rapid growth of state and provincial hunter education programs, including the passage of many new state laws requiring hunter safety training, provided the impetus for these changes.

This period also witnessed the development of professional staffs to lead hunter safety programs. Increased budgets allowed many states and provinces to hire hunter safety coordinators and support staff. With professional staffs and more secure funding a national hunter education constituency and leadership emerged.

In 1966, the NRA sponsored the First Annual Hunter Safety Coordinator Workshop to provide a forum for the exchange of ideas and the development of a uniform approach to training. As an outgrowth of these workshops, the North American Association of Hunter Safety Coordinators (NAAHSC) was formed in 1972. This was a major step in unifying programs and establishing reciprocal agreements between states and provinces. The NAAHSC continues to grow in strength and effectiveness each year, providing needed direction for a national program for both Canada and the United States.

Having a national organization that could influence the standards of training in different states opened the door for reciprocal agreements that allowed the training in one state to be recognized in other states. To date, these agreements are verbal, but all states and provinces recognize each other's programs.

Amendments to the Pittman-Robertson Act in 1970 and 1972 provided needed funding for the expanding state programs. Monies collected from excise taxes on handguns, ammunition, and bows and arrows provided funds for the states to use for hunter safety training and the construction, maintenance, and operation of public shooting ranges. This money is available on a matching basis, with three federal dollars available for each state dollar. Pittman-Robertson funding also provided an impetus for standardizing state programs by requiring states to meet certain federal guidelines.

The concern for standardization also led to a desire to evaluate hunter education programs. In late 1978 the International Association of Fish and Wildlife Agencies appointed a Blue Ribbon Study, headed by Fred Evenden, to review state hunter education programs and make recommendations for improvement. A rating system with three levels, A, AA and AAA, was developed to provide states with a means of analyzing their programs and setting attainable goals for improvement. By 1983, 40 of the 60 states and provinces had attained the highest AAA rating. The report made recommendations for standardizing hunter education programs and for the adoption of a proposed Mandatory Education Model Law. Other recommendations addressed agencies' roles, the basic hunter education course, instruction techniques and evaluation and research.

By 1978, all 50 states and 12 Canadian provinces conducted hunter safety programs and were training over 500,000 students per year. In addition to the NRA manual, many states were now using NRA materials or information derived from their own experiences to publish state specific manuals, many of them through the Outdoor Empire Publishing Company, established in 1971. The traditional theme of hunter safety was expanded to the broader theme of hunter education, as course material on hunter ethics, bowhunting, survival, field care of game, and muzzleloader hunting were added. In 1973, the NRA revised its manual to include these topics in addition to providing training aids, instructor tips, examinations, charts and films.

NRA program support also changed during this period. In 1971, responsibility for hunter safety programs was transferred from its Training Department to a new Hunting and Conservation Division. In 1977, program responsibility was transferred again to a new Education and Training Division. In 1980, all NRA hunter education programs were put under the direction of the Hunter Services Division. Thse changes reflected NRA's effort during this period of transition to move away from direct involvement with training volunteer instructors and certifying students, to one of program support and promotion.

In 1980, the Province of Alberta published a definitive hunter education text, *Alberta Hunter Education,* and in 1983, this was adapted for general North American use and published by the NRA as the *NRA Basic Hunter's Guide.* The guide is intended to supplement hunter education manuals and serve as a reference book for all hunters.

The NRA also worked in cooperation with the NAAHSC to develop a Hunter Education Academy program in 1978 to provide advanced training for volunteer and professional instructors and staff. To date NRA academy programs and similar volunteer and professional programs have been held in most states and provinces. The North American Hunter Education Championship was developed by the two organizations in 1984 to promote the development of skills directly relating to hunting.

In addition to the NRA, many other organizations have worked to improve hunter knowledge and responsibility. The National Shooting Sports Foundation sponsors National Hunting and Fishing Day each fall, produces films and videos and publishes support materials. The Izaak Walton League of America has developed an ethics program for hunters and is an active promoter of hunter responsibility and hunter/landowner relations. The National Bowhunter Education Foundation offers a bowhunter education course which addresses needs specific to bowhunters.

Many arms manufacturing companies support hunter education on state and national levels through advertising, equipment donations, sponsorships, essay contests, and other programs. The Hunter Education Council, comprised of representatives from private organizations and state and federal agencies, was formed in 1983 to provide support and promotion for the hunter education movement.

Today, incrased demands for outdoor recreation combined with limitations on hunting habitat, has restricted the growth of hunting opportunities. The goal of hunter education programs has subsequently shifted from maximum participation to enhancing the quality of the hunting experience. Today's hunters have a responsibility to their fellow hunters, nonhunters, and the wildlife resource. They must be knowledgeable, ethical and safe, and, most importantly, must pass these responsibilities along to succeeding generations.

Hunter education programs have been successful. Over 16 million students have been graduated and the safety record of North American hunters has improved dramatically since 1949. In the 1984 North American Hunter Accident Report, covering the years 1981-1983, there were 9.3 hunting accidents for every 100,000 of the 19 million hunting licenses sold in the U.S. and Canada. This rate compares with ranges in individual states of 20 to 50 hunting accidents per 100,000 hunting licenses sold, as reported in the NRA Uniform Hunter Casualty Report form 1950 to 1958.

In 1950, the New York hunting accident rate was 22.3 per 100,000 hunting licenses sold. By 1983, that rate had dropped nearly 60 percent to 8.4. Wisconsin experienced a similar decline. In 1967, when the state's hunter education program began, the accident rate was 43.5 per 100,000. In 1983, it had been reduced to 9.5, a reduction of 78 percent.

The hunter education programs of the states, provinces, and other organizations have played an important role in improving the quality of hunting. However, it is becoming increasingly clear that these training programs alone do not provide a total means of securing the future of hunting. For hunting to survive, it must be viewed by the general public as a legitimate leisure activity and as an important aspect of outdoor recreation and wildlife management. A new effort is needed to tell the American public about the excellent skills and ethics of hunters now being trained by Canadian and United States hunter education programs. Hunter education has made hunting safer, and it hs produced hunters who respect the wildlife resource and are committed to using it wisely.

In addition, the development of advanced hunting seminars and clinics now being offered on a voluntary basis by some states and national hunting organizations like the NRA, will help to expand the involvement and improve the skills of many more hunters and serve to give state and provincial natural resource agencies a larger and better educated game management constituency.

The NRA has a deep and long-lasting commitment to hunter education in North America, and has provided leadership starting with the initial development of state hunter safety training programs and continuing through its recognition of state and provincial efforts with awards, promotional efforts, and assistance with advanced skills programs. The challenge now is to meet the growing needs of hunters in a changing society through programs that continue to improve the skills, knowledge, and ethics of hunters and to enhance the public's understanding of hunting as an integral component of the management of North America's renewable wildlife resource.

Advanced Hunter Education and Tomorrow's Programs

Delwin E. Benson
Colorado State University
Fort Collins, Colorado 80523

Introduction

To chart a course for the future, trails from the past must be explored. Progress is made in steps toward a goal. So, plans for tomorrow or decades to come should be based upon a clear understanding of expected outcomes and influences from the past. Finally, a sense of responsibility for action adds moral fiber to the plan. Hunter education has evolved in North America into an active part of wildlife management. In fact, hunters are becoming the most formally trained of all non-organized sports enthusiasts. Few other sports encourage, and in many cases require, the time and attention formally provided to hunters. Other papers here will help to place a current perspective on hunter education. My role is to explore the future—the goals, the procedures, the attitudes—and to recommend ways to advance hunter education. If thoughts seem old, then perhaps opportunities from the past have not been fully utilized. If ideas appear new, they face the risk of being passed over until later. As I look ahead, I must conclude that hunters should strive to become more knowledgeable, skillful, and ethical. The greater their dedication and commitment to the sport, the greater will be their own enjoyment and our wildlife profession will be enhanced.

Leopold (1966) suggested that "Recreation . . . is not the outdoors, but our reaction to it. Daniel Boone's reaction depended not only on the quality of what he saw, but on the quality of the mental eye with which he saw it." Leopold's "Conservation Esthetic" suggested a progression of thought and action as hunters mature. Initially, hunters wanted a trophy or certificate to hang on the wall. Over time, they learned the capacity of isolation, perception and husbandry. Jackson and Norton (1979) suggested similar stages of behavioral change for waterfowl hunters. Kellert and Berry (1980) and Kellert and Westervelt (1981) respectively grouped human attitudes about animals into categories and reported that attitudes shift over time. In the future, progress will be made when hunters react with higher levels of behavior. Providing opportunities to accelerate the rate of behavioral shifts is the role of wildlife agencies, hunter educators, and all persons who touch the actions of hunters. To tolerate behavior that never grows up is denying recreationists the opportunity to reach their potentials and denying the opportunity in wildlife management to have hunters as responsible partners.

Basic hunter education in North America has evolved markedly through topics taught and time involved, yet offerings are still primarily knowledge-based and short-term. Effective learning and behavioral change must include knowledge, skills, and attitudes. Basic knowledge about hunting can be learned from books, but it takes time and special learning environments to develop skills and attitudes. Can the existing course continue to offer more topics, require greater time, and seek more age groups? Can they continue to expand? If so, a great burden will be placed on agencies, volunteers, and sportsmen. I predict that significant additions of time, topics, or clientele to the existing basic courses will not happen. Rather, minimum standards will be agreed upon throughout North America that will change only slightly over the years. However, advanced topics will be offered more systematically on a volunteer basis to wider audiences.

Progressing from basic courses to advanced hunter education will be a respected accomplishment, encouraged and expected among peers. If wildlife management agencies are involved in the shift, they could interact positively with a more complete cross section of their hunting publics. Or perhaps organized sportsmen's groups will take up the responsibility for advanced training, similar to programs in Europe. I predict that agencies and organizations will join forces and work together. Enthusiasm from the North American Association of Hunter Safety Coordinators (NAAHSC) suggests to me that they will help wildlife management agencies to progress and advance. The unclear part of the crystal ball is whether existing sportsmen's organizations or new organizations will be the ones to support advanced hunter education.

Basic Hunter Education Standard

Minimum standards for the basic course are informally in place and are being considered for more formal action. A state of the art report entitled *Hunter Education In The United States With Recommendations For Improvement*(Evenden et al. 1981) suggested minimum times from 9 to 11 hours to cover the list of topics outlined. The NAAHSC has established standards over the past decade for the basic course (T.O. Melius, Status Report On Minimum Standards For A Basic Hunter Education Course Developed by the International Association of Fish and Wildlife Agencies' Hunter Education Subcommittee, September 6, 1984). Melius also reported that reciprocity standards were established in 1974, and since 1977 unsuccessful attempts were made to develop a uniform manual for students. Federal Aid funds from U. S. Fish and Wildlife Service are used by 47 of 60 states and provinces for hunter education, thus the Service also promotes some degree of standardization in order to qualify for funds. Currently a committee of NAAHSC is surveying its membership to establish minimum standards for the basic hunter education course.

Need For Performance Standards

Red flag! The future looks confusing! Are standards that are based upon time and topics legitimate? I think not! Webster lists the following definitions of a standard: for comparison or judgment; qualities or attributes required by law or established by custom; uniform; widely recognized as acceptable and authoritative. A lot of "unstandard" activities can be conducted within standard times and as needed upon topical outlines. Performance is the real standard! The task ahead is to establish learning objectives within the topic list based upon a reasonable time frame expected for accomplishment. For example, it is not sufficient to say that students will learn about shooting skillfully. Rather, one must say that students will be able to demonstrate the skill of hitting a specified target with a certain accuracy at a predetermined distance during a part of the training program. Or, one might require that 8 of 10 ducks must be identified from slides during the final test in order to get a hunter safety card. The examples are not important, but being specific about accomplishment is valuable.

Clear objectives make everyone's job easier: students, instructors and administrators. Objectives, stated in terms of what students are expected to learn, should include: (1) specification of the type of learning (knowledge, skills, attitudes); (2) descriptions of observable behaviors; (3) statements of acceptable levels of performance; and (4) conditions under which performance will be measured (Davis and McCallon 1974). Instructors will have a clear mandate about how students should perform and can use their own creativity to reach the objective. Some instructors may use reading assignments to reach a standard while another instructor may use discussions or lecture. Administrators will know how to assist and evaluate the process if they have a clear picture of the ultimate objective. Decisions of reciprocity can be made from learning objectives and performance standards, but can never be clear merely from broad topics.

Overall Improvement of Basic Hunter Education

The quality of programs is improving in North America based upon existing standards. Forty of 56 states and provinces evaluated received a AAA rating (highest possible) in 1983 compared with 15 of 50 in 1981, according to a 1984 report by T. O. Melius (A Review of Trends in Hunter Education Programs 1981 to 1983 Based on International Association of Fish and Wildlife Agencies Hunter Education Program Evaluation Forms). Notable accomplishments included instructor certification (23 percent increase) and better use of teaching aids (25 percent increase). Most criteria used to evaluate programs are based upon numbers of participants and presence or absence of activities participated in by students, instructors, and administrators. The number of "hoops" to jump through are increasing, yet quality of performance within "hoops" is poorly measured. Once objectives are clearly stated for learning, teaching, and administration, then performance will be measurable.

The future looks promising for overall program enhancement. Few other disciplines are blessed with the opportunity for hands-on processes, copious literature, and excellent audio/visual aids. More aids exist than time to use them. Additionally, neither instructors nor students have taken full advantage of aids for learning and teaching.

Application of sound principles of learning and teaching should be the next step toward improving students, instructors, and overall programs. Since instructors are the ultimate orchestrators of information, my comments will center upon them. Monologues, war stories, and unprofessional approaches to teaching should be stopped. Because instructors volunteer to teach does not indicate that they should be allowed to. Instructors have interest and enthusiasm about hunting and guns that they want to share for various reasons: some honorable, some questionable. The lack of intuition and training about transferring knowledge, skills, and attitudes to learners can create problems. Good instructors may provide an atmosphere of motivation that will carry students into life-long learning. Poor instructors make hunting, wildlife departments, and hunters look bad. Recruitment, training, evaluation, and rewarding of instructors will be the challenge ahead. Once talented and trainable instructors are found, it is the current job of state wildlife agencies to train them. Excellent sources of hunting-related content exist. The ***Basic Hunter's Guide-***

published in 1982 by National Rifle Association (NRA) is the most comprehensive of the new literature. Knowing and teaching content is not enough however. Converting content into teaching strategies for learning is the goal. The *Advanced Hunter Education and Shooting Sports Responsibility* manual (Benson and Richardson 1980) provided instructors with a compendium of references, outlines for subject matter, methods of teaching hunters, and self-learning guidelines for instructors about principles of learning and teaching. A correspondence course is used in part for instructor training by Colorado Division of Wildlife and is available for other instructors through Colorado State University (Benson 1981). Instructors must be helped to turn their interest and enthusiasm into effective learning environments. It will no longer be enough to merely care; instructors will be rewarded by what they are able to share.

Styles of teaching, and therefore learning, will change. Students will learn about certain subjects through reading and other assignments outside the classroom, while class time can be used more effectively for hands-on activities and discussion. My crystal ball predicts that a self-study workbook (already used in some programs) will become popular—very similar to the books in drivers education. Tests of knowledge will be taken from information therein. Class time will be used for evaluation of skills, exploration of attitudes, and learning where subjects are most appropriately taught through interaction of instructors with students. All testing will be based upon learning objectives. And, instructors will utilize class time efficiently because they will know the most useful teaching methods to accomplish the objectives.

Advanced Hunter Education: Levels II and III

There is never time to learn everything. Hunter educators will realize that, accept minimum standards for learning, then proceed to offer more. Basic hunter education will become a primer. Its graduates will join with additional groups and age categories to enjoy hunting-related learning for a lifetime.

Expanded offerings will not have to be taught by traditional means: wildlife agency personnel and volunteer instructors. Wildlife agencies can be central in planning, while presentations can be made by outdoor writers, local experts, and persons affiliated with sportsmen's clubs, school systems, and universities. If objectives for learning are clearly established, it will be easier to locate competent instructors and to evaluate outcomes.

If existing hunter education can be termed Level I, let us call advanced programs for youth Level II. A strong national trend in 4-H shooting sports programs provides excellent opportunities for youth in Level I to move forward. 4-H provides year-long training, over several years, allowing details of knowledge, skills, and attitudes to be developed around shooting, hunting, and wildlife management. Youth may also compete in the new North American Championship Program, available through NRA, where skill of identifying animal habits and habitats ranks evenly with shooting. Persons who complete these types of programs will be better contributors to the wildlife and hunting cause if educators do their job properly. Close cooperation, coordination, and integration between Levels I and II will advance hunter education.

Hunter education opportunities have not been systematically available to adults. Currently, offerings around the country include seminars about wildlife identification, trophy estimation, field care of game, how to hunt, where to hunt, habitat improvement, survival, and more. One can never be sure if and when an opportunity for adults to learn will arise. Incentives for adults to learn are too few. The hunting fraternity has accepted that youth should learn, but it is unsure about getting adults involved. Rooms fill when state wildlife officials discuss harvest prospects for the year, but hunter responsibility seminars seldom command similar attendance. Are we still at the trophy stage of thinking, or is our approach to education incorrect?

To determine educational desires of adults, a survey of 475 out of 1,017 adult hunters responded to a questionnaire about their interests in organized training about hunting. The sample was taken from members of Colorado Wildlife Federation who are resident hunting license buyers in Colorado. It was agreed by 91.8 percent that adult hunters should have the opportunity for organized training about hunting, wildlife, and associated skills. Desirability for learning and methods preferred were reflected for 21 topics normally associated with hunting (Table 1). Most obvious conclusions drawn from the data are that topics such as field care of game, home butchering, survival, and first aid ranked highest for hands-on learning programs. Respondents preferred most to read about wildlife management, habits and habitats of animals, cooking wild meats, and hunting laws and regulations. Existing opportunities for learning ranked low for all subjects. Some hunters indicated that they knew enough about using firearms (43.6 percent). And 47.2 percent and 44.2 percent respectively indicated that they were not interested in learning about hunting with archery equipment or muzzleloaders. Educators can interpret the results in many ways. Undoubtedly, hands-on seminars about field care and butchering should draw a larger crowd than one about hunting regulations. But, to say that there would not be enough interest in archery or muzzleloading to merit a training session would be a mistake. One would have to target communications to those segments of the hunting public. Of the 21 topics presented, 16 were desirable for learning in some form by more than 75 percent of the respondents.

With this type of educational marketing analysis in hand, educators can organize various media and cooperators to provide delivery systems for adults. With educational aids such as the advanced hunger education manual (Benson and Richardson 1980); the *Basic Hunter's Guide* from NRA; *The Complete Book of Hunting* (Elman 1980); and publications available locally through hunter education, wildlife agencies, and Extension Service (Ruff 1982), any aspiring educator or administrator should have a library with more ideas for educating adults than time allows.

Through Colorado State University, we have offered several opportunities for adults. We developed some success with wildlife fairs associated with local county fairs. The goal was to make spectators aware of learning opportunities about wildlife and the environment. They could participate in elk and turkey calling contest, see wildlife trapping equipment, watch as a big game carcass was field dressed, shoot bows and rifles, see various dog breeds in action, and other topics. In the Fishery and Wildlife Biology Department, we teach a 100-hour instructor training course in advanced hunter education. Our goal is to graduate future professionals who appreciate the role of trained sportsmen in the wildlife profession. We conduct seminars and short courses about hunting, trapping, and wildlife management as part of our extension and continuing education program.

Around North America one finds many programs that benefit adults: Operation Respect, S.P.O.R.T., Minnesota's Adult Hunter Education, NRA's Hunting Semi-

Table 1. Interest in subjects normally associated with hunting and media of learning desired by a sample of 475 adult hunters in Colorado.

	No response	Hands on	Read	Opportunities exist	Know enough	Not interested
Field safety	2.7%	20.4%	29.3%	13.7%	31.6%	2.3%
Home safety	2.9%	12.6%	34.1%	13.1%	34.5%	2.7%
Sportsmanship	3.2%	15.8%	37.5%	10.9%	30.5%	2.1%
Wildlife management	2.7%	29.9%	49.5%	9.1%	6.5%	2.3%
Field care & handling of game	2.1%	39.4%	27.4%	5.5%	24.0%	1.7%
Home butchering techniques	2.3%	42.7%	26.9%	4.8%	16.6%	6.5%
Survival	3.4%	36.4%	33.5%	10.5%	14.9%	1.3%
First aid	4.8%	37.3%	22.7%	16.8%	17.7%	0.6%
Principles of using firearms	4.0%	18.7%	16.8%	14.7%	43.6%	2.1%
Animal identification	2.7%	15.2%	28.0%	11.6%	40.2%	2.1%
Habits & habitats of animals	2.9%	24.8%	50.1%	8.6%	11.6%	1.9%
How to hunt big game	2.9%	24.0%	34.1%	11.6%	25.9%	1.5%
How to hunt small game	3.8%	15.2%	31.2%	13.1%	28.4%	8.4%
How to hunt waterfowl	3.8%	17.1%	29.9%	11.8%	17.7%	19.8%
How to hunt predators	3.6%	19.4%	34.5%	10.9%	13.7%	17.9%
Hunting with archery equipment	4.8%	16.4%	15.2%	10.3%	6.1%	47.2%
Cooking wild meats	2.7%	23.6%	45.1%	10.5%	13.9%	4.2%
Hunting laws & regulations	3.8%	10.9%	46.7%	17.3%	19.8%	1.5%
Nonhunter & antihunter concerns	4.4%	15.8%	40.4%	12.0%	7.4%	20.0%
Hunting with muzzleloaders	3.2%	17.7%	16.8%	10.5%	7.6%	44.2%
Map reading & outdoor skills	3.2%	31.4%	28.8%	9.5%	22.1%	5.1%

nars, and seminars and workshops sponsored by wildlife agencies, Extension service, wildlife clubs, and individuals. Surprisingly, no working effort has caught on continent-wide where adults are given a systematic opportunity to learn about their sport. Attempts to form a national advanced hunter education council began in 1978, with heads of national conservation organizations present for several meetings. The concept never materialized. Recently, Izaak Walton League has become a clearinghouse for outdoor ethics activities. One soon learns that ethical complaints are not leveled at youth, but at adults, so our meager attempts at education should not go in vain.

My crystal ball provides a hazy, yet distinct vision that adults will be trained more in the future. They will request it, and wildlife managers will see the value of targeting messages in a planned manner to their clients. I see the earth becoming more populated, wild land resources diminishing, and demands for what is left in conflict. Pressures to manage animals, habitat, and hunters more closely will require more learned sportsmen. Sportsmen will turn in increasing numbers to hunting on private land where they have more control over other hunters and their quarry. They and landowners will manage private lands more intensively; thus new knowledge, skills, and attitudes will be required. Level III hunters will have come through Level I and perhaps Level II. Their needs will be different from youth, but their desires for learning will have been sparked, not diminished.

Conclusion

If Leopold was right that one's reaction to the outdoors is the important component of recreation, then hunter educators need to decide what reactions or learning objectives are acceptable. They then can develop training strategies to promote acceptable behavior. Basic, Level I programs can only progress to a certain minimum level and still maintain needed continuity among states and provinces. Level II programs for youth can follow to provide longer-term practice and reinforcement of knowledge, skills and attitudes. Traditional hunter educators such as state wildlife agencies and their volunteers, 4-H, or other groups will carry on with intensive training for youth in Level II. Level III training is valuable for adults because they need the training, want to learn, and are the target of criticism. As North America becomes more populated with conflicting demands on wild land resources, wildlife management will become more complicated and hunters will become more dedicated. To survive, they will participate more in management and many will assume partnership roles as managers on private lands and volunteer workers on public lands. For this, they will need education.

The role of hunter educators will be to provide opportunities for learning that meets the needs and desires of their clientele. Educators will agree upon objectives for learning that are clearly stated. Success will be evaluated by hunters' performance in the educational process and ultimately by their behavior in the field.

Literature Cited

Benson, D. E. 1981. Hunter education for instructors. Division of Continuing Education, Colorado State University, Fort Collins. 54 pp.

Benson, D. E., and R. E. Richardson. 1980. Advanced hunter education and shooting sports responsibility. National Wildlife Federation, Washington, DC. 286 pp.

Davis, L. N., and E. McCallon. 1974. Planning, conducting and evaluating workshops. Learning Concepts, Austin, Texas. 310 pp.
Elman, R., ed. 1980. The complete book of hunting. Abbeville Press, Inc., New York. 320 pp.
Evenden, F. G., G. B. Boyd, and R. G. Nelson. 1981. Hunter education in the United States and Canada with recommendations for improvement. International Assoc. of Fish and Wildl. Agencies and U. S. Fish and Wildlife Service, Washington, DC. 51 pp. plus appendixes.
Jackson, R., and R. Norton. 1979. Improving ethical behavior in hunters. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44:306-318.
Kellert, S. R., and J. K. Berry. 1980. Knowledge, affection and basic attitudes toward animals in American society. Phase III. U. S. Department of Interior, Fish and Wildlife Service, U. S. Government Printing Office, Washington, DC. 162 pp.
Kellert, S. R., and M. O. Westervelt. 1981. Trends in animal use and perception in twentieth century America. Phase IV. U. S. Department of the Interior, Fish and Wildlife Service, U. S. Government Printing Office, Washington, DC. 166 pp.
Leopold, A. 1966. A Sand County almanac and sketches here and there. Oxford University Press, New York. 269 pp.
Ruff, R. L. 1982. A bibliography of Cooperative Extension Service literature on wildlife, fish, and forest resources. Dept. of Wildl. Ecol., Coop. Ext. Progrm., Univ. of Wisconsin, Madison. 42 pp.

Ethics For All Outdoor Recreationists

Jack Lorenz
Izaak Walton League of America
Arlington, Virginia 22209

In his call for this 50th North American Wildlife and Natural Resources Conference on page 3 of our program, former Secretary of Interior William Clark said two things that struck me as being of particular importance: "We must re-emphasize our resolve to conserve the soil, water, plants, wildlife, fish and other resources" and "continued progress will require new alliances and more effective teamwork at all levels, public and private."

Judge Clark also urged us to "make this 1985 Conference a milestone in our country's history." I agree with each of the Secretary's points and see them as much more than the *pro forma* observations one is expected to offer on such occasions.

I find Judge Clark's words especially helpful in examining the importance of outdoor "ethics" to the future of outdoor recreation.

But in order to put recreation's future in proper perspective, we should first take a brief look back to see where we've been. The market hunters of the late 1800s and early 1900s were among the first to catch the heat of the pens and evangelistic oratory of America's early conservationists, outdoor communicators and astute politicians. Some of the toughest language was delivered in the 1920s by men like Zane Grey, who became so distraught over some of the abuses he saw and learned of that in 1922 he wrote in a front-page editorial in the Izaak Walton League national magazine:

> If honest and direct appeal fails to win thoughtless and ignorant hunters and fishermen to our cause then they must be scorned and flayed and ostracised until they are ashamed of their selfishness. No such appeal, however, can touch the heart of the hardened automobiling sportsmen or the harpooning anglers or the fakirs and would-bes who want to see their pictures and names in newspapers and magazines.
>
> Naturalists and biologists and true lovers of nature either despise or disapprove of sportsmen. There is justice in this. Something is wrong. Our heritage of outdoor pursuits is certainly a noble and splendid thing. Manly endeavor and toil and endurance makes for the progress of the race. Nature abhors weaklings. And red-blooded pursuits operate against the appalling degeneracy of modern days. Nevertheless sportsmen, as a mass, are hypocrites, *and are blind to the hand-writing on the wall.*

Stirring words, those, and they carried across the land. The Roaring 20s were a flamboyant time and flamboyant words were what the public wanted to hear. Grey and his fellow Waltonians delighted in the fervent pledges of support they received and an entire army of sportsmen rose up ready to purge the "fish and game hog" from their ranks.

In the 1930s the great J. N. "Ding" Darling carried the banner of true sportsmanship through his hard-hitting editorial cartoons. Darling lambasted both greedy hunters and fishers and those who dared drain a productive wetland or plow under all protective cover for a few more rows of corn.

In the 1940s the simple yet straightforward messages of Grey and Darling and their followers hit home and garnered support because American citizens were still fairly close to the land. If they didn't actually till the soil, they probably planted victory gardens and raised a few chickens in the back yards of their new city homes.

After the war more and more people flocked to the cities and grew further and further away from the resources to which they now drove instead of walked. And because they could get further faster, all types of fledgling recreational activities such as backpacking, wilderness canoeing and camping, and mountain skiing increased in popularity.

It was at this time that America missed a great opportunity. In 1949 a little book of essays was published that, if listened to and heeded, would have lessened if not eliminated the need for a modern outdoor ethics movement.

In *A Sand County Almanac*, published in 1949, Aldo Leopold warned us and gave us the answers we only recently came to realize were the proper recipe for preserving the rich outdoor recreation heritage that is ours to protect. Listen to these words from the essay, "Round River":

> The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little is known about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Leopold was telling us that the secret to harmony between men and land is understanding—in the fullest sense of that word. What comes from harmony? Respect. And it's difficult to abuse something you respect.

Again listen to Leopold, this time from his essay, "Natural History," 20 pages deeper into *Sand County*:

> We shall never achieve harmony with land, any more than we shall achieve absolute justice or liberty for people. In these higher aspirations the important thing is not to achieve, but to strive. . . .
>
> When we say 'striving,' we admit at the outset that the thing we need must grow from within. No striving for an idea was ever injected wholly from without.
>
> The problem, then, is how to bring about a striving for harmony with land among a people many of whom have forgotten there is any such thing as land, among whom education and culture have become almost synonymous with landlessness. This is the problem of 'conservation education.'

Now Leopold and Judge Clark are beginning to talk to one another. But let's go on a little further in the *Almanac*. Just two pages deeper, Leopold removes any remaining mystery out of what he is saying:

> . . . there is value in any experience that exercises those ethical restraints collectively called 'sportsmanship.' Our tools for the pursuit of wildlife improve faster than we do, and sportsmanship is a voluntary limitation in the use of these armaments. It is aimed to augment the role of skill and shrink the role of gadgets in the pursuit of wild things.

> A peculiar virtue in wildlife ethics is that the hunter ordinarily has no gallery to applaud or disapprove of his conduct. Whatever his acts, they are dictated by his own conscience, rather than by a mob of onlookers. It is difficult to exaggerate the importance of this fact.
>
> Voluntary adherence to an ethical code elevates the self-respect of the sportsman, but it should not be forgotten that voluntary disregard of the code degenerates and depraves him.

Leopold was really getting into it in that essay, telling us what we had to do to make sure that we preserved our most valued and most necessary outdoor traditions. But he drives the point home once again near the end of "Goose Music" where he says:

> . . . the ethics of sportsmanship is not a fixed code, but must be formulated and practiced by the individual, with no referee but the Almighty. The other is that hunting generally involves the handling of dogs and horses, and the lack of this experience is one of the most serious defects of our gasoline-driven civilization.

The fact that millions of Americans don't understand that is not a tragedy. The real tragedy is that we don't appreciate the need to communicate that truth to new generations. It is not passed along by osmosis. It is communicated through hands-on experience and enlightened innovative conservation education techniques.

We go forth day in and day out telling our outdoor recreationist brethren, whether they be deer hunters, bass fishermen or 500 species life-listed birdwatchers, that certain things they do are to be avoided. We're making a little progress, we see an increased level of involvement in peer group pressure and even a few *mea culpas* once in a while, but what are we really doing to instill ecological awareness in people before they reach the age when remedial action is the best we can hope for?

Judge Clark said we should try to make this Conference a milestone in our country's history. He said we should work together to do it.

That's the *only* way it will be done, and by "together," I mean all of the 150,000,000 outdoor users, not just those of us who hunt or fish. If I've learned anything about outdoor ethics in the past eight years of wrestling with it every day of the week, it's that an uneducated, unappreciative resource-abusing camper, hiker or boater is just as responsible when he or she does something dumb in the outdoors as any rod-wielding angler or gun-toting hunter.

Ethical behavior flows from respect and understanding. I'm not sure of all the elements, all the tools we need to do this job, but we have the best minds in America at this golden anniversary North American and we should begin here.

In October, Bud Eyman and the folks in Missouri are giving me a special opportunity to follow both Aldo Leopold's and Secretary Clark's advice. I've been assigned a five-hour stint on ethics at their eagerly awaited National Outdoor Education Conference. I may simply have them all read *A Sand Country Almanac* clear through. There are certainly less effective educational techniques around.

Our own ethics program at the League will be adjusted in the coming weeks and months to do two things: Appeal to and involve more young people, and do so in unison with other groups that care about the quality of outdoor recreation.

It is only appropriate that I let Leopold close this paper for me. And the last sentence of *A Sand County Almanac* seems most fitting here as well: "Recreational development is a job not of building roads into lovely country, but of building receptivity into the still unlovely human mind."

Missouri's Outdoor Recreation Skills Program: Hunter Education And More

Cheryl K. Riley
Missouri Department of Conservation
P.O.Box 180, Jefferson City, MO 65102

Introduction

One thing we can all count on — besides paying taxes and dying — is that the world is changing. We can be excited about change and take part in it, or we can throw up our defenses and be left behind.

Outdoor Recreation Skills and Education is a product of our changing times, of our changing recreational interests, and, in some cases, changing goals for our agencies.

As we look to what changes we can and should be making, a key word to keep in mind is *cooperation*. In 1930, Aldo Leopold (1930:287) wrote in his "Report to the American Game Conference on an American Game Policy"

> The public, not the sportsman, owns the game.
>
> The public is (and the sportsman ought to be) just as much interested in conserving non-game species, forests, fish, and other wild life as in conserving game.
>
> In the long run lop-sided programs dealing with game only, songbirds only, forests only, or fish only, will fail because they cost too much, use up too much energy in friction, and lack sufficient volume of support.
>
> No game program can command the good will or funds necessary to success, without harmonious co-operation between sportsmen and other conservationists.

We have a unique opportunity, through outdoor recreation skills programming, to bring together a variety of outdoor users and to assert some influence over the attitudes of young people

The Importance of Education

Before I launch into specifics, let me briefly point out why education is so important to our agencies. When I say "education," I'm not talking about an expanded information program. I'm talking about a well-planned, staffed and funded approach to reach and teach all ages through formal and informal systems. I'm talking about well-defined goals and objectives that are implemented in ways that allow us to measure what is learned. We don't want our audience to go away with just a good feeling about our message. We want to impart knowledge, teach skills, affect attitudes, and modify behavior through actual involvement.

In some of his writings, Leopold expressed his concern that people looked too much to their own economic self-interest when it came to the land, wildlife and other natural resources(Leopold 1949:207). Outdoor education offers us a chance to change this perspective by capturing curious youthful minds and instilling a caring for the outdoors that evolves from personal experiences. Why not teach people how to use the outdoors, how to take advantage of what it offers recreationally? Reverence and respect are hard to teach. They must follow from seeing, doing and understanding by becoming involved. We cannot expect the voters of tomorrow to support conservation measures if they are not active users of our natural resources.

Hunter Education and More

As I talk about hunter education and more, I am going to use Missouri's outdoor skills education program as an example since it is one approach that has proven successful.

Hunter education has been the traditional venture beyond the schoolhouse gate for most wildlife agencies. In Missouri, we conducted our first class in 1958. Although hunter education has continued to be an important program, fortunately, it was not our only educational venture. As early as 1937, a conservation education program was introduced to Missouri youth. We think that almost 40 years of conservation education programs helped create a citizenry that voted in 1976 to impose on itself a one-eighth of 1 percent sales tax for conservation programs. Since then, cooperation has been especially important because *all* Missourians contribute to the Department, not just hunters and fishermen.

With increased revenue from the sales tax to expand programs, forward thinking people, unafraid of change, realized that hunter education was only a first step in teaching how to use the outdoors responsibly. The hunter education unit was renamed outdoor skills education and field staff hired to help implement an expanded program.

To develop a comprehensive plan, we brought together the people who were interested in teaching outdoor education — school teachers, college professors, camp leaders, scouting and 4-H organizers. These people contributed ideas and teaching outlines and brainstormed ways to provide materials and training. From their suggestions and expressed needs, we devised our game plan.

Subject areas were divided into various series-outdoor living skills, shooting skills, casting and angling skills, archery skills, historic skills, and aquatics skills. Curriculum modules, or instructor manuals, were proposed for each series. For example, in the outdoor living skills series, we have modules on basic principles, backpacking, backpack cookery, map and compass, campground cookery, emergency preparedness, and nature photography. The shooting skills series includes firearms safety, hunter education, rifle, pistol, and shotgun.

Modules are written by appropriate Department personnel or contracted to other experts outside the Department. Included in each module are content material on the subject, detailed lesson plans, goals and objectives, a glossary and bibliography, and any other information that would be helpful in teaching the subject. We make sure that ethics and safety are covered for each subject. While the materials have been developed with the classroom teacher in mind, they can be easily adapted for other groups.

Remember, too, that materials will be used more often and more effectively if instructors are trained to teach the subject. This is especially true in outdoor skills where safety is an important factor. It's important to have well-trained leaders teaching shooting sports and archery or taking a group on a backpacking trip into the wilderness.

In Missouri we have found workshops to be a good way to train teachers. Undergraduate and graduate credit are offered for most of our workshops. Week-ends and summers seem to be a good time for teachers and youth leaders to take advantage of leadership training. You will better use your staff if you train teachers, youth leaders, and volunteers, then let them work with youth. Be wary of getting caught up with student programs or training. You can never meet the demand and you miss out on the important chance to incorporate outdoor education or recreation classes into the regular school curriculum. Rather than spend a day demonstrating how to cast a rod and reel to all eighth grade classes in a school, train the teachers and encourage them to teach a week-long basic fishing class that also covers fish habitat, water pollution, fisheries management, fishing ethics, ***and*** how to bait a hook, cast, retrieve, and even clean and cook the fish. This way, science, physical education, and even home economics classes take part. The more adaptable your program, the more inclined administrators will be to use it.

Teaching materials and in-service training are important budget considerations for an outdoor skills program. You should also consider budgeting for some equipment. A school principal may not be receptive to purchasing guns, bows and arrows, rods and reels, or other equipment until he or she has seen the benefits of these programs. In Missouri's program, we try to furnish basic equipment for the first year or two of a program, then let teachers and administrators know the best sources to obtain their own. We also budget for films and slide shows to be used when teaching many of the subjects.

What I have just described to you is the heart of Missouri's program and can be adapted by any state wanting to expand their hunter education program. Our materials are available and can be reprinted.

Let me give you a few more ideas that have also worked well for us. Our education section has helped fund and build outdoor classrooms and ranges throughout the state. Mr. Glaser will give more specific information on this. By contributing expertise and some funding, we have provided areas for teaching the subjects we want taught. Ranges, particularly, have also earned us public relations points because they are used by the public. Not wanting to ignore our still loyal constituency of sportsmen, we have offered seminars in deer and turkey hunting and trapper education. Our outdoor skills education specialists get involved with national hunting and fishing day activities, wildlife week programs, and other special events. Most recently, they have been working with an expanded fishing, or aquatic education, program. We see a rich potential, especially now with the expansion of Dingell-Johnson by the Wallop-Breaux Bill, to develop an aquatic education program that is as successful as our hunter education program has been.

Conclusion

I can't stress enough that we have a waiting and ready market of outdoor users. With more leisure time and expendable income, people are going to get outdoors. They may or may not choose to hunt and fish, but we have an opportunity to influence how they use their leisure time. Perhaps even more important is the responsibility we have to service the activities we license. We are in the business of managing for the recreational use of our natural resources.

Let us not become complacent and unwilling to change what we think is a good thing. We should not be afraid of the challenge to expand our hunting and fishing fraternity to include other outdoor users. To do so will give us additional political and perhaps financial support. It's a matter of priority, not dollars. We are also insuring that youth receive the facts and the message we want them to have. The future of the outdoors, and our recreational interests, is going to depend on all of us pulling together. It has to be a cooperative effort.

Literature Cited

Leopold, A. 1930. Report to the American game conference on an American game policy. Trans. Amer. Game Conf. 17:284-309.

______.1949. A Sand County almanac. Oxford University Press, New York.226 pp.

Funding Outdoor Skills Programming: How to Pay the Tab for Hunter Education and More

Edwin H. Glaser
Missouri Department of Conservation
P.O. Box 180, Jefferson City, MO 65102

Each of us has our thing—our avocation or first love. For those here it is often the great out-of-doors or the things associated with that realm. Others not so fortunate have not had the opportunity to discover the natural world or to develop the skills to know how to use and enjoy it. For those of us who are blessed and possess that love, we will find the time to do the things in which we are interested and will allocate the necessary resources.

It seems that one mission of the conservation organizations is to make the best of nature available—no, not just available—but well known to all citizens. This is where an outdoor skills education program fits—not only in the small towns or the big cities, but wherever there are people. Translated, here at the North American, this breaks down to 50 states in the United States, the provinces in Canada, and the state in Mexico having a need to accomplish these things to best serve their citizenry.

Let me offer from a conservation agency administrator's viewpoint what I perceive to be the need and to identify some pitfalls. Perhaps the biggest problem is to find an answer to financing such a program.

In its most simple form a resource administrator's role should be to establish a program, assure its continuity, and operate it effectively with a minimum of problems. Establishing a program denotes an administrative commitment to a plan and to seeing it carried out. This involves allocation of resources, perhaps the most readily recognized being funds, but possibly as important is authorizing some of the always too few personnel slots to the program. I have a feeling that often the latter is more of a problem that the former. Finding bodies to run a new or expanded program when there are constant pressures for more management, more law enforcement, or more development isn't easy. Rule one is to be aware that an outdoor skills program will not run itself. Someone must be at the helm.

Know, too, that funding for an outdoor skills program does not all need to be direct. Often the most effective programs are those well integrated within the sponsoring organization and well coordinated with outside interests. Not only the staff assigned directly to the outdoor skills program should serve to make it go, but also your foresters, biologists, administrators, conservation agents, engineers, and even the secretary. We have found these individuals to be willing and able. All they need is motivation to contribute their talents.

The motivator or program coordinator will assure that within the unit programs, whether it be fisheries, forestry, wildlife, or parks, there will be room found for and priority placed on outdoor skills. Simply stated, it's the team concept. The effectiveness of a team, a complete conservation agency or an organization, can only be measured by the sum total of the well directed effort of all team members. So too, will the effectiveness, the productivity of the outdoor skills program, be measured by how many have put how much into it and what is the total score at the end of the time period.

What are we talking about in the way of funds? Let me use for example, our Missouri program. To measure directly, there are ten slots—one outdoor skills coordinator, an assistant who produces training materials, and eight outdoor skills specialists in the Missouri Department of Conservation. These positions are among almost 1,400 full time equivalents, of which 1,000 are permanent personnel. The multiple effect of the many Department employees contributing to an outdoor skills program is tremendous.

From a dollar standpoint, the direct allocation of Department funds to outdoor skills approximates $456,000 in the current fiscal year.

In speaking here, I assume each of you in the public sector is aware of the sources of funding available, whether they be of private, local, state or federal origin. You have a choice of going with conventional sources or of branching out. Probably the best way—but not necessarily the smartest—to accomplish a truly outstanding new outdoor skills program would be to work for the 'big bundle' of outside or new financing, with a *commitment* to serve all interests. I emphasize the word "commitment" to stress service to more than just the hunters and fishermen. That, I feel, is a fatal mistake often repeated. When Missouri achieved the sales tax funding it was a large new source. Administratively the Department had pledged to *all* the people that if the funding came about, *all* should be served.

State general revenue funds are often viewed as the most available for program use. For me though, it is easy to remember that they who giveth can also taketh away. When deciding to compete for general revenue funds, you are deciding to play in the big leagues with education, social services, highways, prisons, and other programs—all worthwhile and often with a motherhood connotation. In my book, this is not a good horse to tie your total program to: however, it is an excellent source for program enhancement.

In preparing for this I thought back to my years as a Boy Scout leader, particularly as related to outdoor skills education. I remember the many years of Monday night meetings which were at some point always devoted to getting ready for the monthly campout. I recall the summer camps, Philmont Scout Ranch, national jamborees, canoe trips, hikes, compass courses, and fishing expeditions. I remember cookouts, campouts, rope work, packing, trail hikes, and what have you. It wasn't uncommon to have 40+ young people on the expeditions, or to have 50 or 60 youngsters at a meeting along with the associated adult help in the form of Assistant Scout Masters. The Monday night meetings were essentially outdoor skills training sessions. The goal was to give both the young scouts and their adult leaders sufficient background to have an enjoyable outdoor experience.

I wonder just how many outdoor skills benefits we could buy with a modest investment in the Boy Scouts, in the Girl Scouts, in the Future Farmers of America, or in the Campfire Girls? Is it possible that the time spent by people active in these organizations or the time that people like you as a volunteer spend is perhaps the most productive ever? There must be many professional staff and volunteers serving such organizations who could, with a small investment by your department or mine, in materials, counselling, or coaching, help us make great strides in outdoor skills education.

Or better yet, what can we accomplish in the schools with some seed material—the paper, the initial training, or the follow up? You talk about a multiplier! That's certainly to be found there. Last year our Fisheries Division piloted a program cooperatively with the outdoor skills people. It was basically "Kids Fishing"—a pilot program in eight schools. The highlight was an actual fishing trip, an outing—the first for many of the kids. The classwork involved the basics—fish identification, fishing ethics, water pollution, fish habitat. Youngsters learned to use a stringer, to properly tie a hook to a line, to hook the line to the pole, to string a worm and how to use it. They even got to see fish cleaned and to eat them.

Here was a tremendously popular program incorporated into the school system and carried out with the cooperation of some local park agencies. I suspect the actual "fishing" phase could be accomplished with the cooperation of your fisheries people through special stockings in public or private lakes or ponds.

Our outdoor skills program is also carried out at a higher level through cooperative agreements with universities and junior colleges. Basically, the program involves cost sharing with an institution on facilities. Then their primary responsibility is to conduct the program. For what may seem to be a sizeable initial investment, the rewards are minimal involvement for the agency in carrying out the program. If there is an outdoor skills facility—for instance, a shooting range—the primary question is "can the public use the facilities provided?" It is imperative that the legal documents—contract, memorandum of understanding, etc.—reflect the conditions for public use. Our department has found such agreements to be quite useful. For instance, at Missouri Western College our initial investment in the facility was around $18,000 in a skeet/trap overlay and an outdoor classroom. Documented organized use alone at the facility this past year was 368 hours, of which 222 were by the general public, with the remainder being intramurals, continuing education, children lifetime sports, physical education classes, and group rentals.

The Department has entered into a 15-year renewable agreement with Pemiscot County to construct a range which it will operate and maintain. Use will be not only for training those involved in law enforcement, but also by the public. There, on a 50-50 cost share, for an investment of up to $40,000, we will gain a 20-point rifle range and a trap/skeet facility where needed.

Our Department also has a recent agreement with Mineral Area Junior College in east central Missouri for trap and skeet ranges and associated facilities, with an expenditure of up to $50,000 in Department funds.

Under development is a similar agreement with the St. Louis County Parks and Recreation Department. Total value might be $350,000, with our investment about $125,000. Use your authority to cooperate with other public agencies to achieve program goals.

Continue to seek the help of others. For example, although management rather than outdoor skills oriented, our Wildlife Division operates two demonstration farms—one in northwest Missouri and one in southwest Missouri. The Wildlife Division has enlisted the support, not only of other Conservation Department personnel, but of the Soil Conservation Service, University of Missouri Extension Service, and others in developing plans for managing these farms and using them for demonstration purposes. The same scheme should work in outdoor skills programs. Enlist other agencies and interests, then when your activities come to fruition, whether at a training session, or a special tour to show accomplishments, the group, whether governmental, sportsmen's club, or of an educational persuasion, can be of great service and also be given appropriate recognition.

Be aware, however, that there can be problems. We entered into an agreement with St. Francois County to develop a stream access on a river in east central Missouri. Our contribution was a minimal $2,600, with the county to police, operate, and maintain the area. In just a few months after the facility became operational in early 1984, there were public use problems; then the county wanted us to take over area operation. This we refused to do because, based on the agreement entered into at the county's request, operation and maintenance was a local responsibility.

Such problems will arise. The success secret is follow-up with the sponsoring organization, whether it be a sheriff's department, a county, or a junior college, especially to assure that the facility is being maintained and is available to the public as the agreement specified.

No doubt you have contemplated the joys of using federal funds in developing and operating such programs. This is fine, but always be aware of the associated pitfalls, A bit removed from outdoor skills, but equally as applicable, is an agreement we entered into with what was then the Bureau of Outdoor Recreation. We accepted limited funds to develop a stream access on a south central Missouri river. This boat launching area was developed and successfully operated for many years. During this period the Corps of Engineers constructed a major reservoir several miles upstream which, among other purposes, serves to run a hydropower operation. The large discharges down the river have created many problems at the access area, including erosion and siltation. For the user the problem is launching a boat in a relatively high velocity, high volume stream during power generation.

Because federal funds were used, you can't imagine our problems in trying to abandon a site we consider no longer useable for outdoor recreation purposes. Federal funds, whatever their source, will have strings attached. Sometimes utilizing small amounts of federal funds on a project is not worth the future management headaches.

Some of our other low budget type operations, in what I view as the outdoor skills area, are special events such as Prairie Day, Day on the River, Day in the Forest, and Eagle Day. Here, using volunteers from the Department, other agencies, and the private sector, anywhere from a hundred or so to hundreds are educated in the ways and skills of the out-of-doors. These are cooperative events which actually help train both the volunteer and the participant.

In conclusion, when thinking of an outdoor skills program, look outside the proverbial nine dots. Successful programs neither need to be wholly department-run, nor big and flamboyant. High level funding is not necessary. There must, however, be someone at the program helm with a plan; administration must permit it to get off the ground and assure its continuity. Remember always the fruitful fields of volunteers and agreements.

I am pleased to have had this opportunity to express a personal perception of an outdoor skills program from an administrator's standpoint.

The Role of Volunteers in Training Programs

Gerard J. Kennedy
The National Rifle Association of America
Washington, DC 20036

Introduction

I'll bet most of us in this room have had the experience of trying to recruit a volunteer to help with an activity. But let's try an experiment. Raise your hands if you've tried to recruit a volunteer. Now keep them raised if you got a "yes" answer the first time you asked. Quite a difference, isn't there? Even though volunteerism is synonymous with our American way of life, the techniques of recruiting and utilizing volunteers require practice. After all, we're asking an individual to take some of his or her leisure time and give it to someone else. And the results of these efforts may be pretty intangible. The volunteer won't get a paycheck, and doesn't even know whether he'll be successful or appreciated. But with a little planning, volunteers can easily become an important part of hunter and outdoor education training programs. To begin, lets examine the benefits of involving volunteers, then review some of the proven techniques which can be used to recruit the right volunteer for the right job.

Benefits of Involving Volunteers

The most obvious benefit of involving volunteers in hunter education training programs is financial. After all, volunteers can do jobs that would otherwise require additional paid staff. However, while this premise is accurate, the cost of staff time to recruit, train, and supervise volunteers must be considered. After all, volunteers can't just be turned loose without staff support. Also, depending on the task assigned, volunteers and the agency should be insured against liability claims. But with proper planning, volunteers can perform many tasks which otherwise need to be completed by paid staff.

Examples of volunteer involvement in various youth and civic service programs abound. Scouting, 4-H, the Jaycees, and Rotary are but a few. Almost every social and fraternal organization, including local sportsmens clubs, successfully operate without any paid staff. With so much volunteer involvement in the private sector, it's surprising that volunteers aren't used more extensively in local, county, and statewide governmental agency programs. After all, with proper training and supervision, one staff member can easily coordinate dozens of volunteers. In addition, volunteers can bring enthusiasm and vitality to programs beyond that normally provided by paid staff. And perhaps most important, encouraging volunteers to participate in hunter education programs gives sportsmen an additional way to become involved in agency activities. These sportsmen-volunteers can easily become advocates for the increased funding of hunting programs. Now let's look at the techniques for successfully recruiting and utilizing volunteers.

Recruiting and Utilizing Volunteers

The basics of recruiting the right individual to perform a specific task can be divided into three stages. Those things which are done prior to making contact with the prospective volunteer are termed *pre-recruitment.* Those things which are done after contact has been made and the prospect recruited are called, appropriately enough, *post-recruitment.* Finally, after the task is completed, there are activities which can be termed *follow-up.* Each of these stages is of equal importance to obtaining success in working with and through volunteers.

Pre-Recruitment

The first step in pre-recruitment is called *job assessment.* Essentially, once the position which needs to be filled is identified, a job description must be developed. This document includes a detailed definition of the job, specifies the background and skills required, and includes a description of how the job is to be accomplished. Initially, job descriptions can be prepared with the assistance of individuals who have held the position previously and performed effectively. Volunteers can also be asked to review job descriptions at the close of a term or task, and make suggestions for changes or improvements. This will keep the description current and reflective of any changes in the task(s) described. It goes without saying that a good job description will help the recruiter avoid the pitfall of selecting a person with only some of the skills required. Moreover, it will also allow the prospect to make a decision based on the total job, thereby reducing the opportunity for misunderstanding, and contributing to the successful completion of the task.

The second step is *prospecting.* While this isn't done with a burro and pick ax, in a very real sense this step helps identify the "gold nuggets" of talent, ability, and willingness to serve. Prospecting can be a continuous process, or it can be done once, near the beginning of the program year. Whichever method is used, prospecting consists of gathering and classifying information about people who may be interested in hunting and hunter education, or who could be persuaded to assist in some manner. Lists of hunter safety instructors and NRA certified instructors are a likely place to start. When the opportunity presents itself, the use of a questionnaire or data card is a good way to collect information about the interests, training, skills, and experience of potential prospects. Often individuals who help in one successful volunteer activity may be willing to try another challenge. Don't fail to overlook clubs which put on major hunting and fishing or sighting-in-day activities, staff members at hunter education championships, graduates and parents of training programs, and senior citizens who would like to "invest" in the future.

The third step in pre-recruitment is *matching and selection.* This is the process of comparing individual background information to the job description. Whether done by an individual or a group, the objective is to select an individual whose background most closely resembles the demands of the job description. This isn't always as easy as it seems, so it may help to rank prime candidates in terms of "fit." This step is often very subjective, so the use of a "selection committee" can also be helpful.

The next logical step is to *recruit* the top prospect. Work to achieve a good match between the recruiter and prospect. The recruiter must be thoroughly familiar with the job for which the prospect is being recruited, should command the respect of the prospect, and should in every sense be a fitting representative of the hunter education program. Whether a staff member or a successful volunteer related to the program, the recruiter must have visible enthusiasm and a commitment to achieving the goals of the program.

Recruiting can be done by individuals or small groups. An appointment should be made to meet with the prospect at his or her convenience. This helps to assure an uninterrupted discussion and conveys to the prospect that the recruiter is considerate of his time. It also subtly signals the importance of the discussion. Ideally, the recruitment committee for a major volunteer should consist of two or three people, one of whom knows the prospect personally. It is difficult for a prospect to turn down a sincere group of people who explain that he is the number one choice to do an important job. During the meeting, the prospect should be given a copy of the job description and told why he or she was selected for the particular responsibility. It is imperative that the prospect understand the importance of the task and the special contribution he can make. After adequate discussion and an opportunity for the prospect to ask questions, he should be asked directly whether or not he is willing to accept the position. This last step is important, since the recruiter needs to know whether the prospect is actually willing to do the job.

Post-Recruitment

Once the prospect has accepted the position, the next steps are *orientation and training*. The orientation session may be conducted on a one-on-one basis, but it might include interaction with other volunteers working on the same or similar projects. It will usually include a fuller discussion of the job description, details of the task to be performed, reporting relationships, and other basic considerations. The orientation session should be conducted as soon as possible following recruitment and must be part of the overall plan to motivate the volunteer. During the orientation phase, the volunteer should be given appropriate written material, such as a manual or other aids, which can be studied in advance of the more formal training session. Depending on the type of job to be performed, training can take place at an evening meeting or on a Saturday before the program year begins. It could also be held just before a major event such as the state hunter education championships. It's important to remember that volunteers are building their commitment and job-specific skills at the same time, so a training session held in advance of the time when the job is to be performed can really be a help. Whatever schedule is used, it is usually best to combine new volunteers with those who are more experienced, keeping the training session informal and growth-oriented rather than requiring the participants to sit and listen. By the end of the training session, every volunteer should have a specific task or assignment to complete. Remember that practical experience reinforces learning and develops confidence.

Every gathering of volunteers should be aimed at training for a particular task or segment of a project. This requires careful preparation by project leadership. Certainly an important aspect of this preparation is the development of a careful agenda, the use of interesting presentors, and care to avoid the impression of drudgery. Volunteer experiences should be fun, and enthusiasm is contagious. Remember, people like to: be needed, be successful, and be recognized.

Follow-Up

After the event, activity, or term of office has ended, the not-so-new volunteer should be invited to participate in an *evaluation* session. This evaluation or critique will allow the volunteer to contribute creatively to improving the activity the next time it is held. It will also help provide a feeling of satisfaction, the chance to turn any negatives into suggestions for change, and will encourage the volunteer to accept another assignment. It is essential that volunteers be made to feel comfortable in this role. Opinions and suggestions should be considered seriously, and certainly not dismissed without explanation. Remember the job description accepted by the volunteer includes the requirement to suggest improvements. Frequently an "after action" meeting or critique immediately following the event will not only generate worthwhile suggestions for improvement, but a commitment from volunteers to help organize the next event or activity.

Recognition is an important aspect of utilizing volunteers, and it is not always the final step. No significant volunteer effort should go unrewarded, although the recognition must be appropriate to the service performed. Even those who didn't perform with distinction should be thanked for trying. Recognition can be given in many forms, from an oral "thank you," to a note or letter, a handmade souvenir, or a formal plaque. When the project has had community service value, a letter to the volunteer's employer might be a good way to provide recognition. Genuine appreciation, thoughtfully expressed, is a valuable part of keeping volunteers satisfied, and willing to serve again.

The benefits of involving volunteers in hunter education and outdoor skills training programs are numerous. With some good planning and follow through, the results can be significant.

The Future For Outdoor Training

Robert M. Jackson
Department of Psychology, University of Wisconsin
La Crosse, Wisconsin 54601

Homer E. Moe
Wisconsin Department of Natural Resources
Madison, Wisconsin 53707

The concern for the future development of outdoor recreation in North America is not a new one. That is not to say that we are resurrecting the same old problems, discovering similar or exact same solutions, or mouthing the same tired cliches as used by many preceding generations. Historical development does, however, give us an important perspective on why we are addressing these issues through this session and projecting in this paper what is often conceptualized today as "futurism."

Leopold (1938) pointed out that "recreation became a problem with a name in the days of the elder Roosevelt." He went on to say that, "barring love and war, few enterprises are undertaken with such abandon, or by such diverse individuals, or with so paradoxical a mixture of appetite and altruism as that group of avocations known as outdoor recreation." In describing "Outdoor Recreation-Model 1938," he noted how it had become a self-destructive process of seeking but never quite finding, a major frustration of our increasingly mechanized society.

The trends that Leopold cited prior to World War II were heightened and exaggerated by the technologically dominated society that emerged later. Shorter work days and the greater need for escape led researchers some 30 years later to point out that individuals were now centering their lives around leisure activities as well as work. Thus Roberts (1970) noted, "It can be argued that for many people leisure has now become such a central and dominant part of their lives that it is their behavior and attitudes towards work that are determined by their leisure rather than the other way around."

The literature suggests that it was about this time that a deeper scientific interest in outdoor education and training emerged. Hawes (1978) credits a report by the National Academy of Sciences (1969) as providing a major impetus to leisure and recreational research when it states, "In order to understand recreation better . . we must recognize (1) the forces that drive it, springing from the behavior patterns of people who engage in it, the social and psychological needs they seek to satisfy, and the established forms of consumption. . . ."

Hendee and Potter (1971) also commented on this need for a better understanding of outdoor recreationists. Based on a review of the literature of wildlife management, they reported that of almost 700 total articles published in the *Journal of Wildlife Management* between 1960 and 1970, only 6 were on human behavior. They challenged wildlife scientists and managers to broaden their horizons to include more research on human behaviors by pointing out that "most game managers profess that wildlife management was also people management, with a human element possibly dominant." Hendee and Potter went on to cite many of the problems associated with bringing research on the human behavior aspects of wildlife to play on the human behavior issue and the people problems surrounding wildlife management. These include the need to attract competent researchers to investigate wildlife-people problems, the need to find adequate financial support for this research, and the need to train wildlife managers to integrate behavioral research findings into policy.

In the 14 years which followed these papers a great deal of research on these "human dimensions" has been reported to these North American meetings, as well as to other professional societies and popular outlets. At this meeting last year, Heberlein and Klepinger (1984) surveyed the number and use of hunter surveys on wildlife management and hunter education in just one state, Wisconsin. They concluded that the cumulative impact of these studies "was substantial." They forecast an ever increasing demand for this sort of information and encouraged agencies to develop linkages with university researchers. As evidence of this potential they cited a developing professional interest within both sociological and psychological professional societies in the problems associated with outdoor recreation. Heberlein and Klepinger pointed out that this growing support network is promoting an intellectual exchange that motivates both resource managers and behavioral scientists. As evidence of this they suggest that the human dimension literature produced in the last ten years is not sufficient to "generate its own interesting questions" as well as address those of wildlife managers and outdoor educators.

The series of papers which has been presented at this session is evidence of the motivation and historical development described above. We have heard Eyman refer to this recreational boom and cite the challenge and complexities of the problems facing the managers of fish and wildlife resources in providing not only instruction in skills, but education in "values" (the use of these wildlife resources in a responsible and ethical way). Melius has described the particular growth and expansion of hunter education over these last two decades and reported a national movement towards a broader-based definition which stresses *hunter responsibility.* Lorenz went on to recommend that the "teaching of responsible living" in the outdoors must become the first priority of outdoor users. He has called for a public delivery system to teach outdoor responsibility and to better implant the seeds of the land-conservation ethic. Riley has illustrated the concepts of Melius and Lorenz by describing the program developed by Missouri to address specifically the issues of outdoor recreational behavior. We note that this need to teach a wise, responsible participation in a broad range of outdoor activities developed out of an existing hunter education program.

It is apparent to us, based on both our review of the literature and this sequence of papers, that a strong sense of both need and commitment exists in terms of the future of outdoor training. Spokespersons from management, research, administration, and our wildlife and sportsmens organizations apparently agree on both the need and the direction for this training. Greater financial support is being offered to these efforts at the federal level and at the state level, as reported by Glaser. Kennedy reminded us of the importance and desirability of preserving the role of volunteers; we need both financial and human resources from the private sector.

Our own perspectives on the future of outdoor training have been derived from years of experience in administering outdoor education and enforcement programs, and in research on hunter and angler behavior and performance. Training workshops and seminars which developed out of this work provided us direct contact and visitation with managers, educators, professionals, and sportsmen in literally almost every province and state in North America. These contacts, and our research findings in Wisconsin, have given consistent evidence that recreationists in *1985* are ready for an expanded program of outdoor training (Jackson and Anderson 1979, 1983, Jackson et al. 1981). Based on hundreds of lengthy personal interviews with both gun and bowhunters, two deep currents of interest and motivation emerged as vital to this development. First, recreationists in their many roles and activities are eager to acquire both information and skills. The making of a hunter or angler is a lifetime process; sportsmen related that they were continually challenged to develop and enhance their skills. The word "challenge" cropped up again and again in the interviews with hunters where we probed motivation to hunt. The second of these readiness factors discovered in this research with recreationists was that all of the hunter and angler groups cited the irresponsible behavior of the participants as the principal reason for their dissatisfactions with their sport. Unethical behaviors of others, not failure to bag, spoil our days in the outdoors.

In describing the "futurism" described by the title and desired by so many, our thoughts and projections will be presented under three broad headings: conceptualization, facilitation, and education.

Conceptualization

In describing a new or revised conceptualization of outdoor recreation for the next decade, we would first like to stress that *outdoor recreation must be for everyone.* States like Missouri and Pennsylvania have led the way in recognizing a need for outdoor education programs that cover a multitude of recreational activities. All the states and provinces represented at this North American meeting are offering hunter education, and many provide programs dealing with snowmobiling, trapping, angling, boating, orienteering, etc. But the future of outdoor training deals with not just the substance of outdoor recreation, *it must clearly be extended to all people as well as all sports.*

In particular, we are referring to women, minorities, and the handicapped. Research and personal observation reveals that some men are not ready to share their outdoor recreation with women. They apparently find some unique sense of identity and satisfaction in defining their sport in exclusively masculine terms. In the *National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (U.S. Fish and Wildlife Service 1982), it was reported that 2 percent of all women had hunted and that only 8 percent of all hunters were women. For anglers, the percentages are 15 and 31. Pomerantz (1977) evaluated the recreational participation of males and females in 20 outdoor recreationally oriented wildlife activities. The only two categories where women participated more than men were horseback riding and going to the zoo. While it seems evident that the almost revolutionary growth in the participation of women in interscholastic sports has yet to develop in outdoor recreation, we predict that the change is coming.

Hunting, of course, bears a particular burden. The realization is growing that the future of hunting is in the hands of the non-hunter . . . and most non-hunters are women. Pomerantz (1977) and Shaw (1978), among others, have noted how the attitudes of the female population (non-hunters) are skewed against hunting activity. But we would rather emphasize the values to be gained by shared participation in outdoor recreation as a dynamic facet of healthy communication and positive human relationships.

Outdoor training programs of the next decade will need to develop a new psychology based on the unique motivations, satisfactions, self-perceptions, and patterns of identification of an expanded clientele. Curriculum and instructional patterns will have to vary accordingly. The leisure life of women, minorities, and the handicapped are shaped by different forces. Pomerantz (1977) reported that interests of males, for example, were more likely to be influenced by relatives and organizational leadership (scouts, recreational group, etc.), whereas females were more influenced by teachers and classmates. Hawes (1978) noted that married women sought people contact, novelty, memories, and stronger family relations through their favorite recreational activities, whereas married men looked for challenge, mastery, control, recognition, and independence. Kraus (1970) noted that blacks were more likely to make use of opportunities for picnicking, fishing, or biking rather than boating, skiing, or riflery. Pittinger and Hunt (1984) have reported that black students apparently enjoy the stimulation of competition more than whites.

Applegate (1982) suggests that many outdoor education programs were originally motivated with a new hunter or recreationist in mind. A typical new hunter was a young man, probably white, who had seen previous experience with hunting or other recreation within a family context. Applegate found important differences in backgrounds, recreational experiences, and opportunities for developing groups of new hunters in New Jersey and suggests that different formats for first time hunters be developed. We are conducting comparable studies in Wisconsin right now to assess the need for different curricula and methods for women, minorities, and the handicapped.

There is evidence that these non-traditional participants can and do respond when given educational opportunities. Studies conducted by Drawbaugh and Locandro (1978) on the New Jersey Hunter Education Program found that the attitudes of females improved more than those of males. They suggest that females may be more open and willing to accept the behaviors, morals, and values of hunting and hunters as described by the hunter education instructor. Shooting instructors consistently point out that women and the handicapped can achieve unusual success in skeet and trap shooting. They may be more teachable and have fewer bad habits to unlearn.

Our second factor in a futuristic conceptualization of outdoor recreation is that *outdoor education is a lifelong process*. We stress in hunter education, for example, that certification from a basic introductory course does not denote graduation in the terminal sense. Rather it is only the beginning. The implications of this are many. For example, rather than attempting to solve problems by doubling or tripling the hours of basic introductory classes, let's develop a lifelong sequence of offerings. Our research indicates that more than half of the bowhunters and waterfowlers in Wisconsin are introduced to their specialty after the age of 16. (Jackson and Norton 1978, Jackson and Anderson 1983). Over half of the muskie anglers in our state first fished for this trophy after the age of 30 (Jackson 1985). From these findings we think that development occurs long after the age when most youth complete a basic outdoor recreation class. This clearly supports the development and expansion of advanced outdoor education programs as noted by the Benson paper in this session. The forms of this will be many: short courses, specialized clinics, workshops and seminars. We see no better cause for national, state, and local sport groups (National Wildlife Federation, Izaac Walton League, etc.) than to encourage, support, and promote these advanced outdoor education programs. We project that in time they could become self-supporting, given a firm sense of direction and initiative by the agency.

Facilitation

We have described a decade that will see a continuing surge of interest and a broadened definition of what and who should be included in outdoor training. We have credited a readiness for this growth in both agency and organizational leadership and the ranks of sportsmen. What is not available, yet, is the organizational framework, communication, and coordination to move these programs forward effectively. At the national level we note there are separate organizations for environmental education and conservation education. Shooting sports programs are sponsored by the National Rifle Association, the 4-H clubs, Boy Scouts, state agencies, and a wide variety of national and local shooting groups and conservation clubs. At the state level we find an uneven profile of commitment and leadership of agencies and organizations. Performance seems to be based more upon an accident of charismatic leadership than a national consensus.

There is separation, and some confusion, within state agencies. When given an interest or even a mandate to provide training in hunting, fishing, trapping, snowmobiling, etc., it is not unusual that each program within the state will be administered by different coordinators and attached to different bureaus within the agency (enforcement, wildlife, fisheries, information and education, etc.). This assignment to different sections with different professional perceptions and objectives inhibits communication and coordination both within the agency and across state and provincial lines.

The paradox of this is that there is strength and power to be gained from the very diversity of these different segments. A fully coordinated blend of these elements could create an even stronger program. Many of us who work with outdoor education definitely want wildlife managers and field conservation officers active in our programs. While these personnel might only reluctantly admit their interest in education, they also acknowledge that, "Our problems are really people problems." Supervisors and administrators look at the overwhelming load of their field personnel and feel that they must protect them from additional workloads. We understand, but disagree. Professionalism in resource management is more than just determining and responding to the needs of the sportsman. As Jahn (1980) has stated, "The best offense and defense is to base population management proposals on the best scientific facts available, and to carry out strong wildlife and resource education programs, including hunter and outdoor education." The challenge as we see it is to involve all of us in outdoor education in its broadest sense, and to find the organizational structures and the communication commitment to make it work.

We make three specific recommendations to accomplish this. The first is that every agency with more than one bureau or division active in outdoor training develop some internal form of coordination and communication. The second proposal is for organizing local, state, and regional outdoor education committees or councils. Membership would include agency personnel, interested citizens, and all the sportsmen and community groups providing training and services. This grass roots level organization should be encouraged to provide pro-active rather than reactive guidance and leadership. By that we mean that the role of these councils would be to create ideas and concepts, not just to react to and evaluate agency programs. Their concerns should extend to any resource-related outdoor recreation activities that occur on public and private lands. Finally, we see a national council meeting concurrent with either this North American meeting or with the annual meeting of the International Association of Fish and Wildlife Agencies. Its principal function would be to provide a repository of information and to facilitate communication and sharing of ideas, materials, and curricula.

A second aspect of facilitation concerns the funding of these programs. Hendee and Potter (1971) recommended that "shifts in available money are warranted from biological-ecological research to human behavior study—considering the problems and priorities confronting the wildlife field and the current imbalance." Concerns and complaints about funding, of course, are typical of all agencies these days. We conducted an informal poll of the hunter education coordinators in North America prior to this conference. When asked what their greatest need or problem was, one-fourth described in some way the need for greater administrative and fiscal support from their own agency, a finding confirmed by the International Association of Fish and Wildlife Agencies' Hunter Education Study Team. Our survey indicated an inconsistent support of outdoor education across North America, based primarily on the ups and downs of Pittman-Robertson funding and license revenues, along with a constant struggle and competition for funding within each agency.

In making this plea for support we draw attention to what seems to us to be an obvious fact. There may be nothing else that an agency does that is more productive in bringing about positive support and good will to the agency than providing these outdoor training programs. Agencies have to live with the fact that part of their role is enforcement and regulation, with the incumbent anger, frustration, and hostility that they inevitably create. Outdoor education, in contrast, is a fully positive factor. It uniquely brings agency, sportsmen organizations, and citizens together in a mutually satisfying cause. Where else can these separate groups and persons work together for mutually acceptable goals?

We are emerging from a period of time when state and provincial agencies were communicating to sportsmen "back off or get out." The attitude communicated was that we (the agency) can do it better ourselves. Undoubtedly, they could. The attitude, however, is changing rapidly. Part of the reason for the change is a recognition that the involvement of sportsmen does pay off in developing sportsmen responsibility. A second reason is economic. Agencies need money. Voluntary contributions of time and labor are also an important resource. If we need hard times to convince us that we need each other, then let them come. Sportsmen need to be involved, and outdoor education is a significant place for the sportsman to invest time, money, and himself.

Psychology reminds us (Jackson 1981) why increased agency support should not exclude voluntary involvement and cooperation of the lay person. Participation creates a sense of identification with a project. Sportsman organizations have probably discovered that the strength and health of their organization depends on the degree to which they actively involve members in group planning and responsibilities. When members become involved they are rewarded with a sense of group identity and belonging. They discover a feeling of responsibility towards group activities plus the satisfaction of mutual achievement and accomplishment. The lesson for the agency seems obvious. By involving sportsmen in cooperative activities, this sense of mutual identity between agency and sportsmen can be created.

The lack of cooperation between consumptive and nonconsumptive enthusiasts needs also to be addressed in terms of facilitation. Witter and Shaw (1979) pointed out that in this next decade hunting tradition will face one of its greatest challenges. They contended that drawing nonhunting citizens into a conservation coalition with sportsmen could provide more of the political and financial reinforcement needed by wildlife agencies. "Incorporating more non-hunting considerations into the programs of wildlife management agencies will undoubtedly require some compromises . . . but the effects of such concessions on the interest of sportsmen might be quite minimal and beneficial in the long run. Habitat management and preservation benefits all types of wildlife and wildlife enthusiasts."

Fifty years ago, Leopold (1933) noted that "the attempt to control hunting has suffered from ignoring economic and psychological factors." We have come a long way, but *facilitation* in the next decade will mean even greater utilization of human dimension research both within the agency and in cooperation with academia. Last year Heberlein and Klepinger (1984) cited the following considerations needed to facilitate this relationship: initiating contact with academic researchers; capitalizing on the scientist's motivation with intrinsically interesting questions; providing stable funding; developing mechanisms for communication, and providing continuity of programs through hiring human dimension specialists through the agency. Bromley and Bryan (1980), too, theorized that a productive relationship between the agency and the university at the research level would lead to incorporation of social scientists with natural resource management perspectives on agency staffs. We note that this happened in Wisconsin in the last six months. It's a model we would recommend to you.

These writers all emphasize the need for communication and facilitation to achieve maximum results. This supports again our belief that the goal of facilitation should not be to establish territories or exclusiveness, but rather a partnership based on common interests and goals from which will develop the communication and consensus needed to achieve the superior outdoor education programs we all envision.

Education

In defining the outlook (future) of outdoor recreation we choose to look first at one word, *involvement. Involvement* is one key to effectively educating tomorrow's recreationists. Kellert (1979), in his study of attitudes towards animals, found that those hunters (naturalistic) who demonstrated strong feelings of responsibility and compassion towards wildlife were typically deeply involved with wildlife. Hunting for these persons provided a means to communicate and become involved with nature.

Leopold (1938) had earlier noted that "to promote perception is the only truly creative part of recreational engineering." He, too, anticipated our concern for involvement noting that a sense of husbandry developed in an outdoors person "not by voting but by working with his hands."

Research tells us that moralizing, in contrast, or merely providing information, doesn't change value. Borden and Schettino (1979) state that increased concern about the environment did not lead to the seeking of knowledge. Conversely, the acquisition of environmental facts did not result in increased affective reactions. Apparently, too, it cannot be assumed that there is a carry over or transfer from general values of the hunter to environmental or hunting values. Baker et al. (1978) profiled their subjects' environmental values and found that these same environmental values were largely independent of general values. It would seem, then, that outdoor educators cannot assume that the existence of knowledge or general values in young recreationists, for example, can and will be translated to responsible hunting practices in the field.

To more effectively change moral values and behaviors in the field, outdoor recreational education needs to more effectively involve students in a learning-discovery process. Generations of teachers know the rules: "Tell me and I'll remember; but *involve* me and I'll understand." (Jackson 1984).

We know that individuals learn values best when they are personally involved. Two individuals of comparable ability read the same passage. One individual not only reads it but underlines certain elements. This simple *involvement*, underlining, improves memory (learning). Comparably, all of us have discovered how much we learn about any subject when we have had the responsibility or opportunity to teach others. It is, of course, a basic principle of learning. As outdoor education increasingly is concerned with outdoor responsibility, the education curriculum and methods to be utilized in the programs will be dependent on student involvement and concrete experiences.

Observations of the methods being used in the Missouri S.P.O.R.T. program or in Wisconsin's hunter education program today would show you that these outdoor education courses increasingly stress learning where students find their own answers through carefully thought-out series of hands-on, concrete experiences simulating the skill performances or value-based decisions which must be exercised and faced in the field.

If the programs invested in outdoor education are to grow in quality as well as quantity in the next decade, a comparable value of importance has got to be based on what educators call in-service education. In-service education in essence means training the trainers. This need was also cited by a large number of hunter education coordinators as surveyed for this paper. These coordinators recognize that there is an art of pedagogy and that a systematic and extensive series of training programs are needed to achieve improvement. The involvement methods for teaching both skills and values that we advocate *cannot be mastered by simply reading a lesson plan.* Fortunately, volunteer instructors are typically highly motivated to improve their own skills and competencies. They will even travel to and attend workshops and in-service programs at their own expense. And they learn readily!

Professional educators know that in-service education is an art as much as a science. Results are never guaranteed. Experience tells us, however, that follow-up efforts are necessary if in-service is to be effective. Frankly, bookshelves are full of valuable outdoor and environmental education materials and curricula that have never been fully used and adopted. We assert that the future of in-service education for outdoor educators must be built on programs that demand firm plans for follow-up evaluation, additional training, and recommitment of instructors. Certainly the network we recommended for facilitation earlier in this paper needs also to be used to communicate and share effective new curricula and methods, particularly across types of outdoor education or agency structure.

Summary

In summary, we need to remind ourselves that regardless of how these programs or our actions develop and expand in the future, the bottom line is always the wildlife resource. As one manager stated at a recent conference, "every outdoor education class should begin with a unit on wildlife because that is where it all begins and ends." We know that even the most innocuous appearing forms of outdoor activities still have an impact on the wildlife resource. In this paper we have asked for new concepts of outdoor education and greater coordination and communication among all parties. To achieve the latter we need a *superordinate cause* to unify us and to create a larger sense of common identity. That cause, of course, has to be our sense of appreciation and responsibility towards the wildlife resource. As Kozicky (1977) has stated, this mutual commitment will not only help create a solid ethical base for all forms of outdoor recreation, but a sound political base from which we can help develop and perpetuate a quality environment and its wildlife component.

The fact that outdoor recreation impacts on wildlife is a primary reason why agencies have become involved and why they need to continue to expand their programs. We endorse this development unequivocally. We remind you however, that this must be done in partnership with wildlife and sport organizations and with concerned individuals. Our strength will come from both our diversity and our common interests. Our final challenge to you is to reassess your priorities based on the consensus to be found running through the papers presented in this session. *Given support and commitment*, we can make the future for outdoor training a great one!

Literature Cited

Applegate, J., and R. Otto. 1982. Characteristics of first year hunters in New Jersey. Rutgers Univ., New Brunswick, NJ. 27pp.

Baker, M. R., et al. 1978. Analysis of environmental values and their relation to general values. J. Environ. Ed. (fall) 10:35-40.

Borden, R. J., and A. P. Schettino. 1979. Determinants of environmentally responsible behavior. J. Environ. Ed. (summer) 10:35-39.

Bromley, P. T., and H. Bryan. 1980. The human dimension. Proc. Annual Conf. S.E. Assoc. Fish & Wildl. Agencies. 34:530-535.

Drawbaugh, C., and R. Locandro. 1978. The effects of the New Jersey hunter education program and selected demographic variables of students on knowledge and attitudes scores about the sport of hunting. New Jersey Dept. of Environmental Protection. Div. of Fish, Game and Shellfisheries, Trenton. 61pp.

Hawes, D. K. 1978. Satisfactions derived from leisure time pursuits: an exploratory nationwide survey. J. Leis. Res. 10(4):247-264.

Heberlein, T. A., and K. E. Klepinger. 1984. Hunter surveys and wildlife management: Wisconsin's experience. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:70-81.

Hendee, J. C., and D. R. Potter. 1971. Human behaviors and wildlife management: needed research. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 36:383-396.

Jackson, R. M. 1981. Get involved: be a better hunter. Wisc. Nat. Resour. Magazine. 5(6):10s-11s.

______. 1984. Effectively teaching outdoor ethics. Outdoor Ethics. Published by the Izaak Walton League of America, Arlington, VA. 3(3):2-4.

______. 1985. Profile of a muskie club: what makes us tick? Muskie. Published by Muskies, Inc. 19(2):11-17.

Jackson, R. M., and R. K. Anderson. 1979. Improving ethical behavior in hunters. Trans N. Amer. Wildl. and Natur. Resour. Conf. 44:306-318.

Jackson, R. M., and R. K. Anderson. 1983. A comparison of the characteristics and behaviors of Wisconsin bowhunters and gunhunters. Trans. Bowhunters and bowhunting in the Midwest: a conference/workshop. pp. 159-172.

Jackson, R. M., R. K. Anderson, and R. C. Norton. 1981. The resource manager and the public: an evaluation of current concepts and practices. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:208-221.

Jackson, R. M., and R. C. Norton. 1978. A profile of Wisconsin waterfowl hunters. Wisconsin Hunter Performance Study—Report 1. 85pp.

Jahn, L. R. 1980. Challenges for the 1980s: fish and wildlife habitats. Presented at 42nd Midwest Fish and Wildl. Conf. St. Paul, Minnesota.

Kellert, S. 1979. Attitudes and characteristics of hunters and anti-hunters. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:412-423.

Kozicky, E. L. 1977. Tomorrow's hunter—gadgeteer or sportsman? Wildl. Soc. Bull. 5(4):175-178.

Kraus, R. G. 1970. Negro patterns of participation in recreation activity. Pages 323-343 *in* J. A. Nesbitt, Recreation and Leisure Services for the Disadvantaged. P. D. Brown and J. F. Murphy, eds. Lea and Febiger, Philadelphia.

Leopold, A. 1933. Game Management. Scribner's Sons, New York. 481pp.

Leopold, A. 1938. Bird-lore. Conservation Esthetic. 70(2):101-109.

National Academy of Sciences. 1969. A program for outdoor recreation research. National Academy of Sciences, Washington, DC.

Pittinger, J. F., and S. L. Hunt. 1984. Effects of race upon the meanings of leisure among universitystudents. J. Negro Ed. 53(1).

Pomerantz, G. A. 1977. Young people's attitudes toward wildlife. Wildl. Div. Rep. No. 2781. Michigan Dep. Nat. Resour., Lansing. 79pp.

Roberts, K. 1970. Leisure. Longman Group Limited, London.

Shaw, W. W. 1978. American disposition toward hunting in 1976. WSP 6(1):33-35.

U.S. Fish and Wildlife Service. 1982. 1980 national survey of fishing, hunting, and wildlife associated research. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Witter, D. J., and W. W. Shaw. 1979. Beliefs of birders, hunters and wildlife professionals about wildlife management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44:298-305.

Summary—Outdoor Recreational Skills and Education: Responsibilities, Ethics, Successful and Needed Programs.

Edward L. Kozicky
North American Association of Hunter Safety Coordinators
Godfrey, Illinois 62035

It has been said that the history of past events is but a prologue to the future. It is also obvious that the hunter education programs of today are but the forerunners of outdoor recreational skills programs of tomorrow. Therefore, through the careful analysis of today's hunter education programs, we can learn how to meet tomorrow's challenges.

Our panel has given us an excellent overview of hunter education as to its successes and needs. A few of the outstanding successes of today's hunter education programs are as follows:

1. Forty of 56 states and provinces evaluated by the International Association of Fish and Wildlife Agencies (IAFWA) in 1983 had AAA ratings, which means they are not only teaching students the proper handling of firearms but also to be responsible and knowledgeable hunters.
2. Volunteer instructors have brought needed enthusiasm and vitality to our programs. Through hunter education we have not only involved sportsmen but many private organizations. In doing so, we have helped to insure the future of sport hunting.
3. As Gary Anderson indicated, using the states of New York and Wisconsin as examples, good hunter education programs will decrease the rate of hunting accidents.

Without volunteer instructors, about 40,000 strong across North America, hunter education programs would have never achieved their current overall successes. It's been a two-way street. Jackson and Moe state that sportsmen volunteers need a sense of identity and belonging. Sportsmen are concerned about the future of sport hunting, and they want to help. Hunter education has given them an opportunity to do so.

No human effort is without room for improvement, including hunter education programs. There are some needs. Benson states that we need to establish a basic minimum course which should be structured on objectives and performance standards rather than on a given number of hours. Benson, Jackson, and Moe stress the importance of sound principles of learning and teaching. For example, they indicate that "involvement" on the part of the student is essential in teaching skills and attitudes. "Involvement" may very well be the teaching tool requested by Jack Lorenz to teach respect and understanding that lead to ethical behavior by outdoor recreationists.

The challenge ahead in hunter education is to funnel the energy and enthusiasm of the volunteer instructor into an effective teacher. As indicated by Kennedy, the recruiting, training, evaluating, and rewarding of volunteer instructors is slowly becoming more of a science than an art.

Several of the panelists indicated that, since hunter education is a lifelong effort, we need to recognize a basic course for beginners and voluntary advanced courses for all hunters.

The only highly successful advanced hunter education courses are skill oriented. Hunters will flock to a seminar on hunting turkeys, ducks, geese, deer, etc., but not to a seminar on hunter responsibility. It just doesn't captivate the attention of the average sportsman.

So, it is important how we label a broader approach to outdoor education. The title needs to stimulate the public's interests and curiosity at least enough to get them to enroll; and then, we have to make the course so interesting that the students are not only anxious for more but become walking and talking testimonials on the benefits of the training.

For the moment, the title, "Outdoor Recreation Skills Program" is successfully being employed in the State of Missouri. It has far more people appeal than "Education in the Outdoors." Words, such as "outdoors," "recreation," and "skills," are action oriented, and people want to excel in both their vocation and avocation.

Outdoor recreation skills programs are designed for all people in a state interested in a given outdoor activity as a lifetime avocation. Sounds impossible? It isn't.

Cheryl Riley outlined Missouri's program, which is based on cooperation with any group, organization, or individuals that have an interest in a given outdoor skill. They involve all groups—school teachers, scouting, 4-H organizers, Future Farmers of America, etc.—not only in the teaching but in the development of the material, teaching outlines, and, of course, implementation. The modules are either written by Department personnel or outside experts.

Glaser states that outdoor skills programs do not have to be wholly department operated or heavily funded. Primary needs are a coordinator, a plan, and administrative support. Much can be accomplished through volunteers and innovative agreements.

One panelist expressed concern that state agencies need to enlist the support and assistance of organizations and concerned individuals, which leaves me in a quandary. The very success of any outdoor recreation skills program hinges on their cooperation. The job ahead will require the help of educators, social scientists, the other academic disciplines, as well as conservation groups, sportsmen, and wildlife organizations. A statewide annual workshop, such as Missouri's, assures all these good folks not only of their input, but makes it possible to enlist their specific expertise when needed.

In conclusion, Aldo Leopold must be smiling. Throughout the presentations by the panelists you have heard his writings quoted time and time again and rightfully so. As Lorenz indicated with a Leopold quote, "Recreation development is a job not of building roads into lovely country, but of building receptivity into the small unlovely human mind." "Bud" Eyman mentioned in his opening remarks that the goal of a viable outdoor recreation skills program is to plant the seeds of a land-conservation ethic not just within hunters but within all people interested in outdoor recreation. And in doing so, we will build a sound political base to ensure the future of a quality environment.

The question confronting state conservation agencies is not whether they can afford such a program, but rather how can they afford *not* to implement an outdoor recreational skills program under centralized direction and with the full cooperation of the whole department.

Agricultural Lands: Conservation Farming and Its Values to Wild Living Resources

Chairman:
CARL H. THOMAS
National Biologist
USDA Soil Conservation Service
Washington, D.C.

Cochairman:
ROGER HOLMES
Chief
Wildlife Section
Department of Natural Resources
St. Paul, Minnesota

Agricultural Lands and Wildlife: A Perspective

George V. Burger
Max McGraw Wildlife Foundation
P.O. Box 9, Dundee, IL 60118

It may come as a surprise to some of you that major problems plaguing farmland soils and wildlife today were firmly established over 200 years ago in the U.S. In the 1700s, cotton and tobacco occurred as monocultures over large acreages in the Southeast, accompanied by the same problems—soil erosion, insect pests, and fluctuating markets and prices—that have been synonymous with crop monocultures in recent years. Thus, while today's solutions may be different, today's problems haven't changed all that much. *Deja vu?*

Then agriculture moved west. The tall-grass prairie was the first to go, its rich soils succumbing to the steel mold-board plow, and convincing farmers that crops *could* be grown on lands that did not support trees. They should have been convinced; this was the world's best soil.

There was a problem, however. Prodded on by free homestead land, the blandishments of land speculators, and their own belief in opportunity and the American ethic that hard work can conquer all, the "sodbusters" moved more than a tad too far. They plowed the mid- and the short-grass prairies, seeking to reap the same harvests and rewards garnered by their Midwest compatriots. There were warnings. Over 80 percent of the folks who homesteaded in Montana between 1900 and 1918 had abandoned their farms by 1922.

Despite such warnings, few were prepared for what came next. The "Great" Dust Bowl of the 1930s was coincident with the "Great" Depression. This double whammy was devastating. Unprotected soils from Oklahoma, the Dakotas, and Kansas blew away, moving up to 300 million tons of topsoil eastward, burying farmlands in neighboring states, and depositing a pall of dust as far as New York and Washington, D.C. Out of the Dust Bowl came this nation's first major move toward "conservation farming." This was the U.S. Soil Conservation Service (SCS)—born from dust. With inspired leadership and dedicated personnel, SCS put cover, erosion control, and wildlife back on the land. Grass terraces and waterways, contour and strip cropping, windbreaks and shelterbelts, farm ponds, and other SCS practices helped rebuild a devastated landscape to control soil erosion, and to aid farm wildlife.

Unfortunately, the lessons of the 30s did not long endure. With the economy-boosting war-years of the 1940s, plus a series of perfect weather years for crop production in the Midwest and the Great Plains, we quickly forgot those lessons. By the 1970s, the old shelterbelts and windbreaks were being bulldozed, and the sod waterways and grass terraces leveled and plowed under. The age of the big machine had arrived, in force.

Big machinery is only efficient in big fields, on big farms, and with a minimum of obstacles. Hence, an increase in field and farm size on prime ag lands, plus elimination of many "little things"—"forties" in hay, pasture, or small grains; a family orchard; even lilacs down the lane—that were a key to farm wildlife numbers.

There was one hopeful interim. The Soil Bank program of the 1950s and the 1960s gave relief to soil erosion and wildlife problems by ensuring perennial cover on the land, for extended periods. The consequent prospering of wildlife—game *and* non-game—on these retired farmland acres is well documented, and serves (or should) as a model for future federal agricultural subsidies for land retirement.

But our crop surpluses soon disappeared, and it was back to "boom or bust" on the land. Short-term land "retirement," including the recent PIK program, proved largely meaningless for wildlife and soils.

So where are we today? Facing a farmland situation and an agricultural economy that do not bode well for soils or wildlife—with two possible exceptions. One of those exceptions is the apparent likelihood that wildlife agencies and organizations may have a greater input in and impact on future federal farm programs. Hopefully, such input will lead to more useful habitat on ag land should acreage retirement programs again be deemed necessary.

The second exception may have greater long-term importance in view of the volatile and changeable nature of federal subsidies. This exception is the growing interest in and acceptance of "conservation farming" and the several tillage practices associated therewith.

The positive impact that such practices may have on farmland soils and their wildlife could well be *the* "story" of the 1980s. That impact is the subject of the following session.

Farm Conservation Measures to Benefit Wildlife, Especially Pheasant Populations

Richard E. Warner and Stanley L. Etter
Illinois Natural History Survey,
Champaign, Illinois 61820

Introduction

Heightened public awareness of agricultural resource conservation is increasing the probability of more effective technologies and programs to enhance soil and water quality. Whether wildlife resources benefit substantially for these soil and water conservation measures, however, remains questionable. Rapidly changing farming practices challenge wildlife professionals to (1) articulate the relationships of agricultural practices to farmland wildlife habitat and abundance, and (2) to identify and promote habitat conservation initiatives effective in today's dynamic agricultural technology and economy; habitat patterns of the past will not return.

This paper considers the response of ring-necked pheasants *(Phasianus colchicus)* in Illinois to agricultural land use since World War II. It also outlines how future farm conservation programs —despite intensive farming practices—might accommodate temporal and spatial events critical to the well-being of pheasant populations in Illinois.

Critical Dimensions of Pheasant Habitat

Land Use and Population Trends

Since World War II, the trend toward more intensive land use has accelerated in Illinois, as elsewhere. Fields of small grains and forage legumes—prime pheasant habitat (Warner 1981)—were supplanted by corn-soybean cropping after the phase-out of the Federal Soil Bank and Feed Grain programs (Joselyn and Warnock 1964, Edwards 1984). Since 1962, row crop acreages in Illinois have expanded 48 percent, farm size has increased 37 percent and hay-oat acreages have declined 82 percent. The few remaining herds of livestock are raised primarily in confinement, in the more intensively farmed portions of the state.

If a crude parity is assumed for pheasants per unit of nonrow-crop farmland from 1964 through 1973, the general momentum of agricultural production in Illinois was favorable for pheasants through the early 1960s, when cropland diversion programs were extensive, and has been unfavorable for the last 10-or-more years of all-out production (Figure 1). However, quantitative shifts in agriculture alone are not sufficient for developing a working definition of pheasant habitat—nor are they useful for establishing or preserving critical elements of such habitat through soil conservation practices. The changing momentum of agriculture (Figure 1) has affected not only field size and the types and frequencies of crops but also the means employed to increase production—the inputs, machinery, and the timing of farm operations. These interacting quantitative and qualitative factors associated with land use all describe what limits and determines pheasant abundance. Aspects of agriculture significant to pheasants can be identified by considering key time and space factors.

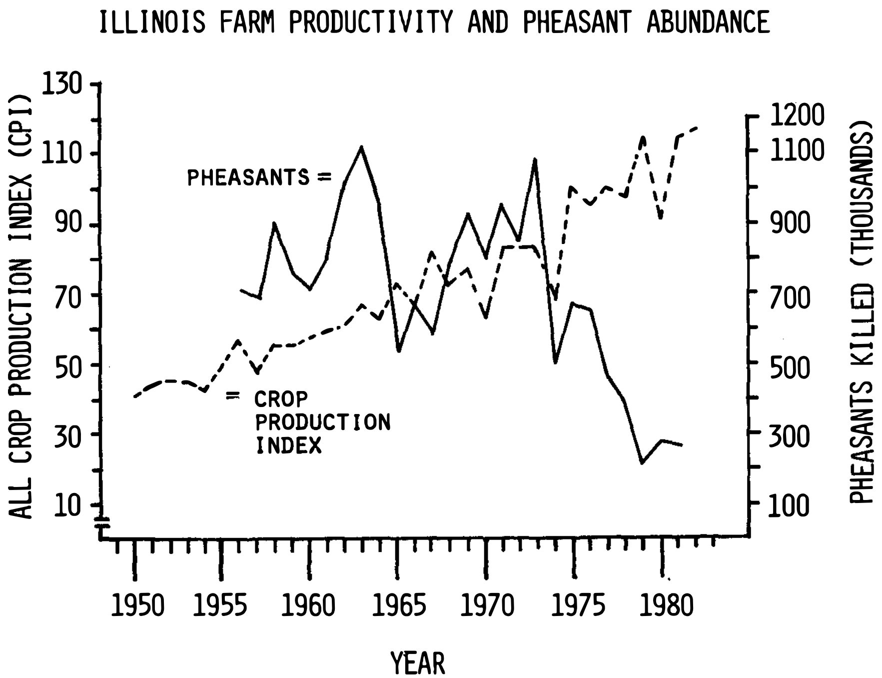


Figure 1. Cock pheasants reported killed by hunters and the all crop production index for Illinois, 1949-83.

Spatial Factors

Three spatial scales are useful for understanding interactions of agriculture and pheasants. The *field* scale describes the primary site for a particular biological function. The farm scale represents a unit of land management and describes cover types near sites of biological activity. The *regional* scale as it relates to pheasant range describes the mosaic of cover over an extended area that encompasses several farms.

All three scales are significant to the occurrence, location, and outcome of specific events in the life of a pheasant. These scales vary in importance from season-to-season, however, depending upon weather, type of farming, and the biological activity of the pheasants (Figure 2). For example, regional scales are particularly relevant to the movement of pheasants during crop harvest and fall tillage and to winter grouping and spring dispersal (Figure 2). The farm scale is especially pertinent during brood-rearing (Warner 1984) and the establishment of territories. Configurations of cover present in proximity to breeding territories affect the selection of cover for nesting (Warner and Joselyn 1985). The site-field scale is most relevant to nest success but also relates to night roosting, predation, and other phenomena (Figure 2).

Temporal Factors

Time scales can be used to describe and explain how farm-related disturbances affect pheasant reproduction and survival. Subtle shifts in the timing and nature of

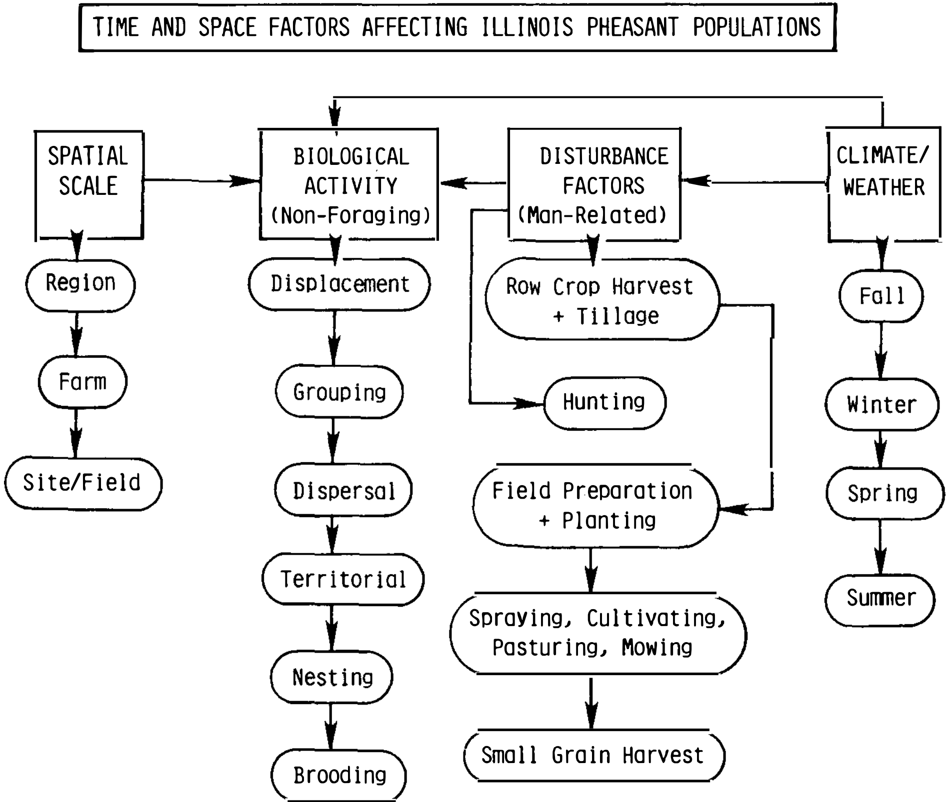


Figure 2. Time and space factors affecting pheasant abundance in the intensively farmed regions of Illinois.

disturbances (Figure 2) can profoundly affect pheasant abundance. For example, hay mowing has been critical to the survival of nests and hens; forage legumes are attractive nesting areas but are typically mowed during the nesting season (Robertson 1958, Labisky 1968). In the 1960s, up to 25 percent of all hens were destroyed by midseason hay mowing in some regions of Illinois (unpubl.) Although farm field operations such as mowing (Figure 2) can be highly negative for reproduction, the timing of these events varies among farms depending upon such factors as weather, livestock operations, and the limitations of relatively small machinery. Within a region, dispersal of pheasants among farms has traditionally buffered to some extent the variable effects of mowing on reproduction and survival.

Improved farming equipment and methods have greatly reduced the time needed to complete seasonal farm operations. Therefore, variability in pheasant reproduction and survival for some regions has declined. In addition, row crop farming has expanded such that pheasant populations are sparse, with remaining areas of concentration unevenly distributed on the landscape. The result has been less movements of birds from farm-to-farm; hence, the buffering effect of a widely dispersed and abundant population over good quality range has been much reduced in recent years.

Farm Conservation Programs and Strategies for Enhancing Illinois Pheasants

Size of Management Area

The size of the region over which specified farm conservation practices are to be applied is important, especially as soil conservation methods vary somewhat with soil type. Research in east-central Illinois suggests that dispersal of pheasants may dilute the results of local management efforts—at least when hunting is used to judge the success of programs implemented on areas smaller than a township (Etter et al. 1985). Optimally, management practices should extend over several contiguous townships.

Management Opportunities on Intensively Farmed Landscapes

Possibilities for management of pheasant populations differ among regions in Illinois with respect to practices and likely responses. On areas of township size or larger, for example, roadside management has been shown to have a positive effect on local pheasant abundance where 80-85 percent of the farmland is in corn-soybeans and 5-10 percent is in small grains and forage legumes. However, where farmland mosaics exceed 90 percent row crops, the positive effects of roadside management on abundance is dampened by poor survival in the absence of habitats critical to other life activities (Warner and Joselyn 1985).

Even where 10-15 percent of the farmland is used to produce forage legumes and small grains in Illinois, numbers of pheasants have been low since the phase-out of the Federal Set-Aside Acres Program (Warner 1981). Because of current low densities, a significant lag can be expected from the time of habitat development to substantial increases in pheasant numbers. Also, because extant habitat and pheasant populations are not evenly disributed across regions, the initial location of habitat measures would be critical to evoking short-term responses. Conservation measures must be extensive and long-term to significantly benefit the sparse pheasant populations currently existing in Illinois.

Priority Habitat Initiatives

Because of the ecological effects of modern intensive agriculture, especially in the north central corn belt, several habitat-improvement initiatives may have to be applied to address the survival needs of pheasants throughout the year (Figure 2). The need for several habitat initiatives contrasts with the era of rotation farming when fields were smaller and oats-hay associations were common and highly beneficial to pheasants throughout their life. Managed roadsides or grassy terraces, for example, are suitable for nesting (Warner et al. 1985) but may provide only minimal benefits during other seasons.

Management-by-objective is useful for identifying priorities for habitat initiatives. First, it is desirable to be able to predict likely numerical responses of pheasant populations to specific initiatives, assuming that factors affecting reproduction and survival can be improved. To obtain such estimates, a computer population ecology model for pheasants was developed, primarily from long-term research conducted in central Illinois. The model tracks weekly demographic trends relative to intrinsic and extrinsic factors that affect pheasant abundance. It was employed to consider farm conservation measures that could enhance pheasant populations in an area where land use is typically 70 percent corn and soybeans, 8 percent small grains, 6 percent forage legumes, and 16 percent other farmland (uncultivated areas such as terraces, rights-of-way, farmsteads, and odd areas). The area was assumed to be the size of a township, and located within a region of similar farming practices.

Four critical constraints potentially limiting pheasant abundance in Illinois were considered as potential management objectives—reproductive output (chicks hatched), chick survival, phenology of mowing and fall-to-spring survival. It was assumed that conservation practices could be implemented to relax these critical constraints as follows: chick survival rate to six weeks (CHICK) increased approximately 35 percent, from 55 percent to 75 percent (Warner et al. 1984); mowing (MOW) of hayfields and roadsides delayed to 15 July; fall-to-spring survival (SURVIVE) increased 10 percent; and reproductive output (REPRO) increased about 25 percent. Winter storms decimating 50 percent of the population (Warner and David 1982) were assumed to occur an average of one winter in five in the model, and were deemed not subject to management in any direct manner.

The model was then programmed to consider different sequences in which the individual constraints might be addressed by conservation programs, and to predict the ensuing response curves by the pheasant population (Figure 3). Each point on the horizontal axis (Figure 3) represents an average of a 10-year computer-simulated response, assuming an initial density of 20-30 hens per square mile. The curves represent two orders in which critical factors were theoretically addressed by habitat initiatives; on the top curve, MOW was first improved (1 on horizontal axis), followed by MOW + CHICK (2 on the horizontal axis), followed by MOW + CHICK + SURVIVE (3), etc.

Figure 3 suggests that addressing factors that are critical during the reproductive season are a first priority—which has been demonstrated by field experiments (Warner and Joselyn 1985). These two scenarios (Figure 3) also indicate the value of multiple element conservation packages; they emphasize the desirability of providing

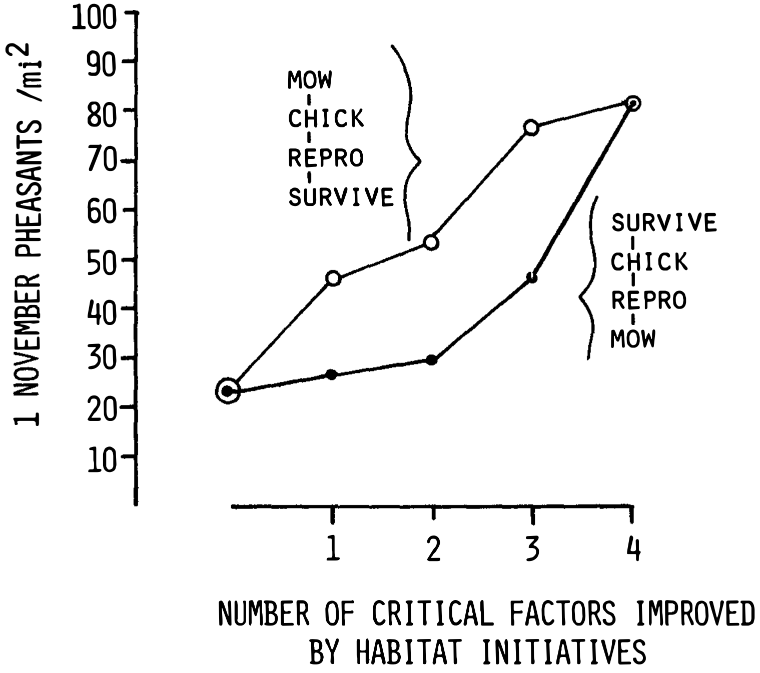


Figure 3. A population ecology computer model describing predicted responses by pheasants in a diverse farming area of Illinois to four habitat measures initiated sequentially for enhancing pheasant survival related to mowing (MOW), chick survival (CHICK), reproductive output (REPRO), and fall-to-spring survival (SURVIVE). Winter storms decimating 50 percent of the population were assumed to occur once in five years, and were included in the model.

attractive nest cover that will be undisturbed as a part of any compendium of resource practices.

Conclusion

Although these model predictions are tentative, in the future tools of this nature in conjunction with field research will facilitate identification of key research questions and the establishment of economically sound priorities for habitat initiatives. Many of these research questions pertain to landscape ecology—the emerging discipline of study that considers the fluxes and redistributions of landscape elements within spatially heterogeneous geographic areas—and human actions with respect to various ecological processes (Risser et al. 1984).

Diverse farming will probably not reappear in some portions of Illinois, and the intensive cultivation of a small number of crops surely will continue into the near future. The movement toward soil and water conservation—the goal of the "T by 2000" in Illinois for meeting soil and water quality goals (Darden 1984)—can be accomplished only by adoption of a broad spectrum of soil conservation practices. These practices are likely to vary in their application among soil types and regions.

Some methods, particularly those of tillage-planting systems, are rapidly developing—with major questions remaining as to their merits for farmland wildlife.

At present, farms in the Midwest have some latitude in addressing soil and water conservation needs. During this critical period, wildlife professionals should be able to identify and promote resource conservation packages that offer significant benefits relative to their cost. Pheasant research and management in Illinois suggests that wildlife habitat initiatives can be integrated with strategies for meeting soil and water conservation goals. Critical research questions remain, however, and the careful management of farm-related disturbances will have to be a strong component of successful habitat initiatives.

Acknowledgments

We thank W. R. Edwards, P. G. Risser, G.C. Sanderson, and E. Steger, IL. Natural History Survey (INHS), and S. J. Brady, Soil Conservation Service, for editorial and technical assistance. This work is a contribution, in part, of Fed. Aid in Wildl. Restoration Proj. W-66-R, the INHS, the IL. Dep. of Conserv. (IDOC), and the U.S. Fish and Wildlife Service (USFWS), cooperating. The IDOC and USFWS have no responsibility for the form and content of the data in this report or for conclusions reached.

Literature Cited

Darden, R. A. 1984. What should government be doing? State government's view. Pages 39-40 *in* Conservation tillage—strategies for the future: executive summaries. National Conservation Tillage Conference, Conservation Tillage Information Center, Fort Wayne, IN.

Edwards, W. R. 1984. Early ACP, pheasants, boom and bust—an historic perspective with rationale! Pages 71-83 *in* R. T. Dumke, R. G. Stiehl, and R. G. Kahl, eds. Transactions: Perdix III: International Partridge/Pheasant Workshop. Wisconsin Dep. Natur. Resour., Madison, WI. 203pp.

Etter, S. L., R. E. Warner, and J. E. Warnock. 1985. Seasonal age ratios and survival rates of Illinois pheasants, J. Wildl. Manage. (Manuscript under review).

Joselyn, G. B., and J. E. Warnock. 1964. Value of federal grain program to production of pheasants in Illinois. J. Wildl. Manage. 28:547-555.

Labisky, R. F. 1968. Ecology of pheasant populations in Illinois. Ph.D. Thesis. Univ. Wisconsin, Madison. 511pp.

Risser, P. G., J. R. Karr, and R. T. T. Foreman. 1984. Landscape ecology: directions and approaches. Special Publication No. 2. Illinois Natur. Hist. Surv., Champaign. 18pp.

Robertson, W. R., Jr. 1958. Investigation of ring-necked pheasants in Illinois. Tech. Bull. No. 1. Illinois Dep. Conserv., Div. Game Manage., Springfield. 138pp.

Warner, R. E. 1981. Illinois pheasants: population, ecology, distribution, and abundance, 1900-1978. Biol. Notes 115. Ill. Nat. Hist. Surv., Champaign. 22pp.

______. 1984. Effects of changing agriculture on ring-necked pheasant brood movements in Illinois. J. Wildl. Manage. 48:1014-1018.

Warner, R. E., and L. M. David. 1982. Woody habitat and severe winter morality of ring-necked pheasants in central Illinois. J. Wildl. Manage. 46:923-932.

Warner, R. E., S. L. Etter, G. B. Joselyn, and J. A. Ellis. 1984. Declining survival of ring-necked pheasant chicks in Illinois agricultural ecosystems. J. Wildl. Manage. 48:82-88.

Warner, R. E., and G. B. Joselyn. 1985. Population ecology of Illinois pheasants relative to block roadside management. J. Wildl. Manage. (Manuscript in review).

Warner, R. E., G. B. Joselyn, and S. L. Etter. 1985. Ecology of roadside nesting by pheasants in east-central Illinois. J. Wildl. Manage. (Manuscript in review).

Responses of Wildlife to Various Tillage Conditions

John S. Castrale
Indiana Division of Fish and Wildlife, Mitchell 47446

Introduction

Until recently, wildlife utilizing cultivated fields has received limited research attention. Agroecosystems, more specifically row-crop fields, offer relatively poor wildlife habitat and possess low species diversity, richness (number of species), and population densities (Dambach and Good 1940, Graber and Graber 1963, Ducey and Miller 1980). However, due to the tremendous amount of acreage devoted to agricultural crops in the Midwest, changing farming practices may significantly affect total animal numbers for species that frequent or depend heavily on these early successional habitats (Warnock and Joselyn 1964, Owens and Myres 1973, Vance 1976, Higgins 1977, Wooley et al. 1982, Rodgers 1983). One such shift that has the potential to profoundly impact farmland wildlife species is the adoption of reduced conservation tillage methods. The acreage of cropland in the United States employing conservation tillage practices has increased steadily from 14 percent in 1973 to over 24 percent in 1982 (Crosson 1982). During 1982, reduced tillage practices were utilized on 34 percent of Indiana's 13 million acres (5.26 million ha) of cropland (Conservation Tillage Information Center 1983). Based primarily on economic advantages and improved technology, conservation tillage in some form is predicted to be used on 60 percent of the nation's cropland by the year 2010 (Crosson 1982).

Although a multitude of tillage practices qualify as conservation tillage, all have in common reduced disturbance of the soil surface resulting in greater amounts of surface residues and savings in soil loss for most situations (Phillips et al. 1980). Before wildlife biologists can fully promote the adoption of conservation tillage, comparative studies are needed to gauge impacts on wildlife. Research over broad geographical areas in order to sample various crops, farming methods, and wildlife communities is necessary before blanket statements can be made about the potential of reduced tillage to provide superior wildlife habitat. A variety of research approaches is also necessary to answer the many questions that can be posed about conservation tillage and its impact on wildlife species.

The purpose of this study was to compare wildlife occurrence in corn and soybean fields as it is influenced by tillage practices in southeastern Indiana. The main no-till planting system was slot-planting for corn and soybeans with some use of no-till drilling for soybeans. The approach taken for this study was to survey the bird and small mammal communities of a large number of fields during both the summer and winter periods and relate these to crop residue amounts. An extensive rather than intensive approach was taken in order to generalize findings to a broad range of conditions that can be realistically expected to occur.

Study Area and Methods

All fields under study were on privately-operated farms in Scott County, southeastern Indiana. The topography is flat to moderately rolling with silt loam soils derived from glacial till. Cultivated fields in this region are generally irregular in shape and less than 40 acres (15 ha) in size due to topography and numerous small waterways. Winter study fields averaged 36 acres (14.4 ha) and summer fields averaged 26 acres (10.3 ha).

Corn is the primary agricultural crop with 55 percent (mean for 1981-1983) of the cultivated acreage devoted to corn, followed by soybeans (26 percent), hay (14 percent), and winter wheat (5 percent). Private woodlands comprise 13 percent of the area in the county.

The average frost-free period for the area is 185 days, with a mean annual temperature of 55.5°F (13.1°C). Precipitation is well distributed throughout the year and averages 42 inches (107 cm) with a mean of 16 inches (41 cm) of snow falling annually.

Winter fields were classified into three categories (corn residue, soybean residue, and tilled) of 13 fields each. Corn residue fields had been planted to corn the previous summer and residues were left unchopped after fall harvest. Four cornfields had been aerially seeded to a cover crop (wheat, ryegrass, sweet clover, or crown vetch). Two soybean residue fields also had cover crops (barley, ryegrass, crown vetch, or hairy vetch) or had wheat residue (three fields) present due to double-cropping. Tilled fields were either corn or soybean fields that had been disked (nine fields), chisel-plowed (three fields), or moldboard-plowed (one field). Three disked fields had been sown to winter wheat.

Thirty-six summer fields were categorized (nine fields each) as conventionally tilled corn, conventionally tilled soybeans, no-till corn, or no-till soybeans. Conventionally tilled fields had been plowed or disked in the spring, with seedbed preparation leaving less than 15 percent residue on the soil surface. No-till cornfields were slot-planted into corn residue. Five fields had cover crops or vegetation resulting from one year of being idled. No-till soybean fields were either slot-planted into wheat residue following harvest of winter wheat (five fields) or slot-planted or drilled directly into the previous year's crop residue (four fields).

Winter fields were studied in January and February of 1983 and 1984, while summer fields were examined in June and July of 1983 and 1984. Summer sampling began 13-74 days (mean = 37 days) after planting. Some fields were used for all study periods while others were not, depending on crop and tillage treatment of the field. Large, nonlinear fields were favored for selection when possible to minimize effects of surrounding habitats.

Ground cover for each field was measured each period by visually estimating the percentage of bare soil obscured by residue and vegetation in 8 by 39 inch (20 by 100 cm) sampling frames (Daubenmire 1946). Twenty samples were taken in each field and the maximum height of vegetation was also recorded in 40 such frames during the winter period. Summer measurements were taken just after crops were planted, while winter measurements were recorded at the conclusion of small mammal trapping in February.

Animal populations were sampled in a similar manner during both winter and summer periods. Small mammals were surveyed using snap traps spaced at 10-m intervals along transects extending from the field edge to the field interior. Transects contained 25 traps and one, two, or four transects were established in each field. Traps were baited with peanut butter or peanut butter mixed with oats and traps checked for four consecutive mornings. Half of the fields were sampled during one trapping period and the remaining fields were trapped one or two weeks later. Capture rate (number of individuals caught per 100 trap-nights) was used as an index of small mammal abundance.

Birds were surveyed by walking a circuitous route in each field 10 days each seasonal period and recording the number and species of birds encountered. Bird surveys averaged 20 minutes in duration with up to 12 fields sampled in a day in random order. Birds flying overhead were ignored, unless, as in the case of raptors and barn swallows (*Hirundo rustica*), they appeared to be feeding or searching for prey directly above a field. Surveys began near dawn and were usually completed by noon. The relative number of surveys on which each bird species was detected was used as an index of bird use. This measure was chosen because it is conservative, simple to calculate, and free of stringent assumptions and problems associated with density measures. In addition, bird densities were expected to be low and highly variable among surveys.

Statistical treatments included least-squares regression, chi-square test for differences in probabilities, Student's *t*-test, Student-Newman-Keuls' test, and analysis-of-variance (ANOVA). The probability level of 0.05 was used as the basis for the rejection of statistical hypotheses.

Results

Ground Cover Measurements

The combination of vegetation height and ground cover was used as a measure of vegetation structure for winter fields. Vegetation structure was most pronounced for corn residue fields and least developed in plowed and chiselled fields (Figure 1). Soybean residue fields had values overlapping with disked cornfields. Ground cover estimates do not take into account residue biomass, and if this variable was measured, soybean residue and disked cornfields would be even more similar and corn residue values more dissimilar than presently depicted. Because of the additional height and greater amounts of residue biomass, untilled corn residue should provide superior microhabitats for protection against wind and concealment from predators.

Differences in ground cover values between no-till and conventionally tilled fields are pronounced (Table 1), with no-till fields having a minimum of 60 percent residue and conventionally tilled fields having less than 15 percent cover. Vegetation structure will change dramatically through the summer as corn, soybean, and other vegetation attain greater height through growth.

Small Mammal Populations

Corn and soybean fields in southeastern Indiana support small mammal populations of moderate density but low species diversity. During 19,600 trap-nights of effort, five species were taken from 91 percent of the study fields for an overall capture rate of 3.26 individuals/100 trap-nights. Shannon-Wiener diversity indices (H') averaged less than 0.50 and species richness averaged less than 1.5 species/field. Deer mice (*Peromyscus maniculatus*) were the most commonly captured mammal, representing 73 percent of all individuals and occurring in 85 percent of the fields. House mice (*Mus musculus*) were next in abundance, comprising 26 percent of the

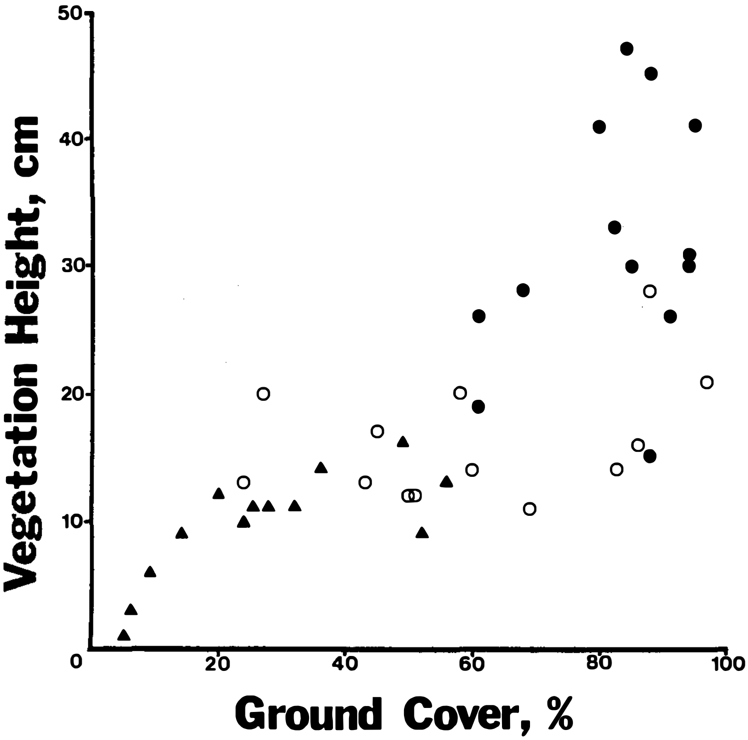


Figure 1. Vegetation structure of winter study fields: corn residue (closed circles), soybean residue (open circles), tilled (triangles).

Table 1. Capture rates of small mammals from summer fields. Means and standard errors are given with number of fields (maximum is 9) from which mammals were captured given in parentheses.

	No-till corn	No-till soybeans	Conventional corn	Conventional soybeans
Capture rates (No. individuals/100 trap-nights)				
Deer mouse	2.8 ± 1.0 (7)	1.6 ± 0.4 (8)	1.4 ± 0.5 (7)	3.6 ± 1.0 (9)
House mouse	1.1 ± 0.5 (5)	0.4 ± 0.2 (4)	0.3 ± 0.2 (3)	0.2 ± 0.1 (2)
All small mammals	3.9 ± 1.2 (9)	2.2 ± 0.3 (9)	2.1 ± 0.5 (8)	3.8 ± 0.9 (9)
Species richness (No. species/field)	1.4 ± 0.2	1.7 ± 0.3	1.4 ± 0.2	1.3 ± 0.2
Species diversity (H')	0.24 ± 0.10	0.32 ± 0.16	0.29 ± 0.10	0.13 ± 0.10
Ground cover (%)	86.8 ± 2.6	84.2 ± 3.3	4.7 ± 1.0	6.3 ± 1.5

total and occurring in 41 percent of the fields. Two additional rodents, the white-footed mouse (*Peromyscus leucopus*) and prairie vole (*Microtus ochrogaster*), and an insectivore, the short-tailed shrew (*Blarina brevicauda*), each made up less than one percent of the mammals captured.

Capture rates of small mammals during the winter were greatest in corn residue fields and least in soybean residue fields (Table 2). Using ANOVA, significant differences among tillage categories could not be shown for any of the variables listed in Table 2 except ground cover. Mean capture rates of deer mice showed an inverse relationship with crop residue amounts that approached statistical significance ($r = -0.26$, $P > 0.05$). Variability was so great, however, that numbers are impossible to predict based on ground cover values (Figure 2). House mice were notably absent in soybean residue fields, but were occasionally found in high numbers in cornfields with large amounts of residue. The correlation between capture rates of house mice and ground cover values was positive but very weak ($r = 0.07$, $P > 0.05$). In tilled fields, house mice were most often captured near field borders.

Overall capture rates in summer fields did not appear to be greatly influenced by tillage practices (Table 1). Again, ANOVA failed to detect significant differences among tillage categories for all variables except ground cover. Capture rates were greatest and most similar for no-till cornfields and conventional soybean fields, and lowest for conventional cornfields and no-till soybean fields. Conventionally tilled soybean fields were especially attractive to deer mice and a negative relationship between capture rates and ground cover values is suggested ($r = -0.10$, $P > 0.05$), although numbers were again highly variable (Figure 3). House mice were more common in no-till fields, being captured in 50 percent of these fields compared to 28 percent of the conventionally tilled fields. The positive relationship between ground cover values and capture rates of house mice approaches statistical significance ($r = 0.25$, $P > 0.05$).

Winter Field Use by Birds

Birds representing 31 species were detected on 47 percent of the 390 winter surveys (Table 3). Bird occurrence was greater ($\chi^2 = 20.9$, $P < 0.001$) in 1983 (29 species on 58 percent of the surveys versus 22 species on 34 percent of the surveys in 1984) when

Table 2. Capture rates of small mammals from winter fields. Means and standard errors are given with number of fields (maximum is 13) from which mammals were captured given in parentheses.

	Corn residue	Soybean residue	Tilled
Capture rates			
(No. individuals/100 trap-nights)			
Deer mouse	1.7 ± 0.3 (11)	2.4 ± 0.4 (12)	2.8 ± 0.7 (10)
House mouse	2.1 ± 1.7 (9)	0.4 ± 0.4 (1)	0.5 ± 0.3 (7)
All small mammals	3.8 ± 1.7 (11)	2.9 ± 0.7 (12)	3.3 ± 0.7 (10)
Species richness (No. Species/field)	1.5 ± 0.2	1.1 ± 0.0	1.4 ± 0.2
Species diversity (H')	0.33 ± 0.08	0.09 ± 0.06	0.23 ± 0.06
Ground cover (%)	82.4 ± 3.3	60.1 ± 6.5	26.6 ± 5.1

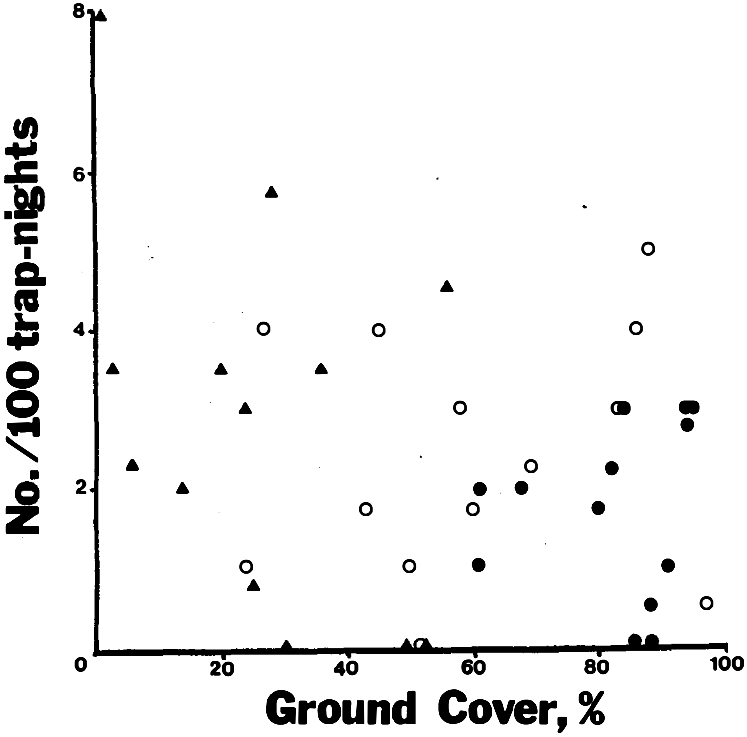


Figure 2. Capture rates of deer mice from winter study fields: corn residue (closed circles), soybean residue (open circles), tilled (triangles).

weather conditions were milder. The mean number of species detected using corn residue fields was approximately twice that of soybean residue and tilled fields ($F = 3.7$, $P < 0.05$). similarly, overall frequency of occurrence of birds was twice as high for corn residue fields than the other tillage categories ($F = 6.2$, $P < 0.001$). Values for soybean residue fields and tilled fields were similar, agreeing with similarities in vegetation structure of soybean residue fields and disked cornfields (Figure 1).

Six of the nine most frequently detected birds showed greatest occurrence values in corn residue fields, where residue and, presumably, food amounts were greatest. Horned larks (*Eremophila alpestris*) and killdeer (*Charadrius vociferus*) occurred most often in soybean residue fields and were least frequently detected in corn residue fields. These two species are noted for their preference for open habitats with sparse, low ground cover. Although these birds commonly used disked cornfields, more intensively tilled fields showed minimal use, presumably due to reduced food availability. Eastern bluebirds (*Sialia sialia*) showed similar patterns of use for the three field conditions.

All bird species in Table 3 are ground feeders, feeding primarily on waste grain and seeds, and some invertebrates. All are habitat generalists, utilizing a wide variety of open, shrubland, and woodland edge habitats. Feeding was the primary use of cultivated fields, although ground-roosting by killdeer, mourning doves

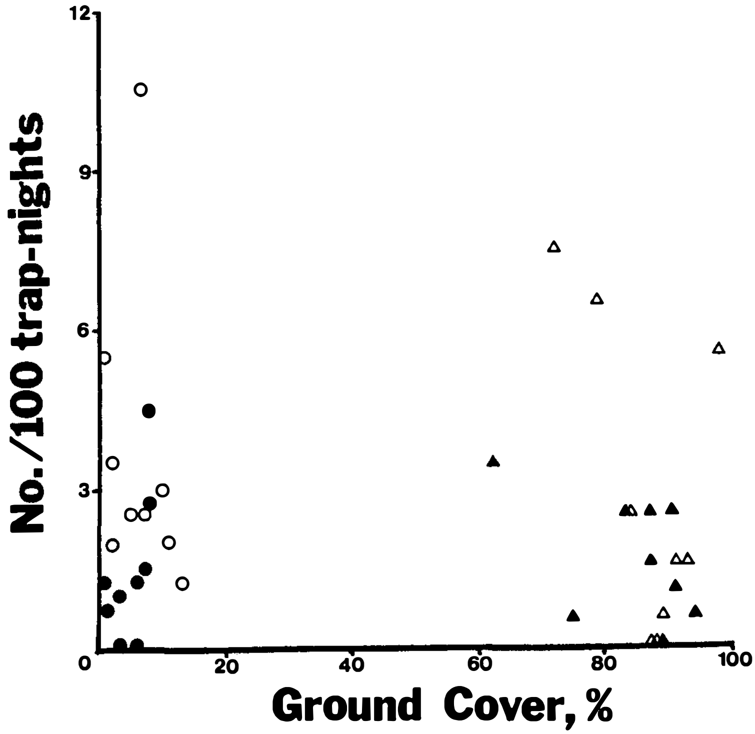


Figure 3. Capture rates of deer mice from summer study fields: no-till corn (open triangles), no-till soybeans (closed triangles), conventional corn (closed circles), conventional soybeans, (open circles).

Table 3. Percentage of winter surveys (10 per field) on which the most common birds were noted.

	Corn residue	Soybean residue	Tilled
No. fields	13	13	13
No. species per field	6.3 A[a]	3.0 B	3.2 B
Horned lark	2.3 C	26.9 A	13.1 B
Mourning dove	23.8 A	0.8 B	3.8 B
Eastern bluebird	9.2 A	6.2 A	9.2 A
American crow	11.5 A	4.6 B	6.9 AB
Dark-eyed junco	16.2 A	0.8 B	3.1 B
Northern cardinal	14.6 A	0.0 B	1.5 B
Eastern meadowlark	12.3 A	2.3 B	1.5 B
Song sparrow	13.1 A	0.0 B	2.3 B
Killdeer	0.8 B	7.7 A	5.4 A
All birds	70.0 A	32.3 B	38.5 B

[a]Dissimilar letters within a row denote statistically significant ($P < 0.05$) differences in means between field types using chi-square tests or Student-Newman-Keuls' tests.

(*Zenaida macroura*), horned larks, and eastern meadowlarks (*Sturnella magna*), probably occurred. Dark-eyed juncos (*Junco hyemalis*), northern cardinals (*Cardinalis cardinalis*), and song sparrows (*Melospiza melodious*) are ecotonal species and when flushed were most likely to leave fields entirely, especially fields with lesser amounts of residue.

Summer Field Use by Birds

Thirty-one species of birds were detected on 69 percent of the 360 summer surveys (Table 4). Occurrence values were similar between years (70 percent in 1983 versus 69 percent in 1984), but total number of species was greater in 1983 (28 versus 23). The mean number of species detected in no-till fields was 32 percent greater (t = 1.95, $P > 0.05$) than in conventionally tilled fields, and birds were 62 percent more likely ($x^2 = 45.3$, $P < 0.001$) to be detected on surveys in no-till fields. The eight most commonly detected birds were found more often in no-till fields and only two (killdeer, horned lark) of the 11 most common birds had greater occurrence values in conventionally tilled fields.

Differences in bird use between no-till corn and soybean fields can be attributed to post-planting field situations. Five of the nine no-till soybean fields were double-cropped with soybeans following winter wheat harvest. Birds using these fields were primarily nonbreeders that were attracted to the abundance of residual wheat following harvest. Double-cropped fields were inferior for breeding birds due to less diverse vegetation and the disruption of breeding activities by wheat harvesting activities.

Since systematic nest searches were not conducted, few nests were found. Breeding can be inferred, however, by a knowledge of the habitats provided and nesting requirements of species using the fields. Of the species listed in Table 4, barn

Table 4. Percentage of summer surveys (10 per field) on which the most common birds were noted.

	No-till corn	No-till soybeans	Conventional corn	Conventional soybeans
No. fields	9	9	9	9
No. species per field	8.0 A[a]	6.1 AB	5.9 AB	4.8 B
Barn swallow	23.3 B	42.2 A	20.0 BC	11.1 C
Mourning dove	16.7 B	38.9 A	6.7 C	0.0 D
Eastern meadowlark	35.6 A	20.0 B	0.0 C	2.2 C
Field sparrow	20.0 A	12.2 A	0.0 B	18.9 A
Red-winged blackbird	22.2 A	10.0 BC	14.4 AB	3.3 C
Song sparrow	11.1 A	20.0 A	2.2 B	4.4 AB
Indigo bunting	18.9 A	4.4 B	6.7 B	4.4 B
Northern bobwhite	20.0 A	11.1 A	1.1 B	1.1 B
Killdeer	0.0 B	0.0 B	11.1 A	7.7 A
American crow	0.0 B	10.0 A	4.4 A	3.3 AB
Horned lark	0.0 B	0.0 B	2.2 B	11.1 A
All birds	85.6 A	85.6 A	53.3 B	52.2 B

[a]Dissimilar letters within a row denote statistically significant ($P < 0.05$) differences in means between field types using chi-square tests or Student-Newman-Keuls' tests.

swallows, mourning doves, and American crows (*Corvus brachyrhynchos*) can be ruled out as breeders. Barn swallows use man-made substrates on which they attach a mud nest, but forage by pursuing flying insects over open habitats. Use figures suggest that populations of aerial insects may be greater over no-till fields. Mourning doves rarely nest on the ground in areas where trees and shrubs are not limiting, but feed extensively on waste grains and seeds in cultivated and disturbed habitats. Corn and wheat are favored over soybeans. American crows are also tree-nesters and forage widely on a wide variety of food items.

Killdeer and horned larks were the only species listed that may nest in cultivated fields. Although much less common on my study area than more highly agricultural areas in northern Indiana, both species are ground nesters and require open areas of sparse, low vegetation. Successful reproduction by these species in conventionally tilled fields is uncertain, however, due to disturbance from planting activities and subsequent tillage operations. The remaining species in Table 4 nest on the ground or in low vegetation and may nest in some no-till fields. Occurrence of these species in conventional fields reflects foraging activity, and for most species these represent use near field borders. The probability of nesting is strengthened by discovery of nests of field sparrows (*Spizella pusilla*) and red-winged backbirds (*Agelaius phoeniceus*) in no-till cornfields elsewhere, knowledge of an eastern meadowlark nest in an Indiana no-till cornfield (Jim McCall, personal communication), and nests of song sparrows and indigo buntings (*Passerina cyaneus*) in idle fields offering habitats similar to those provided by no-till fields. Northern bobwhite (*Colinus virginianus*) may also nest in no-till fields, which certainly provide suitable habitat for brood-rearing.

Discussion

Small Mammals

In most areas of North America, the deer mouse is the predominant small mammal, and generally the sole permanent resident, inhabiting cultivated fields (Linduska 1942, Whitaker 1967a, 1967b, 1968, Houtcooper 1972, Fleharty and Navo 1983, Holm 1984, Navo and Fleharty 1984, Warburton and Klimstra 1984, Young 1984). Greater numbers of resident deer mice were present in a no-till cornfield in southern Illinois than in a conventionally tilled cornfield (Warburton and Klimstra 1984). Young (1984), however, reported comparable densities of deer mice in conventional and minimum tillage cornfields in Iowa. As with my study, no strong correlations between residue amounts and deer mouse densities were evident. Whitaker (1967a, 1967b), however, demonstrated an inverse relationship between deer mouse abundance and residue cover in cultivated habitats in Indiana. Factors that determine deer mouse abundance are unclear, but the buildup of large populations of deer mice due to the adoption of minimum tillage is not supported by field studies. Houtcooper (1972) was unable to demonstrate a relationship between deer mouse numbers and seed abundance in cultivated fields in Indiana. Deer mice construct extensive burrow systems in cultivated fields and cache seeds (Houtcooper 1972). Deer mouse populations show little immediate change due to tillage operations, although individual home ranges may be disrupted (Castrale, unpublished data). Soil type, soil compaction and competitive exclusion have been suggested as factors that may limit distribution and population densities (Whitaker 1968).

Several other rodents and insectivores have been reported using cultivated fields, but population densities are generally low. Most species restrict their use to field edges bordering more favorable habitat. Numbers are generally correlated with greater residue amounts and most species do not tolerate tillage operations. Using no-till techniques may tend to diversify small mammal populations rather than increase total population densities (Young 1984).

Farmers and agronomists are concerned that adopting minimum tillage will result in increased rodent populations that may cause damage to newly planted crops. Rodent damage has occurred in no-till fields with thirteen-lined ground squirrels *(Spermophilus tridecemilineatus)* and voles *(Microtus* spp.) most frequently implicated (Johnson et al. 1982). Although deer mice are opportunistic feeders and do occasionally dig up and eat newly planted corn, overall damage is generally insignificant (less than one percent) compared to insects and weather (Young 1984). Higher damage rates (greater than 10 percent) have been reported in Nebraska, but damage was variable and difficult to predict based on population densities and residue amounts (Holm 1984). Given the habitat relationships of deer mice, their omnivorous and mostly beneficial diet (Whitaker 1966, Houtcooper 1978, Holm 1984, Young 1984), and the relative amounts of food available in conventional and minimum tillage fields, serious concern about rodent damage in no-till fields is not warranted in most cases. Repellents and toxicants are available which are effective in reducing crop damage (Johnson et al. 1982).

Birds

Winter use of cultivated fields by birds was greatest where crop residues were allowed to remain, on the soil surface. However, differences between fall tillage practices may be less important in more northern areas or during years when wintering bird populations are of low densities and when persistent snow cover makes these fields indistinguishable. Snow depth of four inches (10 cm) or more would effectively bury protective crop residues and make foods unavailable for most bird species. Fields of untilled corn residues tend to trap and hold snow for longer periods of time than tilled fields (Rodgers and Wooley 1983).

Reduced tillage practices in the spring and summer provided avian habitat superior to that provided by conventional tillage methods in row-crop fields. Other recent studies support the relative value of agricultural fields under minimum tillage. Warburton and Klimstra (1984) reported that monthly (April-September) counts of birds were greater in a no-till field in southern Illinois than those in an adjacent conventionally tilled cornfield. Birds nested in higher densities in no-till corn and soybean fields in Iowa than conventionally tilled cornfields (Basore 1984). Minimum tillage of small grains in Manitoba resulted in greater densities of waterfowl nests than in conventional tillage situations (Cowan 1982). Nevertheless, no-till fields are still inferior to other early successional habitats that are not planted to row-crops. Frequency of use of cornfields idled under the Payment in Kind program was much greater than conventional cornfields with no-till fields having intermediate values (Castrale 1984). Nesting densities in minimum tillage fields fail to reach levels present in strip cover and other untilled areas (Higgins 1975, Basore 1984). Widespread adoption of minimum tillage practices, however, may increase overall avian production because nests lost to predators can be high in native cover due to its restricted distribution and the high concentration of nests present (Cowan 1982).

Of the bird species considered in this study, only horned larks and, possibly, killdeer would be negatively affected by widespread adoption of reduced tillage practices. Both species are noted for their preference for nest sites with minimum ground cover (Graber and Graber 1963), although nest densities of killdeer were comparable in no-till and conventional fields in Iowa (Basore 1984). Minimum tillage will primarily benefit those grassland species that nest on the ground or in low vegetation. Because grassland birds have experienced drastic population declines from historical levels, widespread adoption of minimum tillage may be a significant development in the outlook for these birds. In a detailed study of the breeding ecology of vesper sparrows (*Pooecetes gramineus*) in Iowa row-crop fields, Rodenhouse and Best (1983) suggested that the adoption of no-till practices would increase production in this species. Birds frequenting woodland and shrubland edges also stand to benefit from reduced tillage because they should be better able to take advantage of cultivated fields for feeding.

Factors Affecting Wildlife Use

Differences in wildlife use of cultivated fields as it is influenced by tillage practices can be generally attributed to three primary factors: food availability, vegetation structure, and disturbance. Minimum tillage would appear to offer more suitable conditions in all three areas relative to conventional tillage. Fall and spring tillage reduce total residue amounts along with waste grain and weed seeds. However, burning, disking, or grazing increases food availability under certain situations (Baldassarre et al. 1983, Rodgers and Wooley 1983). Grain and weed seeds are generally in superabundance in row-crop fields during most of the year except under the most intensive cultivation (Bishop and Spinner 1946). The extent food plays in limiting wildlife abundance and use of cultivated fields is not well known. Deer mouse populations in agricultural fields in Indiana were not positively correlated with seed abundance (Houtcooper 1972). Use of cultivated fields by birds was correlated with food resources in only two (both nonbreeders) of six species studied (Gremaud 1983). This Iowa study was conducted mid-April to June and examined four field characteristics plus four additional variables (distances to other habitats). Less than 50 percent of the variability in bird numbers could be statistically explained for any of the six most common species. Crop type helps explain use of fields for some species. As a food source, corn and wheat are generally preferred over soybeans. Mourning dove use of fields in my study can be partially explained by a preference for corn and wheat.

Insect abundance in cultivated fields is important from the standpoint of a food source for wildlife species and the potential to damage crops and reduce yields. Basore (1984) found similar numbers of insects during June and July in Iowa no-till fields and conventionally tilled cornfields. Other studies have reported greater abundance and diversity of arthropods in no-till fields (Blumberg and Crossley 1983, House and Stinner 1983, Warburton and Klimstra 1984). Relatively more invertebrate predators were found in a no-till cornfield in southern Illinois (Warburton and Klimstra 1984). Sorghum yields in Georgia were unaffected by tillage practice, although insect damage to crops was greater in conventionally tilled plots. Tillage and the use of insecticides may temporarily reduce certain insect populations, but during most of the time wildlife populations in cultivated fields are probably not limited to a great extent by densities of insects.

Vegetation structure may play a more important role than food in observed patterns of use of row-crop fields by wildlife, especially birds. Preferred foods may be readily available in corn and soybean fields, but the lack of adequate cover or suitable vegetative characteristics may prevent some species from utilizing food resources present. Grassland birds have been shown to display characteristic patterns of preference for the structure (vegetation height, ground cover amounts, and vegetation heterogeneity) of vegetation (Wiens 1969). Therefore, different bird species cannot be expected to respond in identical ways to habitats created and modified by various tillage practices. Horned larks, for instance, prefer areas of low vegetation with reduced ground cover, and as a result have greatly increased in numbers and distribution with expanding agriculture (Graber and Graber 1963). Most other grassland birds, however, have experienced drastic population declines due to replacement of native grasslands, tame pastures, and small grain fields by row-crop cultivation.

The condition of a field at the time of planting is more important than the crop that is to be no-tilled into it. For example, nest densities and bird species composition in corn and soybean fields that had been slot-planted into corn residue were much more similar to each other than no-till fields that had corn planted into sod residue (Basore 1984). Sod residue was more attractive to grassland birds such as western meadowlarks *(Sturnella neglecta)* and grasshopper sparrows *(Ammodramus savannarum),* while vesper sparrows had higher and similar nest densities in the former two field types. Regardless of the overall field situation, each bird species showed rather exacting requirements for vegetation characteristics (especially ground cover) in which to locate nests.

These observations have important implications for the use and choice of cover crops in agricultural situations. Many grassland birds would benefit from the structural characteristics of cover crops. Plants that grow tall and maintain their integrity following spraying, such as yellow sweet clover, would be beneficial to birds nesting in erect vegetation. Cover crops are often promoted because of their soil saving properties in the period following fall harvest and spring planting. Their value to most wildlife during the winter, however, is questionable because little plant growth is attained. If tillage accompanied planting, the detrimental effects of reducing residues would offset any perceived benefits of the cover crop itself.

The timing and frequency of disturbance to wildlife residing in cultivated fields is important for its direct and indirect impacts (Rodgers 1983). Although horned larks may nest prior to spring field activities, most other bird species are nesting during planting and post-planting operations. Spring tillage in preparation for planting, especially if planting has been delayed by weather conditions, will totally destroy nests of birds attracted to pre-tillage field conditions. Renesting can occur, but birds must first locate suitable habitat that was eliminated by tillage. Slot-planting will minimize disturbances to nesting birds, although nest losses certainly occur due to the use of equipment and herbicides (Rodgers 1983). The impacts of contact herbicides on nests and nesting birds have not been studied under actual field conditions. Subsequent cultivation for weed control is common in conventional practices and increases the probability of destruction of nests and mortality of adults. Double-cropping of soybeans following winter wheat harvest is also ill-timed and is responsible for differences in the pattern of bird use observed in this study. Although a wide variety of agricultural practices qualify as conservation tillage, each differs in its degree of disturbance to resident wildlife and must be evaluated in this respect.

Herbicide Concerns

Although habitat for farmland wildlife species is superior or at least comparable to conventional tillage, concern over increased pesticide use is often voiced. Minimum tillage may require greater application rates of pesticides than conventional tillage due to increased residue amounts. However, the primary difference between these practices is the spraying of a contact herbicide near the time of planting (Phillips et al. 1980). The greater amounts of surface residues would reduce erosion, thereby reducing the movements of chemicals into waterways. Of more immediate concern to wildlife interests, however, is the impacts of contact herbicides (e.g., paraquat, glyphosate) on wildlife species present in cultivated fields. Herbicides are generally less toxic to terrestrial vertebrates than insecticides (Morrison and Meslow 1983), but paraquat has been demonstrated to have some detrimental effects. Laboratory studies show high levels of mortality and malformations in mallard *(Anas platyrhynchos)* embryos due to paraquat (Hoffman and Eastin 1982, Hoffman and Albers 1984). Northern bobwhite ingesting paraquat at field application rates experienced no reduction in egg production, egg fertility, hatching success, chick survival, or chick growth (Bauer 1983). Paraquat residues appeared to be present in tissues and may have been responsible for liver damage in deer mice inhabiting no-till fields in southeastern Indiana (Benson et al. 1985). Although further field research is needed, it seems prudent to encourage the use of alternative contact herbicides (e.g., glyphosate) that appear less harmful (Hoffman and Albers 1984).

Acknowledgements

Rick Speer provided able assistance in all phases of this study. Dave Fellows, Catrina Motsinger, and Keith Galloway were invaluable in selecting study fields, obtaining landowner cooperation, and compiling cropping histories and planting information. Jim McCall, Rex Hamilton, and Robert Feldt were very supportive throughout the study. Wayne Faatz commented on the manuscript and Jennifer Eckensberger typed several drafts. The cooperation of private landowners on whose fields I worked is appreciated. This study was funded by Federal Aid to Wildlife Restoration Projection W-26-R and the Indiana Division of Fish and Wildlife.

Literature Cited

Baldassarre, G. A., R. J. Whyte, E. E. Quinlan, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildl. Soc. Bull. 11:25-31.

Basore, N. S. 1984. Breeding ecology of upland birds in no-tillage and tilled cropland. M. S. Thesis. Iowa State Univ., Ames. 62pp.

Bauer, C. A. 1983. The effects of paraquat on various reproductive and growth parameters in first and second generation bobwhite quail. Ph.D. Diss., Indiana State Univ., Terre Haute, 70pp.

Benson, D., C. D. Baker, B. J. Forsyth, and J. S. Castrale. 1985. Herbicide (alachlor, atrazine, linuron, and paraquat) residues in deer mice inhabiting conventional and minimum tillage row-crop fields. Proc. Indiana Acad. Sci. 94:(in press).

Bishop, J. S., and G. P. Spinner, 1946. Quantities of weed seeds produced in Connecticut cornfields. J. Wildl. Manage. 10:300-305.

Blumberg, A. Y., and D. A. Crossley, Jr. 1983. Comparison of soil surface arthropod populations in conventional tillage, no-tillage, and old field systems. Agro-Ecosystems 8:247-253.

Castrale, J. S. 1984. Wildlife use of cultivated fields set aside under the Payment In Kind (PIK) program. Proc. Indiana Acad. Sci. 93:173-180.

Conservation Tillage Information Center. 1983. 1982 national survey of conservation tillage practices. Conservation Tillage Information Center, Fort Wayne, Indiana. 83pp.

Cowan, W. F. 1982. Waterfowl production on zero tillage farms. Wildl. Soc. Bull. 10:305-308.

Crosson, P. 1982. Conservation tillage and conventional tillage: a comparative assessment. EPA Rep. No. 600/3-82-027. United States Environmental Protection Agency, Washington, D.C. 72pp.

Dambach, C. A., and E. E. Good. 1940. The effect of certain land use practices on populations of breeding birds in southwestern Ohio. J. Wildl. Manage. 4:63-76.

Daubenmire, R. 1946. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-64.

Ducey, J., and L. Miller. 1980. Birds of an agricultural community. Nebr. Bird Rev. 48:58-66,68.

Fleharty, E. D., and K. W. Navo. 1983. Irrigated cornfields as habitat for small mammals in the sandsage prairie region of western Kansas. J. Mammal. 64:367-379.

Graber, R. R., and J. W. Graber. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. Ill. Nat. Hist. Survey Bull. 28:383-528.

Gremaud, G. K. 1983. Factors influencing nongame bird use of rowcrop fields. M. S. Thesis. Iowa State Univ., Ames. 56pp.

Higgins, K. F. 1975. Shorebird and game bird nests in North Dakota croplands. Wildl. Soc. Bull. 3:176-179.

______. 1977. Duck nesting in intensively farmed areas of North Dakota. J. Wildl. Manage. 41:232-242.

Hoffman, D. J., and P. H. Albers. 1984. Evaluation of potential embryotoxicity and teratogenicity of 42 herbicides, insecticides, and petroleum contaminants to mallard eggs. Arch. Environ. Contam. Toxicol. 13:15-27.

Hoffman, D. J., and W. C. Eastin, Jr. 1982. Effects of lindane, paraquat, toxaphene, and 2,4,5-trichlorophenoxyacetic acid on mallard embryo development. Arch. Environ. Contam. Toxicol. 11:79-86.

Holm, K. E. 1984. Small mammal populations and rodent damage in Nebraska no-tillage crop fields. M. S. Thesis. University of Nebraska, Lincoln. 56pp.

House, G. J, and B. R. Stinner. 1983. Arthropods in no-tillage soybean agroecosystems: community composition and ecosystem interactions. Environ. Manage.7:23-38.

Houtcooper, W. C. 1972. Rodent seed supply and burrows of *Peromyscus* in cultivated fields. Proc. Indiana Acad. Sci. 81:384-389.

______. 1978. Food habits of rodents in a cultivated ecosystem. J. Mammal. 59:427-430.

Johnson, R. J., A. E. Koehler, and O. C. Burnside. 1982. Rodent repellents for planted grain. Proc. Vertebrate Pest Conf. 10:205-209.

Linduska, J. P. 1942. Winter rodent populations in field-shocked corn. J. Wildl. Manage. 6:353-363.

Morrison, M. L., and E. C. Meslow. 1983. Impacts of forest herbicides on wildlife: toxicity and habitat alteration. Trans. North Amer. Wildl. and Natur. Resour. Conf. 48:175-185.

Navo, K. W., and E. D. Fleharty. 1984. Small mammals of winter wheat and grain sorghum croplands in west-central Kansas. Prairie Natur. 15:159-172.

Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51:697-713.

Phillips, R. E., R. L. Blevins, G. W. Thomas, W. W. Frye, and S. H. Phillips. 1980. No-tillage agriculture. Science 208:1108-1113.

Rodenhouse, N. L., and L. B. Best. 1983. Breeding ecology of vesper sparrows in corn and soybean fields. Amer. Midland Natur. 110:265-275.

Rodgers, R. D. 1983. Reducing wildlife losses to tillage in fallow wheat fields. Wildl. Soc. Bull. 11:31-38.

______, and J. B. Wooley. 1983. Conservation tillage impacts on wildlife. J. Soil and Water Conserv. 38:212-213.

Vance, D. R. 1976. Changes in land use and wildlife populations in southeastern Illinois. Wildl. Soc. Bull. 4:11-15.

Warburton, D. B., and W. D. Klimstra. 1984. Wildlife use of no-till and conventionally tilled corn fields. J. Soil and Water Conserv. 39:327-330.

Warnock, J. E., and G. B. Joselyn. 1964. Nesting of pheasants in soybean fields. J. Wildl. Manage. 28:589-592.

Whitaker, J. O., Jr. 1966. Food of *Mus musculus, Peromyscus maniculatus bairdi,* and *Peromyscus leucopus* in Vigo County, Indiana. J. Mammal. 47:473-486.

______. 1967a. Habitat relationships of four species of mice in Vigo County, Indiana. Ecology 48:867-872.

______. 1967b. Habitat and reproduction of some of the small mammals of Vigo County, Indiana, with a list of mammals known to occur there. Occasional Papers of the C. C. Adams Center for Ecological Studies 16:1-24.

______. 1968. Relationships of *Mus, Peromyscus,* and *Microtus* to the major textural classes of soils of Vigo County, Indiana. Proc. Indiana Acad. Sci. 77:206-212.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. 8:1-93.

Wooley, J., R. George, B. Ohde, and W. Rybarczyk. 1982. Nesting evaluations of native grass pastures and narrow-row soybeans. Pages 5-6 *in* R. B. Dahlgren, ed. Proc. Midwest Agric. Interfaces with Fish and Wildl. Resour. Workshop. Ames, Iowa. 54pp.

Young, R. E. 1984. Response of small mammals to no-till agriculture in southwestern Iowa. M. S. Thesis, Iowa State Univ., Ames. 66pp.

Impacts of No-Till Row Cropping on Upland Wildlife

James B. Wooley, Jr.
Iowa Conservation Commission, Chariton Research Station
Chariton, Iowa 50049

Louis B. Best and William R. Clark
Department of Animal Ecology, Iowa State University
Ames, Iowa 50011

Introduction

The demise of wildlife habitat in the face of intensified farming practices is a familiar and oft-repeated story, with similar consequences for game and nongame species that depend on diversified agricultural areas (e.g., Farris et al. 1977, Rodenhouse and Best 1983). State wildlife agency programs frequently seek to combat such habitat losses by providing various incentives to landowners (Dumke et al. 1981), but little progress has been achieved in stemming the general decline of wildlife in agricultural ecosystems. As agricultural technology changes, wildlife managers have attempted to identify how new agronomic practices may either harm or benefit wildlife. One relatively recent agricultural phenomenon is the widespread adoption of various conservation tillage practices in row-crop agriculture (Mannering and Fenster 1983), brought about by advances in tillage technology, heightened public awareness of soil erosion problems, and economic considerations.

The term "conservation tillage" encompasses a diverse variety of tillage techniques designed to leave protective amounts of residue on the soil surface that serve as mulch, thereby reducing soil and water losses in comparison with conventional agricultural practices (Triplett and VanDoren 1977, Mannering and Fenster 1983). Perhaps closest to conventional moldboard plow-based agricultural systems is reduced-till, in which several machinery passes are made over the field, soil is loosened, and about 20 percent of the previous year's crop residue is left on the soil surface. At the other end of the spectrum is no-till, in which soil disturbance is limited to opening and closing a narrow seed slot during a one-pass preparation and planting operation that leaves at least 90 percent of previous crop residues on the soil surface (Conservation Tillage Information Center 1983). Soil savings are substantial for no-till, resulting in up to 90 percent less erosion than that from conventional planting (Griffith et al. 1982).

As a major agricultural state providing more than 15 percent of the corn *(Zea mays)* and soybean *(Glycine max)* acreage in the United States, Iowa has been a focus of rapid expansion of these conservation tillage technologies. Currently, about three percent of the corn and soybean acres in Iowa are farmed by using no-till, and about 60 percent are cropped by using other types of conservation tillage practices (Conservation Tillage Information Center 1983). However, during 1980-84, use of no-till methods in Iowa increased from approximately 111,000 acres (45,000 ha) to 618,000 acres (250,000 ha), an annual expansion rate of about 50 percent (W. Welker, SCS, personal communication). Although long-term projections have not been made for Iowa, Triplett and VanDoren (1977) estimated that by 2010 more than half of all crops in the United States will be grown with no-till methods.

It has been speculated that conservation tillage methods could have positive impacts on upland wildlife species that depend on farmland habitat (Rodgers and

Wooley 1983, Reichenbach and Peden 1984, Soutiere 1984). No-till row-crop systems may have particular potential for increasing available habitat for small mammals and ground-nesting birds because crop residue is minimally disturbed during planting operations, and cultivation operations are replaced by chemical weed control. Attention also has focused on possible pest problems associated with small mammal populations in conservation tillage row crops and on the effect of decreased fall tillage in providing waste-grain food resources for wildlife during winter months (Baldassare et al. 1983).

Some observers, however, have been cautious in concluding that this agricultural trend is wholly positive for wildlife (Cacek 1984, Castrale 1984b). Although some wildlife data are currently available for small-grain conservation tillage applications (e.g., Higgins 1975, Cowan 1982, Rodgers 1983) and for conventionally tilled row crops (e.g., Warnock and Joselyn 1964, Wooley et al. 1982, Rodenhouse and Best 1983), information is largely lacking for row-crop agriculture under various forms of conservation tillage. This paper (1) presents selected results of studies conducted in Iowa that deal with impacts of no-till corn and soybean agriculture on small mammals, nesting birds, and invertebrate populations and (2) with the use of data from these and other studies, examines the implications of this particular tillage practice for wildlife.

Avian Use of No-Till Fields

Tillage systems that prepare the ground for planting and control weeds affect birds that breed in cropland by influencing the residue available for nesting cover, the frequency of equipment passes over the field, and the exposure of wildlife to farm chemicals. One of the major economic and soil erosion benefits of conservation tillage is that fewer passes are made over crop fields with farm machinery, an attribute that also would seem to benefit breeding birds. Each time farm equipment is used in a field, nests may be destroyed or disturbed enough to cause abandonment (e.g., Rodenhouse and Best 1983). The severity of this problem for nesting birds depends upon nest position relative to the crop row, duration of the nesting cycle, ability to renest after failure, and timing of the breeding season. Nests placed between crop rows are more likely to be destroyed during cultivation than those within rows. Birds with long nesting cycles are unlikely to successfully raise young between periodic farm machinery passes in conventionally tilled systems. Species that confine nesting activities to the period when conventional field operations usually occur will benefit most from conservation tillage practices, and especially no-till.

Recent studies in Iowa (Basore 1984), Indiana (Castrale 1984a), and Illinois (Warburton and Klimstra 1984) have shown that no-till corn and soybean fields have higher densities and a greater variety of birds during the breeding season than do conventionally tilled fields. In a three-year study comparing various no-till corn and soybean applications with conventionally tilled row-crops in Iowa, 12 species were found nesting in no-till fields, with an average density of 15 nests/100 acres (36 nests/100 ha). By contrast, only three species, with an average density of < 2 nests/100 acres (5 nests/100 ha), nested in conventionally tilled corn. Major species nesting in no-till fields included the vesper sparrow (*Pooecetes gramineus*), grasshopper sparrow (*Ammodramus savannarum*), western meadowlark (*Sturnella neglecta*), killdeer (*Charadrius vociferas*), ring-necked pheasant (*Phasianus colchicus*), and mourning dove (*Zenaidura macroura*); the most common species nesting in conventionally tilled fields were the vesper sparrow and killdeer. Comparisons of cover characteristics at nest-sites versus those in the crop fields in general indicated that no-till fields were used more for nesting because of greater residue coverage, not because of greater residue height (Basore 1984). Nests in conventionally-tilled fields tended to be concentrated in patches where residue remained. It seems clear that the concealing characteristic of residues in no-till crop fields, not unlike the concealment available in adjacent strip cover, is the major factor attracting birds to nest in these areas.

Strip cover (e.g., fencerows, grass waterways, roadside ditches) generally constitutes only a relatively small proportion of the total acreage in agricultural regions, but its value per unit area to wildlife far exceeds that of the cropland (Taylor et al. 1978). Basore (1984) recorded 14 species nesting in strip cover adjacent to crop fields, and Best (1983) recorded as many as 30 species of birds using fencerows during the breeding season, making this linear cover a particularly important habitat component for breeding birds. Although nest densities in Iowa no-till row-crops were about seven times greater than those in conventionally tilled fields (Basore 1984), the densities of nests on the ground and in herbaceous plants in adjacent strip cover were approximately 10 times greater than those in the no-till fields (Table 1). If nests in woody vegetation had been included, densities in strip cover would have been even greater (Basore, unpubl. data). The value of these linear edge habitats for nesting birds is clear (Table 1), as is the observation that row crops evidently are not an acceptable substitute.

Some studies (Gates and Hale 1975, Taylor et al. 1978) have reported that predators use strip cover as travel lanes, resulting in greater nest predation there than in adjacent crop fields. Thus, even if relative nest densities in crops are less than in strip cover, increased nesting success should theoretically compensate for part of the difference in production. In the Iowa study, however, nests in both row-crop fields and strip cover failed primarily because of predation (Basore 1984), and losses to predators were greater for field nests than strip cover nests in two of three years. Rodenhouse and Best (1983) indicated that production of vesper sparrows in conventionally tilled corn and soybean fields in Iowa was insufficient to maintain population levels, but suggested that success might be greater if tillage operations were reduced and crop residue was retained in fields. Production on no-till fields, however, probably was below levels needed to maintain populations of most nesting species without influx from other habitats where nesting success was greater (Basore 1984).

Focusing on nesting densities and success of ring-necked pheasants illustrates the value of additional nesting habitat in no-till. Pheasant populations in Iowa have declined in the past 20 years (Farris et al. 1977) in response to intensified agriculture and conversion of more favorable habitats to cropland. Biologists have hoped that increasing amounts of no-till row crops might ameliorate some of this loss. At current rates of growth, levels of no-till in Iowa could reach 6 million acres (2.4 million ha) by 1990. Production of pheasants in an area of that size would be large, if nest densities and success were average. But, for pheasants, as for most other species that nested in no-till (Basore 1984), nest densities were much lower than in adjacent strip cover, and were very low when compared with densities observed in other cover types (Table 1). Pheasant nest densities in Iowa no-till corn and soybean fields (Basore 1984) averaged only about 1 nest/100 acres (3 nests/100 ha). Extrapolating from that figure to potential production of successful pheasant nests in no-till row crops in 1990 (6 million acres x 0.012 nest/acre = 72,000 nests x 22 percent nest success [Basore 1984]) yields a figure unlikely to markedly affect future pheasant numbers or hunting success (15,840 successful nests). About six young per successful nest can be expected to survive to the opening of the hunting season (15,840 nests x 6 young/nest = 95,040 pheasants, 50 percent cocks), and about 70 percent of the available cocks will be harvested (Farris et al. 1977). The resulting 33,300 harvested cocks produced from no-till cropland would represent only about 3 percent of Iowa's average annual pheasant harvest during the past five years. Thus, although no-till will probably contribute to pheasant production, it is not likely to solve Iowa's pheasant problems.

The scenario may be different with selected ground-nesting birds such as the mourning dove and killdeer. Nesting densities of these species in no-till approached or exceeded those observed in strip cover (Basore 1984). Because no-till row-crops could eventually supplant vast acreages of conventional systems across Iowa, there is potential for producing substantial numbers of some small, ground-nesting bird species on these acres.

Small Mammal Use of No-Till Fields

As with birds, the predominant feeling among wildlife ecologists is that no-till agriculture will have broadly positive effects on mammalian wildlife (e.g., Warburton and Klimstra 1984). The concensus is based primarily on the belief that increased cover in no-till fields results in more diverse and abundant small mammals. There have been many studies of rodents in agricultural fields, and recently, research has been stimulated in no-till row crops (Castrale 1984a, b, Young 1984, Johnson and Holm 1985). Thus far, the primary motivation for most studies of rodents has been related to their potential to damage row crops. Agriculturalists view the use of no-till methods as presenting a new array of pest-control problems (Beasley and McKibben 1976, Gregory and Musick 1976, Greaves 1982, Johnson and Holm 1985), and some are concerned that farmers may not adopt no-till without information on pests.

Generally, small mammal communities in agricultural ecosystems throughout the corn belt are dominated by deer mice (*Peromyscus maniculatus*) (Linduska 1950, Castrale 1984a, Young 1984, Johnson and Holm 1985), but white-footed mice (*Peromyscus leucopus*), house mice (*Mus musculus*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), and other small rodents also are widespread. Small mammal community diversity is greater in no-till compared with conventionally tilled fields (Castrale 1984a, Warburton and Klimstra 1984, Young 1984) and at margins compared with centers of fields (Young 1984). The presence of alternate cover at field margins probably affects the occurrence of species such as white-footed mice and ground squirrels, but recent evidence has revealed that resident populations of rodents exist even in the center of conventionally tilled fields (Warburton and Klimstra 1984, Young 1984).

Absolute density of rodents in no-till crops is poorly known, but this parameter is critically important to agricultural interests. Most studies to date have used either removal or trap-effort transects to estimate relative abundance (Castrale 1984a, b, Warburton and Klimstra 1984, Johnson and Holm 1985). But, to project potential crop damage or to evaluate control, density estimates are necessary. Young (1984) used recapture techniques to estimate average density of deer mice at 4.9/acre (12.0/ha) and established that densities of deer mice were not consistently greater in no-till fields compared with conventionally tilled corn fields in Iowa. In addition, population levels in the center of fields (at least 100 m from the field margin) were equal to levels at field margins (including the first 10 rows of corn). Evidently, rodents do not simply move into fields from adjacent strip cover. The results were somewhat different for ground squirrels in that densities averaged 1.6/acre (4.0/ha) in corn planted into sod, but only 0.4/acre (1.0/ha) in other tillage treatments (Young 1984). These and other data (Beasley and McKibben 1976) suggest that concern for rodent-caused damage in no-till should be focused on situations where pasture or hay cover is converted to row-crops.

Deer mice, voles (*Microtus spp.*), and ground squirrels, have been documented to consume corn (Whitaker 1972, Houtcooper 1978, Castrale et al. 1984, Young 1984, Johnson and Holm 1985). Ground squirrels seem to provoke the greatest number of damage complaints, perhaps because they are diurnal and large enough to be visible to farmers. Rodent damage to corn typically occurs by excavation of recently planted seeds (Johnson and Holm 1985) or to seedlings while the kernel remains attached to the root (Young 1984). Damage ranged from up to 5 percent in fields in Iowa and Nebraska (Young 1984, Johnson and Holm 1985) to as great as 57 percent on small test plots in Illinois (Beasley and McKibben 1976). Young (1984) examined a large number of seedlings during the period of emergence and estimated that rodent damage occurred to less than one percent of all seedlings. Insect damage during the same years was two to ten times greater. Rodent damage did constitute a larger proportion of the total damage in no-till treatments (especially corn planted into sod) than in conventionally tilled fields but was highly variable between years and among farm operators. Furthermore, there was no evidence that damage was more severe along field margins. Some current data suggest that rodent damage to corn may be greater when emergence is earlier than average (Houtcooper 1978, Young 1984), before alternative food such as insects and other plant foods are available.

Deer mice and ground squirrels in agricultural ecosystems are omnivores (Whitaker 1955, 1972, Houtcooper 1978, Castrale et al. 1984, Johnson and Holm 1985), and the effects of these cropland residents are not always detrimental. Arthropods generally constituted the predominant portion of deer mouse diets (ranging from 33 to 85 percent by weight) in the studies just referenced, but Young (1984) collected food-habits data strictly during the period of corn emergence. He found that agricultural insect pests such as black cutworms *(Agrostis ipsilon)* and armyworms *(Pseudaletia unipuncta)* constituted from 14 to 39 percent of deer mouse diets in Iowa, suggesting a beneficial effect at the time of crop emergence. However, crop damage by rodents may reach economically significant proportions (greater than 5 percent), and control methods are sometimes necessary (Greaves 1982, Johnson and Holm 1985). Rodenticides such as zinc phosphide (Beasley and McKibben 1976) and seed repellents such as methiocarb and mesurol (Johnson et al. 1982, Zurcher et al. 1983) have been tested.

Wildlife Food Resources and No-Till

The proportion of waste grain buried by different tillage practices varies greatly (Warner et al. 1985), and hence, so does availability to wildlife. Fall tillage with the moldboard plow can bury as much as 98 percent of the waste grain (Warner et al. 1985). But intermediate levels of fall tillage, such as chisel or disk plowing, leave greater amounts of both residue and grain and may serve the purpose of mechanically shattering corn ears into pieces, thereby increasing the availability of the remaining waste grain to wildlife that cannot use waste ear corn (Baldassarre et al. 1983). No-till systems, in which fall tillage is avoided altogether, leave all residue and waste grain on the soil surface and would seem to provide the greatest food resources for wildlife through fall and winter. Castrale (1984a) found that untilled fields of corn and soybean residue supported higher densities and a greater diversity of birds in winter when compared with tilled crop fields. The availability of waste grain, however, may be highly dependent on weather patterns. No-till fields may more readily trap snow than conventionally tilled fields, making a more abundant food source less available. Thus, during a particularly severe winter when food is critical, no-till may offer no advantage to wildlife over some forms of fall tillage that create more open field conditions.

Crop residues in untilled fields also harbor arthropods that provide a potential food source for wildlife (Hill 1976, Whitmore 1982, Basore 1984), as well as pose a potential crop-damage problem. Some recent studies have indicated a greater abundance and diversity of arthropods in no-till than in conventionally tilled row crops (House and Stinner 1983, Warburton and Klimstra 1984). Blumberg and Crossley (1983) found that soil-surface arthropod communities in no-till fields were more diverse than those in either conventionally tilled grain sorghum (*Sorghum vulgare*) or old field habitat. Arthropod communities in no-till row crops also have been shown to exhibit relatively larger numbers of predators and parasitic species than do communities in conventionally tilled fields (Blumberg and Crossley 1983, Warburton and Klimstra 1984). Basore (1984), however, found that relative abundance and composition of arthropods were similar between no-till and conventionally tilled row crops during the brood rearing period for pheasants. Insect orders typically eaten by pheasants were observed in all no-till and conventionally tilled treatments. Most differences between treatments seemed to be associated with the type of crop grown or the application of pesticides rather than to the tillage practices or amount of residue, per se. More important, perhaps, is that comparisons made by other observers have suggested that row-crop fields are generally poor substitutes for insect-rich environments such as pastures, hayfields, and idle cover (e.g., Whitmore 1982). Illinois data have indicated that survival of pheasant chicks may be reduced by large expanses of row-crop acreage that have replaced prime brood-rearing cover such as oats and hay (Warner et al. 1984) Thus, although both no-till and conventionally tilled crop fields may provide some arthropod food resources for wildlife, the conversion of other habitats to row crops, even to no-till, is unlikely to be beneficial.

Future Adoption of No-Till Row Cropping and Implications

Acceptance of many conservation tillage methodologies for corn and soybean row cropping is an accomplished fact, and future growth is ensured by increasing public demands to control soil erosion (Ritchie and Follett 1983). Although more technological development is necessary, no-till row cropping seems to be entering a phase of rapid growth in comparison with other conservation tillage methods already widely accepted. Even so, it is unlikely that universal adoption of the practice will take place. Rather, the acceptance of no-till row cropping methods will depend largely upon their suitability to soils and slope, the economic feasibility of conversion from conventional systems (Jolly et al. 1983), and pressure to meet tolerable levels of soil loss. No-till may offer substantial crop yield and soil-saving advantages over conventional methods on steep or well-drained soils (Griffith et al. 1982). However, wet soils may be less conducive to no-till than to other tillage practices, and level land with limited erosion potential may not require cropping with no-till methods (Ritchie and Follett 1983). No-till planting can be less costly than conventional systems, but that is dependent upon time of planting and crop rotations that may necessitate additional pesticides (Griffith et al. 1982, Jolly et al. 1983), sometimes elevating the cost of no-till above that of other conservation tillage schemes. Any of the factors mentioned may limit the expansion of no-till in regions where such tillage practices could potentially provide the greatest benefit to wildlife. In parts of northern Iowa, for instance, nesting cover is a major limiting factor for birds (Farris et al. 1977). Yet, because of its poorly drained soils and flat topography, this region of the state is least likely to see rapid expansion of no-till.

Research thus far has shown that no-till row crops provide a cropfield ecosystem with attributes attractive to both birds and mammals (Basore 1984, Castrale 1984a, b, Warburton and Klimstra 1984, Young 1984). No-till row cropping of corn and soybeans, however, is not necessarily a boon to wildlife. First, the disparity in nesting densities and success recorded by Basore (1984) between no-till fields and strip cover suggests that, for at least some species, efforts to maintain and manage other habitats may be more effective than promoting greater use of no-till agriculture (Table 1). Second, no-till will be beneficial only to the extent that it replaces less favorable agricultural systems, such as conventionally tilled corn and soybeans. In Iowa, land use has been relatively stable in recent years, with about 26 million acres (10.5 million ha) in row crops (U.S. Soil Conservation Service 1984). But a recent survey revealed a medium-to-high potential for converting an additional 2.7 million acres (1.1 million ha) currently devoted to pasture, forest, and other land uses to cropland (U.S. Soil Conservation Service 1984). Similar possibilities exist in other agricultural states. USDA research, for instance, is in progress to determine suitability of using no-till and other methods for cropping soybeans on slopes up to 18 percent (Cacek 1984). Steep slopes such as these may well have formerly been untillable. In many cases, no-till would be employed to convert these more-preferred wildlife habitats to row crops. The effect of such a net gain in total row-crop acres will surely be negative for wildlife in most areas. Loss of alternative habitat types in intensively cultivated areas is critical because they provide wildlife requisites for nesting (Table 1), brood rearing and foraging areas, and ecological diversity. Data are needed on the pervasiveness of this type of habitat conversion.

The exposure of wildlife to chemicals routinely used in conservation tillage fields is another area of concern. Numerous studies of the effects of agricultural chemicals on wildlife have been published (see Hoffman and Eastin 1982, Fleming et al. 1983, and references therein), but little is known of either the immediate or long-term effects of many pesticides to wildlife under field conditions (Balcomb et al. 1984), particularly in the various forms of conservation tillage. Current data suggest that application of pesticides in no-till and other conservation tillage systems is highly variable (Crosson 1982, Hayes et al. 1983, Castrale 1984b, Conservation Tillage Information Center 1984). Levels of pesticide use with these methods, however, may be a secondary issue. More important, perhaps, is that increased wildlife use of conservation tillage fields in general (Castrale 1984a, b), and no-till fields in particular (Basore 1984, Warburton

Table 1. Relative value of various Midwest habitat types for nesting by ring-necked pheasants and nongame birds.

Habitat	Nest density per 100 acres (40ha)	Reference
Ring-necked pheasants		
Conventional corn	0	Basore (1984)
Narrow row soybeans	0	Wooley et al. (1982)
Conventional soybeans	0	Wooley et al. (1982)
No-till row crops[a]	1	Basore (1984)
Row crops[a]	7	Joselyn et al. (1968)
Strip cover[b]	13	Basore (1984)
Grassed terraces	35	Beck (1982)
Pasture	5-70	[c]Footnote
Waterways	90	Trautman (1982)
Fencerows	97-163	Baxter and Wolfe (1973), Trautman (1982)
Roadsides	20-200	[d]Footnote
Nongame birds		
Conventional corn	2	Basore (1984)
Narrow row soybeans	4	Wooley et al. (1982)
Conventional soybeans	13	Wooley et al. (1982)
No-till row crops[a]	13	Basore (1984)
Grassed terraces	14	Beck (1982)
Strip cover[b,e]	142	Basore (1984)
Fencerows	174	Shalaway (1979)
Osage orange hedge	223	Wooley (unpubl. data)
Idle pastures	122-259	Wooley et al. (1984)
Shrub plantings	627	Wooley (unpubl. data)
Farmstead shelterbelts	3,781	Yahner (1982)

[a]Row crops include corn and soybeans.
[b]Strip cover includes waterways, roadsides, terraces and fencerows.
[c]Range of densities from Joselyn et al. (1968), Baxter and Wolfe (1973), Gates and Hale (1975), Trautman (1982).
[d]Range of densities from Joselyn et al. (1968), Baxter and Wolfe (1973), Wolfe (1973), Mead (1973), Trautman (1982).
[e]Does not include birds nesting in woody vegetation.

and Klimstra 1984), creates a potential for increased contact with agricultural chemicals.

Possible routes of wildlife exposure to chemicals in conservation tillage are numerous, including contact transfer from parents or direct spraying of pesticides on eggs and young, and contamination through poisoned arthropod food sources. Resulting direct mortality or sublethal effects that reduce long-term survival or reproduction (Grue et al. 1983) could prove detrimental to species that nest, forage, or reside in conservation tillage fields. Recently, Balcomb et al. (1984) demonstrated that use of Furadan (a carbamate insecticide) in no-till fields resulted in significant mortality of birds. Hoffman and Eastin (1982) documented toxicity of paraquat, a commonly used herbicide in no-till, to mallard (*Anas platyrhynchos*) embryos. Castrale (1984b) found residues of the herbicides alachlor and paraquat, and apparent liver damage, in deer mice collected from conservation tillage fields in Indiana. Rodenticides used in other types of agricultural systems have resulted in secondary poisoning of predators (Mendenhall and Pank 1980, Hegdal et al. 1981, Kaukienen 1982), but little consideration has been given to this potential problem in corn and soybean row-crop systems. Clearly, there is a need to further quantify levels of use and the effects of pesticides in no-till and other conservation tillage systems under field conditions.

Although we have drawn heavily from Iowa studies on no-till (Basore 1984, Young 1984) and the small body of literature available on wildlife use of conservation tillage corn and soybean cropping systems (Castrale 1984a, b, Warburton and Klimstra 1984, Johnson and Holm 1985), our findings should be generally applicable in other regions where these agricultural practices occur. The current dearth of information, however, suggests a need for more research on the values and dangers of these systems to wildlife. Any future research on the effects of no-till and other conservation tillage strategies on wildlife should emphasize long-term approaches in which treatments are closely replicated and in which the influence of proximal habitat is thoroughly evaluated. Areas of investigation could include documenting conversion of marginal agricultural areas to row crops via no-till and other methods, the effects of resident avian and mammalian populations in no-till fields upon agricultural insect pests, and the direct and secondary effects of agricultural chemicals on avian and mammalian fauna of no-till fields. The importance of no-till row cropping to food and cover availability for game mammal populations and its effect on occurrence of nongame small mammals that currently have limited distribution throughout the corn belt are other possible areas of research.

Conservation tillage practices are becoming more widespread for reasons of economics and erosion control. Although unintentional, some attributes of these practices evidently are beneficial to wildlife, particularly in no-till row crops. that generalization, however, must be viewed in the context of the potential for loss of alternative habitats to these practices and dangers to wildlife from agricultural chemicals. More research is needed before definitive conclusions can be drawn about the long-term implications of this trend for farmland wildlife.

Acknowledgements

We thank the USDA-Soil Conservation Service, Iowa Conservation Commission, and Iowa Agriculture and Home Economics Experiment Station for financial support of this research. This article is Journal Paper No. J-11797 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa, Projects 2545 and 2462.

Literature Cited

Balcomb, R., C. A. Bowen, D. Wright, and M. Law. 1984. Effects on wildlife of at-planting corn applications of granular carbofuran. J. Wildl. Manage. 48:1353-1359.

Baldassarre, G. A., R. J. Whyte, E. E. Quinlan, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildl. Soc. Bull. 11:25-31.

Basore, N. S. 1984. Breeding ecology of upland birds in no-tillage and tilled cropland. M.S. Thesis, Iowa State Univ., Ames. 62pp.

Baxter, W. L., and C. W. Wolfe. 1973. Life history and ecology of the ring-necked pheasant in Nebraska. Nebraska Game, Fish, Parks Comm., Lincoln. 58pp.

Beasley, L. E., and G. E. McKibben. 1976. Mouse control in no-till corn. Illinois Agric. Exp. Sta., Dixon Springs Agric. Center, Simpson. DSAC 4:27-30.

Beck, D. W. 1982. Wildlife use of grassed backslope terraces in Iowa. Page 85 *in* Abstr., 44th Midwest Fish Wildl. Conf., Iowa Conserv. Comm., Des Moines.

Best, L. B. 1983. Bird use of fencerows: implications of contemporary fencerow management practices. Wildl. Soc. Bull. 11:343-347.

Blumberg, A. Y., and D. A. Crossley, Jr. 1983. Comparison of soil surface arthropod populations in conventional tillage, no-tillage, and old field systems. Agro-Ecosystems 8:247-253.

Cacek, T. 1984. Organic farming: the other conservation farming system. J. Soil and Water Conserv. 39:357-360.

Castrale, J. S. 1984a. Impacts of conservation tillage practices on farmland wildlife in southeastern Indiana. Fed. Aid Annu. Rep., Proj. No. W-26-R-15, Job XXXV-M-2-3, Population Levels and Habitat Use. Indiana Dep. Natur. Resour., Fish and Wildl. Div., Indianapolis. 11pp.

______. 1984b. Impacts of conservation tillage practices on farmland wildlife in southeastern Indiana. Fed. Aid Annu. Rep., Proj. No. W-26-R-15, Job XXXV-M-4, Pesticide Levels. Indiana Dep. Natur. Resour., Fish and Wildl. Div., Indianapolis. 27pp.

______. R. T. Speer, J. O. Whitaker, D. Benson, and C. D. Baker. 1984. Rodents in conventional and reduced tillage corn and soybean fields: population levels, food habits, and impacts of herbicides. Pages 97-98 *in* Abstr., 46th Midwest Fish Wildl. Conf., Indiana Dep. Natur. Resour., Indianapolis.

Conservation Tillage Information Center. 1983. The 1982 national survey of conservation tillage practices. CTIC, Ft. Wayne, Indiana. 83pp.

______. 1984. Lake Erie demonstration project: evaluating impacts of conservation tillage on yield, cost, and environment. CTIC, Ft. Wayne, Indiana. 18pp.

Cowan, W. F. 1982. Waterfowl production on zero tillage farms. Wildl. Soc. Bull. 10:305-308.

Crosson, P. 1982. Conservation tillage and conventional tillage: a comparative assessment. Soil Conserv. Soc. Amer., Ankeny, Iowa. 35pp.

Dumke, R., G. Burger, and J. March, eds. 1981. Proceedings of the symposium: wildlife management on private lands. Wisc. Chapt. Wildl. Soc., Madison. 576pp.

Farris, A. L., E. D. Klonglan, and R. C. Nomsen. 1977. The ring-necked pheasant in Iowa. Iowa Conserv. Comm., Des Moines. 147pp.

Fleming, W. J., D. R. Clark, Jr., and C. J. Henny. 1983. Organochlorine pesticides and PCB's: a continuing problem for the 1980's. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:186-199.

Gates, J. M., and J. B. Hale. 1975. Reproduction of an east central Wisconsin pheasant population. Tech. Bull. 85. Wisc. Dep. Natur. Resour. Madison 79pp.

Greaves, J. H. 1982. Rodent control in agriculture. Food Agric. Org., United Nations, New York. 88pp.

Gregory, W. W., and G. J. Musick. 1976. Insect management in reduced tillage systems. Bull. Entomol. Soc. Amer. 22:302-304.

Griffith, D., J. Mannering, D. Mengel, S. Parsons, T. Bauman, D. Scott, C. Edwards, F. Turpin, and D. Doster. 1982. A guide to no-till planting after corn or soybeans. Publ. ID-154. Coop. Ext. Serv., Purdue Univ., W. Lafayette, Indiana. 11pp.

Grue, C. E., W. J. Fleming, D. G. Busby, and E. F. Hill. 1983. Assessing hazards of organophosphate pesticides to wildlife. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:200-220.

Hayes, W., J. Antognini, G. Jacques, and A. Worsham. 1983. Weed control: a panel discussion. J. Soil and Water Conserv. 38:194-200.

Hegdal, P. L., T. A. Gate, and E. C. Fite, 1981. Secondary effects of rodenticides on mammalian predators. Pages 1781-1793 *in* J. A. Chapman and D. Pursley, eds., Worldwide Furbearer Conf. Proc., Maryland Wildl. Admin., Annapolis.

Higgins, K. F. 1975. Shorebird and game bird nests in North Dakota croplands. Wildl. Soc. Bull. 3:176-179.

Hill, H. R. 1976. Feeding habits of the ring-necked pheasant chick, *Phasianus colchicus,* and the evaluation of available foods. Ph.D. Thesis. Michigan State Univ., East Lansing. 84pp.

Hoffman, D. J., and W. C. Eastin, Jr. 1982. Effects of lindane, paraquat, toxaphene and 2, 4, 5-trichlorphenoxyacetic acid on mallard embryo development. Arch. Environ. Contam. Toxicol. 11:79-86.

House, G. J., and B. R. Stinner. 1983. Arthropods in no-tillage soybean agroecosystems: community composition and ecosystem interactions. Environ. Manage. 7:23-28.
Houtcooper, W. C. 1978. Food habits of rodents in a cultivated ecosystem. J. Mammal. 59:427-430.
Johnson, R. J., A. E. Koehler, and O. C. Burnside. 1982. Rodent repellants for planted grain. Pages 205-209 *in* R. E. Marsh, ed., 10th Vertebrate Pest Conf., Univ. of California, Davis. 209pp.
Johnson, R. J., and K. E. Holm. 1985. Rodents in conservation-tillage fields: net loss or gain? Conservation Tillage for Row Crop Production. Inst. Agric. Nat. Resour., Univ. Nebraska, Lincoln. Tillage Conf. Proc. 4:161-166.
Jolly, R. W., W. M. Edwards, and D. C. Erbach. 1983. Economics of conservation tillage in Iowa. J. Soil and Water Conserv. 38:291-294.
Joselyn, G. B., J. E. Warnock, and S. L. Etter. 1968. Manipulation of roadside cover for nesting pheasants—a preliminary report. J. Wildl. Manage. 32:217-233.
Kaukeinen, D. 1982. A review of the secondary poisoning hazard potential to wildlife from the use of anticoagulant rodenticides. Proc. Vertebr. Pest. Conf. 10:151-158.
Linduska, J. P. 1950. Ecology and land-use relationships of small mammals on a Michigan farm. Michigan Dep. Conserv., Game Div., Lansing. 144pp.
Mannering, J. V., and C. R. Fenster. 1983. What is conservation tillage? J. Soil and Water Conserv. 38:141-143.
Mead, T. L. 1973. Pheasant production on lands diverted for wildlife and other cover types. M.S. Thesis. Univ. Nevada, Reno. 51pp.
Medenhall, V. M., and L. F. Pank. 1980. Secondary poisoning of owls by anticoagulant rodenticides. Wildl. Soc. Bull. 8:311-315.
Reichenbach, W. H., and J. R. Peden. 1984. Conservation tillage benefits agriculture and wildlife. Pages 96-97 *in* Abstr. 46th Midwest Fish Wildl. Conf., Indiana Dept. Natur. Resour., Indianapolis.
Ritchie, J. C., and R. F. Follett. 1983. Conservation tillage; where to from here? J. Soil and Water Conserv. 38:267-269.
Rodenhouse, N. L., and L. B. Best. 1983. Breeding ecology of vesper sparrows in corn and soybean fields. Amer. Midl. Nat. 110:265-275.
Rodgers, R. D. 1983. Reducing wildlife losses to tillage in fallow wheat fields. Wildl. Soc. Bull. 11:31-38.
______, and J. B. Wooley, Jr. 1983. Conservation tillage impacts on wildlife. J. Soil and Water Conserv. 38:212-213.
Shalaway, S. D. 1979. Breeding bird abundance and distribution in fencerow habitat. Ph.D. Thesis, Michigan State Univ., East Lansing. 73pp.
Soutiere, E. C. 1984. Farm wildlife production: what does it cost? Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:159-163.
Taylor, M. W., C. W. Wolfe, and W. L. Baxter. 1978. Land-use change and ring-necked pheasants in Nebraska. Wildl. Soc. Bull. 6:226-230.
Trautman, C. G. 1982. History, ecology and management of the ring-necked pheasant in South Dakota. S.D. Dep. Game, Fish, Parks, Pierre. 118pp.
Triplett, G. B., Jr., and D. M. VanDoren, Jr. 1977. Agriculture without tillage. Sci. Amer. 236:28-33.
U.S. Soil Conservation Service. 1984. National resources inventory, Iowa. Unpubl. State Rep., SCS, Des Moines, Iowa. 50pp.
Warburton, D. B., and W. D. Klimstra. 1984. Wildlife use of no-till and conventionally-tilled corn fields. J. Soil and Water Conserv. 39:327-330.
Warner, R. E., S. L. Etter, G. B. Joselyn, and J. Ellis. 1984. Declining survival of ring-necked pheasant chicks in Illinois agricultural ecosystems. J. Wildl. Manage. 48:82-88.
Warner, R. E., S. P. Havera, and L. M. David. 1985. Effects of fall tillage systems on corn and soybean harvest residues in Illinois. J. Wildl. Manage. (in press).
Warnock, J. E., and G. B. Joselyn. 1964. Nesting of pheasants in soybean fields. J. Wildl. Manage. 28:589-592.
Whitaker, J. O., Jr. 1966. Food of *Mus musculus, Peromyscus maniculatus bairdi* and *Peromyscus leucopus* in Virgo County, Indiana. J. Mammal. 47:473-486.
______. 1972. Food and external parasites of *Spermophilus tridecemlineatus* in Virgo County, Indiana. J. Mammal. 53:644-648.

Whitmore, R. W. 1982. Insect biomass in agronomic crops as food for ring-necked pheasant chicks, *Phasianus colchicus*. Ph.D. Thesis. Univ. Nebraska, Lincoln. 67pp.

Wooley, J. B., Jr. R. George, B. Ohde, and W. Rybarczyk. 1982. Nesting evaluations of native grass pastures and narrow-row soybeans. Pages 5-6 *in* R. B. Dahlgren, ed., Proc. Midwest Agric. Interfaces Fish Wildl. Res. Workshop, Coop. Wildl. Res. Unit, Iowa State Univ., Ames.

Wooley, J. B., Jr., R. George, and R. Munkel. 1984. Evaluation of upland cover types on state wildlife management areas. Fed. Aid Compl. Rep., Study No. 4, Proj. W-115-R, Iowa Conserv. Comm., Des Moines. 26pp.

Yahner, R. H. 1982. Avian nest densities and nest site selection in farmstead shelterbelts. Wilson Bull. 94:156-175.

Young, R. E. 1984. Response of small mammals to no-tillage agriculture in southwestern Iowa. M.S. Thesis. Iowa State Univ., Ames. 68pp.

Zurcher, N. J., R. J. Johnson, and R. H. Timm. 1983. Methiocarb and thiram as corn seed repellents for thirteen-lined ground squirrels. Wildl. Soc. Bull. 11:38-42.

Ducks Unlimited's Agricultural Extension Program

Wayne Fraser Cowan
Ducks Unlimited Canada
1190 Waverley Street
Winnipeg, Manitoba, R3T 2E2

Introduction

Ducks Unlimited (DU) has preserved, developed, and maintained wetlands on privately owned farmlands in prairie Canada since the drought of the 1930s. As land values increased and agriculture intensified, diverse methods of procurement and management were added to provide landowner benefits such as flood control, back-flood hay production, fish, fur, hay and grazing. To date, we have secured about 3.5 million acres (1.4 million ha) of duck breeding habitat across Canada, an impressive achievement. But we are by no means winning the battle, for, on the broad front, duck breeding habitat is deteriorating at a rate far beyond the financial capability of any conservation agency to ameliorate.

Agricultural Impacts

Soil and Water Conservation

The Canadian prairie farmlands are undergoing a transition from a rich mixture of crops, pastures, woodlands, wetlands and native grasslands, to monoculture cropland. For example, 12.7 million acres (5.1 million ha) were "improved" while "unimproved" lands declined by 8 million acres (3.2 million ha) in the period 1961 to 1981.

Meanwhile, "improved" lands in fallow increased by 5.7 million acres (2.3 million ha) (Statistics Canada 1961, 1981). Since virtually all arable soils were already in production, these new lands were mainly of marginal agricultural capability.

Excessive cultivation has been accumulating impacts on our natural resources. Fall tillage, "black" summerfallow, row-cropping, overgrazing, and cultivating low quality soils have increased soil erosion, degradation, and salinization, decreased soil fertility and moisture retention capacity, driven down water tables, and polluted wells. Off-site damages include higher frequencies of flooding, wind and water erosion, stream flow imbalances, sedimentation, and pollution.

Duck Breeding Habitat

Conversion of native habitat affects mainly classes I to III potholes. Of the remaining wetlands, an average 51 percent, and as high as 94 percent, are impacted annually by farming activities (Caswell and Brace 1984). Sedimentation and salinization may prove the most destructive forces over the long run.

Duck nests and cover in stubble fields and haylands are destroyed by tillage and mowing operations. Higgins (1977) determined that only 8 to 15 percent of duck nests in stubble fields under zero tillage management in North Dakota hatched; Giroux (1981) calculated an average 14.4 percent from the current literature. Nests in the remaining strips and patches of native cover are highly vulnerable to predators.

Farm Economy

Declining soil capability is masked by massive doses of fuel, fertilizer, and pesticides at a time of escalating prices for petroleum. Agricultural policies offer incentives for immediate increased production, little for soil and water conservation, and virtually nothing to preserve native lands. Easy loans for land "improvements" and large machines, government assistance programs, and lax municipal land use regulation have been followed by increased taxes and loan interest rates, and dropping produce prices. A great many Canadian farmers are now in financial jeopardy.

Progressive farmers and groups such as the Manitoba-North Dakota Zero Till Farmers' Association are proving that conservation tillage practices are economically viable in western Canada. They have been supported to varying degrees by research and extension efforts of individual universities, provincial agronomists, and private agencies. The Canadian government is studying the problems of soil and water management (Sparrow 1984) but, to date, has not instituted a comprehensive program to solve them.

Investigation of Agricultural Extension Possibilities

In 1976, I began studying the impacts of agricultural technology and policies on natural resources in the Canadian prairies. The objectives were (1) to select soil and water conserving farming practices that benefit duck production, and (2) to devise programs to influence large scale adoption of them.

It was determined that the required changes must meet four criteria to be accepted by farmers. These were, in order of importance:

1. economic incentive or production at a profitable rate;
2. maintenance or improvement of soil quality;
3. improved management and distribution of moisture; and
4. reduced impacts on duck breeding habitat or increased duck production.

I selected one conservation farming method from each of the three major land use categories, grain production, summerfallowing, and pasturing, that showed greatest promise on the bases of farmer interest, low initiation cost, adaptability to western farms, and benefit to breeding waterfowl.

Zero Tillage

The Manitoba Department of Agriculture sponsored a test of zero till spring-seeded small grain with cooperating farmers throughout southwest Manitoba, beginning in 1977. They determined that it was economically comparable to, or advantageous over, conventional farming practices, but depended on astute management.

I took the opportunity to study the effects on duck production on two of these farms in the Minnedosa potholes region in 1977 and 1978 (Cowan 1982). Seed drill operators cooperated by avoiding nests and covering the eggs. Duck nest density on zero till croplands was one nest per 20 acres (8 ha). Success rate was 60 percent. This compared to one nest per 135 acres (55 ha), and zero success, on cultivated croplands. Brood production of upland nesting species in all habitats combined on each farm type was increased by 3.8 times. Duebbert (1984) found a nest per 30 acres (12 ha) and success rate of 26 percent on 4,000 acres (1,620 ha) of zero till crops in North Dakota.

I concluded that provision of standing stubble as nesting cover on croplands induced a dispersal of nests over all available habitats, reduced predation, and significantly increased duck production.

Winter wheat and fall rye farming features zero till seeding in fall, few or no field operations during the duck nesting season, early crop growth that improves nesting cover, and early harvest that virtually eliminates depredation by waterfowl. Interest in the crop has always been high and institution of the zero till method assured its economic success.

Pesticides

Many farmers are concerned about the effects of pesticides on personal and public health and the environment. However, many conservation tillage systems have the potential to reduce the effects of herbicides or amounts used. For example, winter wheat crops often require only 2-4,D in fall, with early crop growth providing control of weeds in spring and summer. Many of the herbicides developed for minimum and zero tillage feature rapid breakdown and non-persistence in the environment (Sprankle et al. 1975a, 1975b). Reduction or elimination of erosion reduces the movement of chemicals off target, especially into wetlands.

The key herbicides used with zero tillage were investigated to determine their probable effects on egg hatchability. Roundup, or glyphosate [N-(physophonomethyl) glycine] is used to eradicate weeds at the time of seeding in spring and to control incursions of perennial weeds. Batt el al. (1980) found no significant effect of Roundup on egg hatching rate. Tests of Poast and Hoechst 00736 (experimental) herbicides developed for weed control in the crop, gave similar results (Batt et al. 1985). There have been no negative effects on bird eggs demonstrated for 2-4,D although it has been in use for 40 years.

There is no proof that minimum or zero till crops reduce or increase insecticide use. Warburton (1984) concluded that a better balanced community of invertebrates developed, with a high proportion of predaceous insects, in zero till corn fields, while agricultural pest species dominated tilled corn fields. Similarly, balanced populations of small birds and mammals have been noted in zero till small grain fields (Cowan 1982, Basore and Best 1982).

Zero till crop production may hold potential for biological pest control which could reduce the use of insecticides and minimize their negative effects. It is essential, however, to maintain a close scrutiny over the use of chemicals developed for minimum and zero tillage croplands.

Stubble Mulch Fallow

Summerfallow covers 25 million acres (10 million ha) annually in western Canada. The majority is in arid southwest Saskatchewan and southeast Alberta, where our program is targeted.

DU borrowed the stubble mulch summerfallow technique from the U.S. Soil Conservation Service as practiced in the northern great plains. It combines the application of herbicides in fall and spring, and an undercutting cultivator in summer, to control weeds. This retains standing stubble until at least mid-June and thereafter buries only 10 percent of surface cover with each cultivation.

This system increases organic soil content and moisture retention, and eliminates erosion, in comparison to the intensive tillage systems in vogue (Johnson and Davis

1972, Bauer and Black 1981). It is also much cheaper than total chemical fallow.

There have been no studies of duck production on stubble mulch fallow. However, the measured success of breeding pheasants and other birds in Kansas (Rodgers 1983) and the advantages to ducks of stubble fields under zero till management (Cowan 1982, Duebbert 1983, Madsen 1984), led me to conclude that stubble mulching would increase duck production in western Canada.

Rotational Grazing

In the Canadian parkland, the livestock industry is considered as secondary at best and pasture management has generally been neglected. Overgrazing, inadequate production, and market disincentives are chronic problems that encourage conversion of these low capability soils to cropland. This often involves wetland drainage.

Provincial departments of agriculture promote the use of fertilized tame forages and rotational grazing to boost pasture production, however the high initiation costs are often prohibitive. Rest rotation management as used on arid rangelands in Montana capitalizes on the phenological development of native prairie plants by providing for timely movement of cattle between paddocks (Hormay 1961). Gjersing (1975) found that duck production was increased by four times over ranges grazed season long. The improved forage provided nesting cover of which a large portion was undisturbed throughout the nesting season. Shoreline vegetation flourished, thereby enhancing brood cover. This was supported by findings in South Dakota (Evans and Krebs 1977).

Agricultural Extension Program

Duck Unlimited initiated a program in western Canada in 1979 to promote conservation farming methods and preservation of native habitats. This featured co-sponsorship of the Manitoba Land Use Conference, the "Health of the Land" pamphlet series, film, radio and television advertisements, presentations and displays at major agricultural conferences, and briefs to land use commissions.

In 1983, we started demonstrating conservation farming methods. The program addressed three major land uses: winter wheat production, stubble mulch summerfallow, and rotational grazing. Demonstrations were set in pothole areas where present land use impacts on duck production.

Demonstrations required the leadership and expertise of local agricultural representatives and specialists, and cooperation of farmers who provided the land and management. DU covered special costs of initiation, and assisted with advertising and tours.

Winter Wheat

The winter wheat demonstration involved three agricultural representatives and nine farmers in an area of Saskatchewan rich in wetlands but impacted severely by intensive fall and spring cultivation. DU provided specialized seed drills by means of rental from a local dealer. Approximately 1,000 acres (400 ha) of stubble fields were zero-till seeded in fall 1984 and a similar area will be seeded next year. This new habitat has the potential to produce a minimum 42 ducks per year on the basis of an estimated one nest per 30 acres (12 ha), 25 percent nest success rate, and five ducks fledged per brood.

Saskatchewan farmers seeded 1.7 million acres (688,000 ha) of winter wheat in fall 1984. At least half was in the potholes duck breeding area. The mimimum potential duck production was 70,800 ducks. All indications are that the acreage will continue to expand and that Manitoba and Alberta will follow.

As winter wheat production increases in southwestern Manitoba there will be an increased potential for outbreaks of diseases indigenous to that area (Evans 1983), which could effectively eliminate this crop in an important duck production area. DU will cooperate with the universities of Saskatchewan and Manitoba to assist funding of disease surveys and complete development of a disease resistant strain of winter wheat.

Stubble Mulch Fallow

Stubble mulching was compared to traditional cultivation methods on four summerfallow fields in the Missouri Couteau in south-central Saskatchewan in 1984. Each field was divided evenly and observed for weed control, moisture retention, and erosion control. Weed control costs were similar, but much more moisture was retained and soil better stabilized on the stubble mulch fields. Approximately 24 farmers observed the undercutter operation during the field tour in mid July. Crop performance on these fields will be measured next year to demonstrate economic feasibility.

All four farmers agreed to provide demonstrations on alternate fields in 1985. Two more projects will be initiated, one in south central Saskatchewan and another in southeast Alberta. We will provide farmer tours on all three and will have a video tape made to promote the technique extensively.

Rotational Grazing

We devised, in cooperation with livestock specialists in the Alberta Department of Agriculture, a rotational grazing method that incorporated principles of both the rest-rotation and tame forage systems. We initiated a trial demonstration on a 160-acre (65 ha) pasture near Red Deer in 1983. It took advantage of the resources already in place: water provided by natural wetlands, bushland, tame forage on unharvested haylands, and existing fences. Ducks Unlimited provided materials for construction of cross-fencing and nitrogen fertilizer for the tame forages.

This provided two paddocks totalling 47 acres (19 ha) of tame forage for spring and fall grazing and four paddocks comprising 97 acres (39 ha) of native grasslands. Sixty cows and calves grazed the tame forage from mid-May to the end of June. Second growth hay was harvested in mid-July from one of them. Three of the native paddocks were grazed from early July until mid-September and the remaining one was untouched. It was assumed that duck nesting was undisturbed in all of the native pastures, or 67 percent of the available cover.

The farmer increased his herd to 81 steers in 1984 and followed a similar pattern of rotation. The cattle entered the first native paddock in mid-June, second in early July, and the other two well after the nesting season. No hay was harvested in this fourth year of continuous drought.

A second rotational pasture was installed on a 120-acre (49 ha) pasture in Alberta and another on 90 acres (36 ha) in Saskatchewan in 1984. Both proved productive of forage and beef and provided 80 acres (32 ha) and 60 acres (24 ha), respectively, of cover unmolested throughout the nesting season. In 1985, we will have one more demonstration in Saskatchewan and two in Manitoba.

DU sponsored the development of a promotional video tape and 16 mm film featuring rotational grazing. This was distributed to all regional agricultural extension offices and rural television stations in the three prairie provinces. It is presently being used to inform Canadian farmers about the specific methods and many benefits of rotational grazing.

Conclusion

The soil conservation movement that is growing in western Canada can provide significant benefits for waterfowl and other wildlife. We know that croplands and pastures intensively managed to conserve soil and moisture provide components of the habitat requirements of many species, such as safe nesting cover and food. Zero tillage, winter wheat, stubble mulch fallow, and rotational grazing techniques fit this mold.

Many other crop management methods are available that can benefit soil, water, and wildlife. For example, forages or other perennial crops planted to replace summerfallow preserve soil quality, increase nutrients, eliminate erosion, and provide nesting cover. Similarly, forages planted at outer borders of some wetlands reduce the spread of salinity into cropland. Agriculture is presently investigating ways to make these practices economical and thereby induce farmers to employ them.

Wildlife agencies cannot become complacent in light of these efforts. We must be aware that native habitats, and especially wetlands, are still at risk. Alberta Agriculture, for instance, is poised to begin a program of wetland drainage unprecedented in scope or intensity. It is provincially funded, and designed to increase grain production.

To combat this onslaught, it will require that farmers receive financial benefits for retaining wetlands. These should come from the public who, after all, stand to gain the most direct benefit from preserving wetlands. The public will accept this only when they have been shown the wetland functions and benefits that they receive by retaining them. Thus, an extensive education program is required.

Financial benefits could be channeled to landowners through changes in major policies such as provincial tax assessment on farm lands and the Canadian Wheat Board quota system. Sparrow (1984) suggested these be instituted in combination to provide powerful economic incentives to preserve wetlands. But these ideas must be promoted to the farmers and local governments, and this requires an all-out educational effort.

I invite all of you who represent the various natural resource agencies and institutions and the general public to join in a cooperative effort to help our farmers manage farm lands for the multiple land use benefit of all users. This is a problem we all share and one we must work together to solve.

As wildlife managers, we have so often taken a reactive role, treating the symptoms of inappropriate land use. We can be much more effective by cooperating with sister agencies like agriculture in land use planning, resource allocation, and promotion of proper land use methods, to provide preventative management. The old saying still holds: "An ounce of prevention is worth a pound of cure."

Literature Cited

Basore, N.S., and L.B Best. 1982. The effects of no-till farming on nesting birds. 44th Midwest Fish and Wildl. Conf.,Des Moines, Iowa.

Batt, B. D. J. , J. A. Black and W. F. Cowan. 1980. The effects of glyphosate herbicide on chicken egg hatchability. Canadian J. Zool. 58 (10) : 1940-1942.

Batt, B. D. J., M. Wayland, and W. F. Cowan. 1985. The effects of Poast and Hoeschst 00736 herbicides on chicken egg hatchability. Delta Waterfowl Research Sta.,Delta, Manitoba.(unpub. rep.)

Bauer, A., and A. L. Black. 1981. Soil carbon, nitrogen and bulk density in two cropland tillage systems after 25 years and in virgin grassland. Soil Sci. Soc. Amer. J. 45:1160-1170.

Caswell, D., and R. K. Brace. 1984. Prairie waterfowl status report; Briefing document. Canadian Wildl. Serv., West and North Region. (Unpub. rep.)

Cowan, W. F. 1982. Waterfowl production on zero tillage farms. Wildl. Soc. Bull 10:305-308.

Duebbert, H. F. 1983. Nesting and production of dabbling ducks in relation to zero tillage small grain farming. U. S. Fish and Wildl. Serv. Work Unit 905.12. (unpub. data).

Evans, K. E., and R. R. Krebs. 1977. Avian use of livestock watering ponds in western South Dakota. Gen. Tech. Rep. R M - 35 U. S. Dept. of Agric. For. Serv., Fort Collins, Colo. 11pp.

Evans, L. E. 1983. Breeding for disease resistance. Winter Wheat Symposium, Saskatoon, Sask., June 1983.

Giroux, J. F. 1981. Nesting cover in prairie and parkland habitats. Chapter 2 *in* Biological techniques manual. Ducks Unlimited (Canada). (unpub. rep.).

Gjersing, F. M. 1975. Waterfowl production in relation to rest-rotation grazing. J. Range Manage. 28(1):37-42.

Higgins, K. F. 1977. Duck nesting in intensively farmed land in North Dakota. J. Wildl. Manage. 41(2):232-242.

Hormay, A. L. 1961. Rest-rotation grazing. . .a new management system for perennial bunchgrass ranges. Prod. Res. Rep. No. 51. U.S. Dep. Agric. For. Serv., Washington, D. C. 41pp.

Johnson, W. C., and R. G. Davis. 1972. Research on stubble-mulch farming of winter wheat. Conserv. Res. Rep. 16. U. S. Dep. Agric., Agric. Res. Serv., Washington, D. C. 13pp

Madsen, C. 1984. Mid-Continent waterfowl management project. Ann. Rep. U. S. Fish and Wildl. Serv., Fergus Falls, Minn.P14.

Rodgers, R. D. 1983. Reducing wildlife losses to tillage in fallow wheat fields. Wildl. Soc. Bull 11 (1):31-38

Sparrow, Hon. H. O., Chairman. 1984. Soils at risk; Canada's eroding future. Rep. on Soil Conserv. by Standing Committee on Agric. , Fish., and For. , to the Senate of Canada. Ottawa 129 pp.

Sprankle, P., W. F. Meggit, and D. Penner. 1975a. Rapid inactivation of glyphosate in the soil. Weed Sci. 23:224-228.

Sprankle, P., W. F. Meggit and D. Penner. 1975b. Absorption, mobility and microbial degredation of glyphosate in the soil. Weed Sci. 23:229-234.

Statistics Canada. 1961, 1981. Censuses of Agriculture. Statistics Canada, Ottawa.

Warburton, D. B. , and W. D. Klimstra. 1984. Wildlife use of no-till and conventionally tilled corn fields. J. Soil and Water Conserv. 39(5):327-329.

Present and Future Use of Herbicides in Conservation Farming

Kent M. Reasons
E. I. duPont Nemours and Co., Inc.
Wilmington, Delaware 19898

Conservation farming is a practice that encompasses sciences, technologies, and industries, as well as economic and environmental considerations. Conservation farming as the agricultural industry looks at it, revolves primarily around the tillage practices employed to produce a specific crop in a specific geographical location. The use of herbicides can be logically considered as a replacement for tillage.

The term conservation farming is commonly used interchangeably with minimum tillage, no-till, and conservation tillage, and has been defined by numerous researchers. I will add yet another personal definition to this long, descriptive list. To me, conservation farming is a practice which optimizes food and fiber production with a minimum disruption of natural resources and the environment. You may not totally agree with my definition, but as my company approaches the task of research and development to discover and commercialize improved crop protection chemicals for world agriculture, this is one of our key objectives.

Most, if not all, farmers in the U.S. today, and in most countries of the world, recognize that their most important non-renewable or semi-renewable resources are soil and water. These two resources, combined with our highly favorable climate and advanced technology from both public and private research, have made American agriculture the world's most efficient and productive. With this in mind, it is only natural that farmers readily adapt new techniques and technologies to maximize productivity and to preserve these resources; however, production economics are almost always the key to acceptance of new practices or technologies. Conservation tillage or conservation farming is certainly a technology or, better stated, a combination of technologies that give farmers an excellent tool to accomplish these objectives.

Conservation farming, as we know it today, is relatively new to agriculture. As recently as 1960, conservation tillage or conservation farming was employed on only very minimal percentage of tilled U. S. cropland. In 1980, approximately 20 percent of the tilled cropland was under some form of conservation farming. The U.S. Department of Agriculture (USDA) projects that by 1990 conservation farming will grow to 50 percent and by 2010 to 95 percent of the tilled U.S cropland! This technology has progressed rapidly , and many new tools have recently become available to farmers. However, I would propose that many of the technologies to be employed in conservation farming in the year 2010 have not yet been envisioned by today's scientist.

Two of the major reasons that conservation farming had been slow to gain acceptance were (1) the lack or inadequacy of farm implements to prepare seed beds and obtain plant populations without completely eliminating plant residues from the soil surface and (2) herbicides that would effectively eliminate existing vegetation and/or control weeds after the desired crop emerged.

Even though the Soil Conservation Service, USDA, and universities have long recognized the need to control soil erosion and to conserve soil moisture, because of the two previously stated limitations, farmers continued to plow the soil with the primary objectives of establishing crops and controlling weeds. The practices of contour farming, strip cropping, and terracing have been well established for many years, but even with these practices our most valuable resources, including wildlife, were continually subjected to extreme pressures, and the losses were, and in some regions continue to be, staggering. Unless these losses are brought under control, the productivity of American agriculture will continue to be threatened. Today's research is discovering and introducing high technology herbicides that will contribute significantly to controlling these losses.

Let's take a brief look at a few historical aspects of the use of herbicides in conservation farming. The advent of selective herbicides in the late 1940s and early 1950s gave farmers the first real chemical technologies to assist in conservation farming.

The herbicides of the past two to three decades have been and continue to be valuable tools, but have limitations that inhibited acceptance of conservation farming. These products tended to be characterized by: high use-rate per unit area; frequently long soil persistence; broad spectrum weed control, and narrow spectrum crop selectivity, and in some cases these early compounds were hard on certain wildlife species. These characteristics meant that the crops where conservation farming could be practiced were limited, and in many cases the farmer's crop rotation possibilities were even more limited.

Further, many of these early compounds were entirely soil active and required well-prepared seed beds for best performance. Many had to be soil incorporated, which essentially eliminated plant residues from the soil surface. These characteristics further limited their use in conservation farming.

Definitive data are not available, however, I am confident that the growth in conservation farming from 1960 to 1980 and the even greater growth projected for the future can be directly correlated with two technologies:(1)improved and more efficient herbicides with fewer of the limitations already discussed and (2)the development of specialized farm implements specifically designed for conservation farming. I am convinced that both public and private research will continue to be devoted to improvements in these areas and these trends will continue. I assure you, my company and others are dedicated to on-going research to discover and develop even more improved herbicides that are adaptable to conservation farming practices.

I have talked mostly about the past use of herbicides and some of their shortcomings that have slowed the acceptance of conservation farming. Now I would like to turn to the present and discuss what is happening with current herbicides in conservation farming, and then, if you will allow, I will attempt to make some future projections in this area.

In the past decade, crop protection chemical research and, in particular, herbicide research, has become more directed. This means that industry is looking for specific compounds to do specific jobs in specific crops.

Several farmer and society needs have driven industry and public research organizations to develop herbicides with characteristics dramatically different from the characteristics of the early generation herbicides that I described earlier. The newer herbicides that are currently in the market and products that will be commercialized within the next few years can be generally described as:

1. Highly active, requiring very low use rates per unit area.
2. Very specific with respect to spectrum of herbicidal activity and crop selectivity.

3. Effective postemergence with systemic activity, which means that they need to be applied only to the plant foliage, thus eliminating the need for soil tillage to ensure results and yet give long lasting residual control of undesirable vegetation.
4. Toxicologically safe and environmentally suitable.

The segment of U.S. agriculture with the longest history of practicing conservation farming is the cereal belt of our Great Plains. Much of this area is characterized by low rainfall and rolling terrain which is very susceptible to both wind and water erosion. In many areas, the annual rainfall will support a cereal crop every other year. In the off year, it is essential to control vegetation to preserve and accumulate moisture for the next crop and at the same time maintain a residue of plant debris on the soil surface to prevent erosion.

The traditional method of controlling vegetation during the fallow period was mechanical cultivation. The three to five cultivations that were required effectively controlled the vegetation, but had several disadvantages:

1. During periods of rain or snow the bare soil allowed rapid run-off, losing much of the needed water to streams and rivers and taking valuable soil with it.
2. The unprotected soil was subjected to high winds at the immediate surface, creating even more soil loss.
3. The escalating cost of equipment, labor, and petroleum products greatly increased the total cost per acre when three to five cultivations were made.
4. The frequent and thorough cultivation wreaked havoc on wildlife nesting habitats. Hormone-type herbicides such as 2,4-D and others were the early herbicides used. However, cultivation was still required as these products did not control the grassweeds or volunteer cereals, plus they have no residual control and multiple applications were required. Obviously these products alone were and are not the answer.

In the mid-70s, soil residual herbicides with grass activity were added to the hormone sprays. These treatments usually achieved the desired conservation objectives; however, frequently the next crop was adversely affected by the residual herbicide remaining in the soil and causing injury to the next crop.

Products such as *Paraquat* and *Round-up* are effective tools in conservation farming. They control most grass and broadleaf weeds, but again do not have residual activity and thus require cultivation or repeated applications to maintain vegetation-free fields during the fallow period. Again, not the complete answer.

In more recent years, selective products such as *Poast* and *Fusilade* have become available. These products are active against more grassweeds but have little to no activity on broadleaf weeds and have no soil residual. Again, very effective tools, but not the answer we seek.

In more recent years, *"Glean"* herbicide has been introduced for the control of broadleaf weeds and some grasses in cereal production. *"Glean"* is active both as a foliar application to growing vegetation and has soil residual activity which provides lasting control. The addition of *Round-up* or other grass active compounds is usually required to control volunteer cereals and other grasses.

An application of *"Glean"* plus *Round-up* applied after harvests and when weeds and volunteer cereals have germinated will control the existing vegetation, and the residual herbicidal activity of *"Glean"* will maintain a weed-free field through the fallow period and until the next planting season. Since *"Glean"* is registered by the

EPA for use in the cereal crop, the farmer can plant his next cereal crop without concern about crop damage from the residual herbicide. *"Glean"*, plus other new products emerging from modern crop protection chemical research, will better meet the needs of farmers, conservationists, and society in general.

"Glean" and other high technology new products from Du Pont's research are typically characterized by:

1. High herbicidal activity and crop selectivity. Weeds are controlled by application of one-third to one-half ounce or less per acre with cereals and other tolerant crops tolerating applications at 10X or greater rates.
2. Low mammalian toxicity and safety to wildlife: LD_{50} in rats 5545 mg/kg—males and 6293 mg/kg—females; LD_{50} bobwhite quail 5000 mg/kg; LD_{50} mallard duck 5000 mg/kg; and not bio-accumulated in bluegill sunfish.

These attributes of *"Glean"* and other related compounds currently in research and development will give cereal farmers and others, additional tools to effectively and profitably practice conservation farming.

New herbicides are making significant contributions toward the reduction of tillage and the acceptance of conservation farming in other major acreage crops such as soybeans and corn. Traditionally, these two crops have been grown under full tillage systems. The advent of atrazine for use in corn some 20 years ago allowed many corn farmers to plant corn into untilled or minimum tilled fields and effectively control weeds with pre- or postemergence applications of atrazine.

In double crop soybeans, which follow winter wheat, the use of *Paraquat* or *Round-up* in combination with *"Lorox"* allows farmers to plant soybeans immediately following wheat harvest, into the wheat stubble with minimum disturbance to the soil. The *Paraquat* or *Round-up* effectively controls the existing vegetation and *"Lorox"* gives residual control of later germinating weeds. This accomplishes several objectives: (1) the available time for planting following wheat harvest is short, thus when seed bed tillage is eliminated valuable growing time is saved; (2) needed soil moisture is not lost during a tillage operation; (3) the soil is not subjected to potential wind or water erosion; and (4) wildlife which nest in established wheat are not disrupted.

In full season soybeans, the advent of new postemergence grass herbicides such as *Poast, Fulisade* and *"Assure"* allows farmers to plant minimum till, no-till, or narrow row soybeans, which leaves 30+ percent of the previous crop residue on the soil surface. This practice is not workable with many of the older soil active herbicides. There are new postemergence broadleaf herbicides, introduced within the past three years, such as *Basagran, Blazer* and *"Classic"* which allow farmers to achieve the same objectives as previously described with the grass compounds.

All these newer compounds have highly desirable characteristics such as: low use rates, high herbicidal activity and selectivity, and low toxicity to humans and wildlife.

The herbicides that I have briefly described are already contributing to the rapid growth in conservation farming that is projected by the USDA. Herbicides that provide effective and economical weed control while being safe to the environment and wildlife, coupled with improved farm equipment and education, will be the keys to accelerating the conversion of American farmers to the practice of conservation farming. I am firmly convinced that all segments of agriculture and conservationism are striving for mutual goals. Innovative new herbicides will help us reach our goals quicker.

State-Federal Partnership for Soil Conservation and Fish and Wildlife Enhancement

Robert D. Miller and David L. Urich
Missouri Department of Conservation
Jefferson City, Missouri

Russell C. Mills
USDA, Soil Conservation Service
Columbia Missouri

Introduction

Changes in American agriculture have had a profound effect on wildlife resources, and the decline in abundance of many species is well documented (Harmon and Nelson 1973, Vance 1976, Fredrickson 1979). Suggestions for altering federal agricultural policies, Agricultural Stabilization and Conservation Service (ASCS) cost-share concepts and tax benefits as means for conserving soil and wildlife resources have been made repeatedly by wildlife professionals and organizations (Farris and Cole 1981). States have responded to habitat losses by promoting a variety of habitat development, restoration, stocking, cost-share, or tax benefit programs which have met with limited success (Madsen 1981). Nationally, Congress responded with the Soil and Water Resources Conservation Act (RCA) of 1977 charging the USDA Soil Conservation Service (SCS) to maintain the quality and quantity of the soil resource and provide for fish and wildlife habitat.

Under the auspices of the RCA, the SCS in Missouri began redirecting personnel and funds to critical soil erosion problem areas, placing more emphasis on applying conservation management practices and trying new approaches to resource conservation on a limited or pilot basis. The Missouri Department of Conservation (MDC) joined this effort under the assumptions that (1) fish and wildlife habitat management goals and soil conservation goals have compatible long-range objectives, and (2) sound soil and water conservation programs properly administered at the state and county level can improve fish and wildlife habitat.

Nationally, Missouri ranks third in the amount of sheet and rill erosion on cultivated cropland. Many Missouri streams are polluted by sediment, and wetland and forest habitats are being converted to other land uses or degraded by improper use. Solving soil, water, and related resource problems in Missouri cannot be accomplished by one agency. MDC and SCS share the goal of directing resources toward proper land use through cooperative programs to improve fish, forest, and wildlife resources while sustaining long-term soil productivity. To achieve this goal, both agencies emphasized new approaches to address the problems of soil erosion and diminishing fish and wildlife resources. This paper describes these cooperative approaches, which include (1) establishing informational and inventory data bases, (2) targeting and personnel sharing to emphasize programs in the state's most critical resource areas, (3) cooperative training and technical assistance, (4) demonstrations of soil saving farming practices beneficial to wildlife, and (5) a cooperative private land program evaluation and monitoring procedure (Table 1).

Table 1. Cooperative Missouri Department of Conservation and Soil Conservation Service Private Land Programs in Missouri.

Program	Activity
Data bases and information system	Statewide fish and wildlife inventory data base with 30,136 sample points.
	Computer fish and wildlife information system with distribution, life history, and management information on 734 vertebrate species.
	Geographic information system for the production of maps and map overlays of resource information.
Targeting and personnel sharing	Critical erosion target projects for addressing the state's worse soil erosion problems.
	MDC private land specialists work with SCS field staff.
Training and technical assistance	Reciprocal training for field staff on agency programs, policies, and techniques.
	SCS assistance with soil conservation on state-owned lands.
	MDC assistance with private land conservation farm plans incorporating fish, wildlife, and forest resources.
	Interagency streambank erosion control and woody riparian corridor committee.
	MDC provides native grass drills and root pruners to private landowners and SCS promotes use.
Demonstrations	MDC demonstration farms document economics and wildlife benefits of MDC-SCS recommendations.
	MDC state lands used for SCS soil conservation demonstrations.
	Warm-season native grass and pasture management demonstrations.
Agricultural liaison	Cooperation on agricultural policy decisions.
	MDC funded agricultural research.
	Inter-agency committee comprised of MDC, SCS and University of Missouri to propose and fund native warm-season grass research and promote forage systems with native grasses.
Evaluation and monitoring	Wildlife Habitat Appraisal Guide (WHAG) for evaluating impacts of private land programs on wildlife habitat.
	Objectives established for improving habitat quality.
	Summaries of program impacts periodically provided to staff of both agencies to facilitate private land program planning.

Informational and Inventory Data Bases

The development of the 1978 Missouri Resources Appraisal (U. S. Dep. of Agric. 1978) identified common fish and wildlife issues and concerns. The consensus was that rapid and extensive changes were occurring to fish and wildlife resources and that the agencies responsible for management or conservation of those resources must respond to ongoing or anticipated habitat changes. Both agencies were interested in working harmoniously toward resource inventory and assessment to provide information on wildlife species and habitat and to avoid an overlap of effort.

A fish, wildlife, and natural resources inventory data base was developed to provide resource information. SCS is required to inventory at 5-year intervals the nation's soil, water, and related natural resources, including fish and wildlife habitat, and to provide summaries to Congress on the status, conditions, and trends of the nation's wildlife resources. SCS developed the National Resources Inventory (NRI) program to collect inventory data at randomly selected points (U. S. Dep. Agric. 1980). All states utilized a standard 8-page NRI field inventory form. In Missouri, SCS staff collected data on land use, soil erosion, land management practices,and other items at more than 30,000 sample points. To enhance the value of the survey for wildlife planning, SCS and MDC developed a supplemental wildlife habitat inventory for Missouri's portion of the NRI. Supplemental inventory data were collected on habitat parameters important to 21 indicator wildlife species selected to represent resource management issues important to both agencies. The inventory data base contains information on cavity trees, field borders, interspersion of habitats, ground cover, and other parameters.

The interpretation of inventory data and effective resource planning required that information on the distribution, life history, and management recommendations of all the state's vertebrate species be available to biologists of both agencies. MDC and SCS developed, in cooperation with other federal natural resource agencies, the Missouri Fish and Wildlife Information System (FWIS), a standard methodology for computer storage of information from the published literature (DuBrock et al. 1981). The FWIS is stored on the Computer Network at the University of Missouri, Columbia, Missouri. Biologists at remote terminals can develop species occurrence lists by 13 geographic and vegetation classification systems such as county, watershed, forest cover type, and potential natural vegetation. Habitat requirements for each species were identified from the literature and biologists can sort species on the basis of various categories within habitat requirements. For example, aquatic habitat categories include water velocity, turbidity, gradient, substrate conditions, salinity, or 31 other physical and chemical properties. Terrestrial habitat categories such as vegetation structure, important foods, habitat interspersion requirements, and 39 other categories can be searched for species. Species can be sorted on the basis of their response, either beneficial or adverse, to 52 broad land and water management categories for making generalized statements on how wildlife diversity and abundance will be affected by management activities.

The NRI data can be related to the information on management and habitat requirements in the FWIS to make judgments on the status and condition of the state's wildlife habitat. Tabular or map data on habitat conditions can be produced for the state, by county, or by any of the regional or vegetation classification systems in the FWIS.

In addition to the NRI data base, SCS in Missouri recognized a need to display geographical inventory data from more than 30,000 sample locations. A geographic information system (GIS) for integrating NRI data with satellite imagery and other geographic map information was developed at the University of Missouri. A Geographic Resources Center (GRC) was formed in 1979 to provide Missouri with a facility for the collection, storage, analysis, and dissemination of geographic data. Both agencies were instrumental in the formation of this center and rely on state-of-the-art geographic analysis techniques for resource planning.

These three data bases permit comprehensive evaluation and planning of programs designed to enhance soil and wildlife resources. Both agencies can analyze wildlife-habitat relationships, model habitat availability and quality, and predict wildlife response to alternative land use and management activities (Salwasser et al. 1983).

Targeting and Personnel Sharing

The SCS initiated two critical soil erosion target areas in 23 northern Missouri counties to promote conservation on severely eroding agricultural land through additional landowner assistance. MDC assigned two private land specialists to work with the SCS in these counties to integrate wildlife habitat considerations into the application of land treatment or systems designed to protect eroding cropland. These specialists are located in SCS offices, attend SCS staff meetings, and serve in the capacity of SCS staff biologists.

The primary objective of MDC private land specialists is to emphasize methods and techniques for incorporating fish, forest, and wildlife management principles and practices into conservation farm plans. MDC provides farm-wildlife training in the target projects with sessions on wildlife habitat needs, wind-break and shelterbelt planning, fisheries management, forest management,and other methods for incorporating wildlife habitat into conservation farm plans.

These private land specialists also serve on regional interagency planning committees. Other responsibilities include establishing soil conservation-wildlife demonstrations on farms throughout the target areas; assisting SCS in the evaluation of wildlife resources; evaluating new plant materials for erosion control, forage, and other uses provided by the SCS Plant Materials Center in Missouri; reviewing SCS field office technical guides; and assisting in an aggressive information program. Each private land specialist serves as a local liaison between MDC, SCS, and other agricultural agencies and has greatly increased the communication and understanding among all agencies' field representatives.

Training and Technical Assistance

Both agencies have conducted reciprocal orientation and training sessions to improve inter-agency understanding and cooperation. SCS sponsored two resource conservation planning conferences to train MDC public and private land management personnel in SCS organization, duties, soil loss calculations, and conservation farm planning. MDC training sessions for SCS personnel concentrated on agency organization, programs and goals. MDC also conducted private land prescribed burning seminars for SCS field personnel who assist landowners with management of native warm season grasses. A native grass prescribed fire training program was then jointly developed for training private landowners.

Reciprocal training resulted in the sharing of technical assistance that has benefited both agencies. For example, an initial step in the development of a management plan for state wildlife management areas (WMA) is the preparation of a soil and water conservation plan by SCS staff. Erosion control on state-owned land is MDC policy, and management plans for providing wildlife habitat must incorporate SCS recommendations for soil conservation. MDC technical asistance has resulted in conservation farm plans prepared by SCS personnel that include considerations for fish, forest, and wildlife resources.

Both agencies deal with resource issues that draw upon technical assistance from combined staff. An inter-agency streambank erosion control committee was established to investigate methods for solving streambank erosion problems and for establishing woody riparian corridors. To promote, demonstrate, and evaluate these techniques, MDC agreed to develop streambank erosion control measures on state-owned land. MDC and SCS combined technical assistance extends to more direct methods. MDC provided funds to selected soil and water conservation districts to purchase native grass drills and root pruners, with both agencies promoting this equipment.

Demonstrations

MDC established two demonstration farms to document the economics and wildlife benefits of farming practices recommended by MDC and SCS staff. SCS recommended and designed the soil and water conservation measures for these farms. MDC monitors wildlife populations, soil loss, and farm economics. Demonstration practices include rotation grazing, contour and stripcropping, minimum and no-till farming, grassed backslope terraces, woodlot management, and pond management. Both agencies conduct personnel training sessions on these farms and provide tours. With SCS assistance, MDC has demonstrated that farm management emphasizing soil, water, and wildlife conservation will result in little or no loss to net income.

MDC has made available other state lands to demonstrate farming and grazing techniques promoted by both agencies. These demonstrations address specific resource management problems peculiar to a region of the state. For example, native grass waterways and grassed backslope terraces are demonstrated on state-owned land in northwest Missouri as one way to control soil erosion while providing wildlife nesting habitat. Joint field tours are conducted to explain demonstrations to local landowners.

Forage systems with warm-season grasses are also demonstrated on state-owned and private lands. MDC staff, with specialized equipment, plants native grasses on seedbeds prepared by landowners. SCS has taken a major role in promoting pasture management systems utilizing warm-season grasses and participates in MDC-SCS farm tours and seminars for landowners.

Agricultural Liaison

MDC established an agricultural liaison position to increase communication and cooperation between MDC, SCS, and other agricultural agencies. Resource problems can be recognized and diminished by providing an awareness of the common goals of agency programs and how activities affect soil, water, and wildlife conservation. This liaison with agricultural agencies is directed at policy changes that improve total resource management. Through the agricultural liaison position, MDC has funded research at the University of Missouri on farm techniques beneficial to wildlife. MDC-funded research is underway on four research projects related to native warm-season grasses, including establishment, fertility requirements, nutrition, and grass-legume compatibility. MDC also funded a bibliography on published native grass studies.

Evaluation and Monitoring

SCS is mandated by RCA to measure the impacts of programs and activities on wildlife habitat. In addition, MDC was interested in documenting the impact on wildlife habitat of private land program activities. Because both agencies were serving the same clientele and shared the goal of monitoring private land program impacts, a unified effort by both agencies was needed to (1) evaluate habitat on private land in a consistent and repeatable fashion as a basis for making consistent management recommendations, (2) predict the effect of planned management recommendations on habitat quality, (3) display in a graphic form to landowners the impact of land management on wildlife habitat quality, and (4) document implemented conditions.

To meet these needs, both agencies developed the Wildlife Habitat Appraisal Guide (WHAG) to numerically evaluate and monitor wildlife habitat (Urich et al. 1984). This numerical appraisal system is based on the Habitat Evaluation Procedures (U.S. Dep. Inter. 1980), or HEP, and produces a habitat suitability index (HSI) calculated from species capability models (U.S. Dep. Inter. 1981). Important habitat characteristics for a species are identified on the appraisal guide and are scored on a 1-to-5 or 1-to-10 scale. Habitat quality is rated by matching existing or planned habitat conditions with the closest value on the appraisal guide. All possible combinations of SCS recommendations for reducing soil erosion and MDC recommendations for improving wildlife habitat quality can be evaluated. Appraisal guides were developed for 12 wildlife species.

A two-day training session was developed for personnel of both agencies to explain the use of the WHAG for farm conservation planning and program evaluation. Each agency assigned personnel to provide follow-up training of field staff. All landowner contacts by SCS in the 23 counties comprising the critical erosion control areas must include an appraisal of bobwhite habitat quality of existing and planned habitat conditions. Applied habitat conditions are evaluated on follow-up visits to determine the extent that farm plans were implemented. MDC developed a FORTRAN computer program to summarize data from WHAG. MDC and SCS periodically review these summaries to monitor the impacts of private land programs on wildlife habitat.

The WHAG allowed SCS to establish a numerical objective for achieving and reporting habitat improvements (U.S. Dep. Agric. 1982). Standards and specifications for wildlife habitat, describing minimum acceptable requirements, were developed. WHAG allows both agencies to establish quantitative habitat improvement objectives for private land programs, monitor progress in achieving those objectives, and relate costs to program activities. This habitat evaluation and monitoring procedure permits the SCS in Missouri to comply with USDA Fish and Wildlife Policy (U.S. Dep. Agric. 1983) developed in accordance with the process established by RCA.

Recommendations

MDC and SCS have been cooperating on soil, water, and wildlife habitat conservation programs. The following recommendations are designed for consideration by state fish and wildlife agencies interested in promoting habitat restoration and management in cooperation with the SCS.

1. State fish and wildlife agencies should review existing private land efforts in relation to all agency activities and define the priority on funding and personnel

commitment for private land programs. Coordination with the SCS offers the opportunity to promote wildlife habitat on a larger scale than can be achieved by a state agency alone. However, both SCS and state personnel must have a clear understanding of the importance and priority private land programs have with respect to other activities.

2. State fish and wildlife agencies should take advantage of the opportunities offered by the RCA for public input into SCS programs. RCA brings new emphasis to fish and wildlife habitat in all SCS activities. Close coordination at the local and state level is required. MDC achieved this coordination by providing private land specialists to work as staff biologists in selected SCS offices and by establishing an agricultural liaison position. The effective integration of habitat needs into SCS programs will require this level of staff input by state agencies.
3. State fish and wildlife agencies should develop habitat monitoring and evaluation techniques in cooperation with the SCS. RCA requires the SCS to appraise on a continuing basis the nation's soil, water, and related resources to guide future conservation activities. Therefore, state agency coordination and input will not be effective without reliable methods for inventorying and evaluating fish and wildlife resources and monitoring quantitative objectives required by RCA. In Missouri, both agencies selected HEP as the evaluation and monitoring system, but other formats are available. Habitat monitoring and evaluation techniques are also necessary for integrating fish and wildlife into SCS activities and for allowing biologists to coordinate habitat portions of conservation farm plans with other SCS disciplines.
4. The RCA requirements for a national assessment offers state agencies the opportunity to participate in the development of an NRI data base. Fish, wildlife, and forest inventory elements can be added to the NRI at the state level to produce a data base for program planning and impact assessment. In Missouri, WHAG was used to identify additional NRI data elements to make the inventory data base more specific and relevant to state conditions. A reliable inventory coupled with evaluation techniques are crucial to setting objectives, establishing programs to achieve those objectives, monitoring impacts, and adjusting approaches to habitat management on private lands by both agencies. A computer information system summarizing published literature on the distribution and habitat requirements of the state's fish and wildlife will facilitate the interpretation of an inventory data base. RCA requires that the SCS consider habitat needs of all vertebrate species, but this requirement can not be effectively achieved without informational data bases to assist biologists.

MDC and SCS cooperation has produced greater awareness by personnel of both agencies of the relationship between soil conservation and wildlife habitat quality, more emphasis on total farm resource planning, and greater impact on the issues of soil erosion and habitat loss than could be achieved by each agency operating independently. This interagency effort has demonstrated that many measures to improve soil and water conservation also may improve habitat quality and that effective total resource management on private land must involve a coordinated approach by resource agencies.

Acknowledgments

The authors wish to acknowledge the Missouri Department of Conservation and the USDA Soil Conservation Service for identifying the importance of total resource development on

private land. Special acknowledgment is due the personnel directly involved in developing wildlife habitat and soil conservation practices on the land. Their realization that they alone cannot significantly impact soil and wildlife conservation and their willingness to cooperate with other agency personnel has made this partnership in resource development effective.

Literature Cited

DuBrock, C. W., D. N. Gladwin, W. T. Mason, Jr., and C. T. Cushwa. 1981. State-of-the-art of fish and wildlife species information systems in the United States. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:156-170.

Farris, A. L., and S. H. Cole. 1981. Strategies and goals for wildlife habitat restoration on agricultural lands. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:156-170.

Fredrickson, L. H. 1979. Floral and faunal changes in lowland hardwood forests in Missouri resulting from channelization, drainage, and impoundment. FWS/OBS-78/91. U. S. Fish and Wildl. Serv., Columbia, Mo. 130pp.

Harmon, K. W., and M. N. Nelson. 1973. Wildlife and soil considerations in land retirement programs. Wildl. Soc. Bull. 1:28-38

Madsen, C. R. 1981. Wildlife habitat development and restoration programs. Pages 209-217 *in* R. T. Dumke, ed. Wildlife management on private lands. LaCrosse Printing Co., Inc., LaCrosse, Wis.

Salwasser, H., C. K. Hamilton, W. B. Krohn, J. F. Lipscomb, and C. H. Thomas. 1983. Monitoring wildlife and fish: mandates and their implications. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:297-307.

U. S. Department of Agriculture. 1978. Missouri resources appraisal: Resources Conservation Act. U. S. Dep. Agric., Soil Conserv. Serv., Columbia, Mo. 205pp.

_____. 1980. National resources inventory 1981-1982: Primary sample unit and point data work sheet. Stat. Lab. Rep. Iowa State University, Ames, Io. 5pp.

_____. 1982. Missouri standard and specification for wildlife upland habitat management. U. S. Dep. Agric., Soil Conserv. Serv., Columbia, Mo. 7pp. (Mimeo).

_____. 1983. Fish and Wildlife Policy. Dep. Reg. 9500-4. U. S. Dep. Agric., Washington, D. C. 7pp.

U. S. Department of Interior. 1980. Habitat Evaluation Procedures (HEP). Ecol. Serv. Man. 102. U. S. Dep. Inter., Fish and Wildl. Serv., Washington, D. C. 214pp.

_____. 1981. Standards for the development of habitat suitability index models. Ecol. Serv. Man. 103. U. S. Dep. Inter., Fish and Wildl. Serv., Washington, D. C. 168pp.

Urich, D. L., J. P. Graham, and E. A. Gaskins. 1984. Habitat appraisal of private lands in Missouri. Wildl. Soc. Bull. 12: 350-356.

Vance, D. R. 1976. Changes in land use and wildlife populations in southeastern Illinois. Wildl. Soc. Bull. 4:11-15.

Conservation Farming and Aquatic Resources

Fred D. Theurer
USDA-Soil Conservation Service
c/o Hydro-Ecosystem Research Unit
P.O. Box E, Ft. Collins, CO 80522

Edward H. Seely
USDA-Agricultural Research Service
Hydro-Ecosystem Research Unit
P.O. Box E, Ft. Collins, CO 80522

William J. Miller
Colorado State University
c/o Hydro-Ecosystem Research Unit
P.O. Box E, Ft, Collins, CO 80522

Introduction

Improved methods are needed for determining the effects of conservation farming on aquatic resources. By understanding these effects, we can increase our options for managing and protecting habitat. Improved methods also help conservation farming by allowing more complete evaluation of economic benefits. Agricultural practices have a direct and profound effect on downstream aquatic resources (Theurer 1985, Dysart 1984). Preserving and restoring aquatic resources will help to economically justify increased levels of conservation farming (SRI 1979, Haas 1984). But, being able to make analyses that includes both on-and offsite effects will involve complex and sophisticated models requiring interdisciplinary and interinstitutional efforts for research and model development, and subsequent simplification of these models for field use (Haas 1980, Theurer and Bayha 1980, Theurer 1985).

This paper presents information concerning the value—economic as well as environmental—of aquatic resources, particularly commercial and sport fisheries. This paper also reviews models being developed and the current research direction for evaluating downstream effects of conservation farming. In particular, a cooperative effort between the Soil Conservation Service (SCS), Agricultural Research Service (ARS), and Colorado State University (CSU) to evaluate the effects of upstream soil and water conservation measures on salmonid spawning and rearing habitat in the Pacific Northwest is described.

Economic Importance of Aquatic Resources

Norton et al. (1983) report that, in 1980, striped bass in the ten Northeast coastal states from Maine to North Carolina generated over $200 million in gross economic output and employment for over 5,600 people. They also reported that up to $218 million per year of economic activity and 7,500 jobs may have been lost in these same coastal states as a result of the two-thirds decline of the striped bass resource since the early 1970s. They reported that the net economic value (gross output minus input) for striped bass is $11.5 million annually.

Bardecki (1984) reports Michigan's coastal wetlands generate a gross annual value of $490 per acre. He refers to a study of wetland values in Virginia which indicates an estimated total annual potential benefit from marshlands of at least $7,108 per acre.

Theurer (1985) cites a report that states $17.3 billion was spent nationally in 1980 on sport fishing by 42.1 million anglers over 857.6 million angler-days. He also reports that an average of 8.7 million salmon were harvested annually in the Pacific Northwest during the mid-1970s. Sixty-seven percent were commercially harvested. Using 1980 National Marine Fisheries Service (NMFS) net economic commercial and sport values (NMFS 1982, Meyer et al. 1983), this would amount to a new economic value of almost $434 million per year, 83 percent of which is value to recreational fishermen. Theurer refers to studies reporting that harvests now are considerably less than half of what they were in the early 1900s because of reduced fish populations—attributed, in part, to agriculture. This reduction in fisheries has occurred simultaneously with a threefold increase in U.S. population since 1900.

The above aquatic resources have several things in common—they are valuable, are losing quality habitat, and are declining in numbers. The net economic values are the amounts that decision makers might best use to justify restoring and preserving the respective aquatic resources. Figure 1 shows the salmonid and striped bass habitat in the contiguous 48 states (Lee et al. 1980).

Watershed Systems Approach to Aquatic Resource Management

Resource managers, representing various viewpoints, have recognized the importance of total resource management. Benjamin C. Dysart, III (1984), President of the National Wildlife Federation, recently addressed the Wild Trout III Symposium where he urged those interested in protecting fisheries resources to focus on the critical forces external to the fishery—upstream land use. He believes that agriculture can be manage to protect streams and offsite values in general.

Joseph W. Haas (1980, 1984), Deputy Chief for Programs, Soil Conservation Service, believes that reduction of offsite effects may prove to be the strongest justification for soil and water conservation programs. He also requests cooperation and coordination at all levels of government and from all levels of professional organizations and universities to accomplish unified total resource management.

A recent study (SRI 1979) has shown that neither the current level of conservation nor additional erosion control could be economically justified using only onsite benefits. Futhermore, offsite effects of conservation may be more significant than onsite (Theurer 1985, Crosson 1984). SRI (1979) reports that erosion control is generally not in the farmers' economic interest; on the average, the farmer receives a return of only 70 cents for each dollar he spends on conservation. The SRI interpretations were based upon national averages. Furthermore, they did not consider conservation tillage.

Effects of Conservation on Aquatic Resources

Agricultural practices are believed by many to be the major contributor to degradation of aquatic resources (Theurer 1985). However, conservation farming can help restore and preserve these resources. In order to relate conservation farming to both agricultural productivity and aquatic resources, we must be able to quantify the on- and offsite effects of land and water use decisions. This effort will require complex

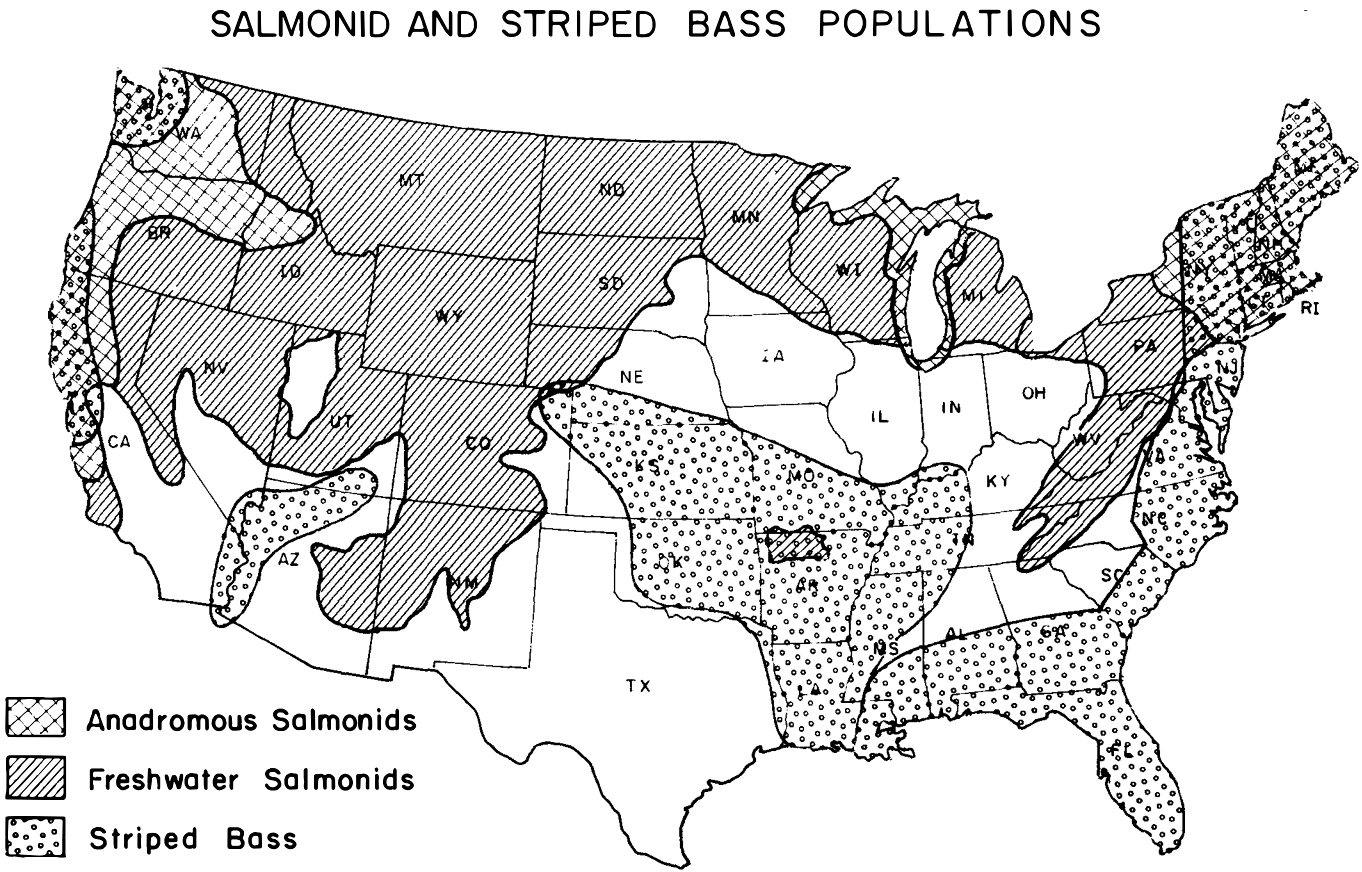


Figure 1. Salmonid and striped bass habitat in the contiguous 48 states.

watershed resource system modeling involving physical scientists, agronomists, ecologists, and economists.

What Is Conservation Farming?

Conservation farming is defined by the authors to mean the economical production of food and fiber while protecting the Nation's total resource base for future generations. The aquatic resource is one of these resources. The inclusion of all significant offsite effects would likely justify *increased* levels of conservation farming, and more than just the current generation of farmers would benefit.

How Conservation Farming Affects Aquatic Resources

Many reports and studies address the impact of agriculture on aquatic habitat (Theurer 1985). Proper soil and water conservation measures should include provisions that will: (1) insure maintenance flows in streams, (2) control erosion so as to produce less sediments with adsorbed chemicals, (3) use a minimal amount of fertilizers and pesticides, and (4) maintain natural morphological and riparian stream systems.

Components of Watershed Resource Systems Management Approach

The Soil Conservation Service (SCS), through its small watershed program, routinely justifies some soil and water conservation projects using model-determined benefits from flood damage reduction; erosion reduction as related to onsite productivity, irrigation, and water supply; and local recreation development. However, only recently has SCS seriously recognized the significance and economic value of offsite aquatic resources (Theurer 1985).

The authors believe that conservation farming can be economically justified, but will require evaluation of both the on-and offsite effects of soil and water conservation measures. This will require the development and use of watershed resource system models involving physio-chemical, biological, and economic components (Figure 2). These components can be provided mostly by existing models that were developed for narrower-focus applications. The physio-chemical component is to be met by watershed models that are being developed to relate agricultural management practices to downstream water, sediment, and chemical transport. The aquatic biological component can be met by a class of models referred to as habitat models. The economic component consists of all sources of net economic benefits (total benefits minus total costs). These benefits include changes in the net economic value of aquatic and other resources, plus changes in agricultural production.

Physio-chemical Component

The physio-chemical processes of the watershed determine the suitability of the habitat for aquatic resources. This component includes the water, sediment, and chemicals produced on upstream source areas and the routing of these watershed products through the stream system. The authors view the component as a comprehensive watershed model that relates land use to the instream response. While a number of limited watershed models have been announced, only one has the capability to estimate the effect of alternative agricultural management practices on down-

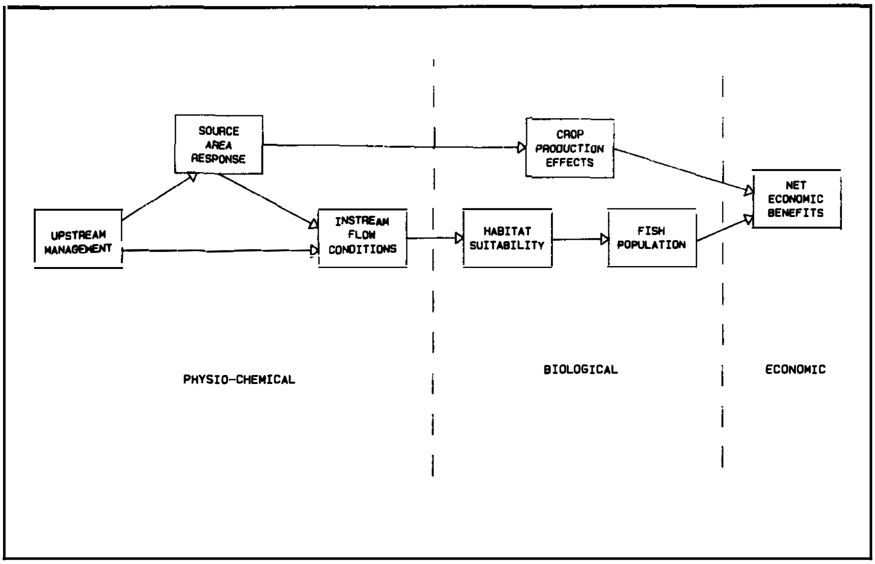


Figure 2. Watershed resource systems management components.

stream conditions. The major limitation of most watershed models is their inability to distinguish between different land use practices.

The authors believe the model which most nearly meets this need will be the Small Watershed Model (SWAM) (Alonso and DeCoursey 1985). SWAM is being developed to show the offsite effects due to changes in land use and management on the water, sediment, and chemical response of predominately agricultural land use watersheds. It will have the capability to simulate upstream conservation practices because it will have a strong physical basis with dynamic source-area processes. These source-area processes have been taken from a field-scale hydrologic model that represents a variety of upstream conservation measures and facilitates comparison of alternative management practices (Smith and Knisel 1985).

Three aspects of the physio-chemical component not yet fully addressed by SWAM are: (1) changes in the bed material (substrate) composition resulting from changes in total sediment transport; (2) comprehensive modeling of all aspects of chemical transport in the channel system; and (3) prediction of basin-scale response. SWAM simulates nutrient and pesticide movement to the stream but does not currently simulate other elements, such as dissolved oxygen, or any chemical and biological interaction within the stream. Although SWAM can conceptually handle large mixed land-use areas, it currently has a practical limitation to areas of about 10 square miles (26 km^2) and smaller, because of the amount of input data needed.

The authors are not aware of any complete sediment intrusion model which provides estimates of bed material composition changes in the substrate due to changes in total sediment yield. Bed material composition changes are necessary for estimating impacts of land erosion on the substrate to determine the substrate's suitability for spawning or food chain support. Such modeling efforts are underway, but further research is needed (Chevalier et al. 1984).

Some chemical transport processes not addressed by SWAM may be met by other models. The Stream Simulation and Assessment Model: Version IV (SSAMIV) can be used to predict instream changes in water quality parameters (Grenney and Kraszewski 1981). However, source-area water quantity and quality parameters are necessary inputs to this model. They may be provided by SWAM.

Basin-scale analysis at present will likely require a combination of models. For example, SWAM may be used to analyze critical areas directly or to calibrate a larger basin-scale model. An example of such a basin-scale model would be the Simulator for Water Resources in Rural Basins (SWRRB) (Williams and Nicks 1985). SWRRB can be calibrated with SWAM and SSAMIV until SWAM itself, or its equivalent, can be developed to be used on a basin scale.

One model, which exists as a stand-alone model and also is built into SWAM, is an instream water temperature model using riparian vegetation parameters as an optional part of its input. This model is a steady-flow dynamic-temperature model that combines stream geometry, meteorological, and hydrological parameters to predict mean daily water temperatures and diurnal fluctuations (Theurer et al. 1984). Some applications, which need water temperature estimates only, could use the stand-alone model more easily than as a part of a more complex model.

Biological Component

Linking the response of the aquatic biota to changes in the physio-chemical component requires the integration of aquatic biota and habitat suitability—using habitat models. Habitat suitability criteria can be determined for many types of aquatic biota, using methods described by Bovee and Cochnaur (1977) and the U.S. Fish and Wildlife Service (1981).

To link changes in watershed physio-chemical processes to changes in the aquatic biota, physical scientists and aquatic biologists must use compatible terminology and models (Lotspeich 1978, Helms 1984). Recently, aquatic biologists have begun to rely on models to predict changes in the aquatic systems. The authors will limit their discussion to those models which predict changes in the aquatic system using only physio-chemical parameters (Fausch and Parsons 1984).

In order to predict the effect of conservation farming on aquatic resources, it is necessary to be able to first predict its effect on aquatic habitat and then the effect of changes in habitat on aquatic biota. Site-specific stand-alone regression model approaches—which are not directly related to the proper physio-chemical cause of a change in suitability—may be applicable to the site where the model was developed, but are generally non-transferable to other watersheds. Sometimes they are no longer applicable at the same site when changes that affect key site-determined coefficients occur. For this reason, these models generally are not preferred for watershed resource system modeling. Component biological models that are developed to be coupled with the physio-chemical model component are designed to be transferable to other watersheds and are preferred for resource systems modeling.

The following site-specific habitat models generally include the use of physio-chemical parameters as independent variables. These variables are incorporated into regression equations to predict the dependent variable (e.g., population). Paragamian (1981) developed a model to predict standing crop in an Iowa river based on the percentage of substrate in the 16-256 mm size. Kelley (1982) developed a salmonid-population model for the Tucannon River, Washington. He used a rating index based on water velocity and depth, substrate, and instream cover to predict the number of juvenile steelhead and chinook salmon in the river. Stowell et al. (1983) developed a model that predicts the percentage of fry emergence for salmonids in Idaho batholith streams based on the percentage of fine sediment in the substrate. However, their model is for sand-fraction fine sediments only. In conjunction with an estimate of the number of eggs deposited, it can be used to help provide population estimates for juvenile salmonids where applicable. Habitat suitability is an inherent parameter of all these regression models.

Some component models currently being used by many aquatic resource analysts link certain instream physio-chemical components with explicit habitat suitability functions to determine instream usable area; for example, the Instream Flow Incremental Methodology (IFIM). IFIM combines steady-state instream physio-chemical habitat components with suitability-of-use criteria for aquatic biota to predict available usable habitat (Bovee 1982). The required inputs to the model are initial hydraulic rating curve data, streambed cross-sections and substrate, and water surface elevations. Discharge versus stage and transverse velocity relationships are developed from the input. These physical parameters are combined with the suitability-of-use criteria to predict the amount of usable area for each species of interest. Some limitations are: (1) streambed cross-sections and substrate remain constant during the simulation and do not change as a function of change in flow; and (2) accuracy of the suitability-of-use criteria directly affects the final results. An advantage of the IFIM technique is that it can be combined with output from other models such as the instream water temperature model, SWAM, and SSAMIV. Nehring (1979) combined the IFIM weighted usable area with fish population data to develop a regression model for predicting standing crop in Colorado streams.

Economic Component

Principles and guidelines for benefit-cost analyses have been standardized by the U.S. Water Resources Council for federal water resource projects (WRC 1983), and federal projects must follow them. However, in order to establish the total benefits for conservation farming, it is necessary to establish net marginal aquatic resource unit values. Little has been done nationally for aquatic values, but a large economic salmonid data base in the Pacific Northwest has allowed the development of some average salmonid unit values (NMFS 1982, Meyer et al. 1983). For example, Meyer et al. report that a spring chinook has an average net economic commercial value of $35 and a sport value of $143; and a steelhead trout has an average commercial value of $22 and a sport value of $144. This same data base also includes, for each salmonid species, escapement data and the ratio of return spawners to the number of commercial and sport catch. In order to economically evaluate the effects of conservation farming on the salmonid fisheries, it is first necessary to relate conservation farming to aquatic habitat and then aquatic habitat to fish production.

Applications

Three typical applications are discussed to illustrate how the watershed resource systems approach can be used to evaluate the effects of conservation farming on aquatic resources (see Table 1). The first is the simplest; it measures the effect that stream withdrawals can have on aquatic habitat. The second is more complex; it

Table I. Watershed resources systems modeling.

Model	Physio-chemical							Biological							Economic
	Source area processes	Instream processes						Suitability					Population		
	U	Q	V	D	T	S	B	V	D	T	B	A	M	#	$
Application I: Aquatic Habitat															
Physio-chemical component															
IFIM - Water surface profile		I	O	O											
Instream water temperature model	I	I			O										
Biological component															
IFIM - Habitat suitability sub-model		I	I	I				I	I	I		O			
Application II: Juvenile Rearing Habitat															
Physio-chemical component															
Instream water temperature model	I	I			O										
Biological component															
IFIM - Habitat suitability					I					I		O			
Mortality model					I								O		
Population model													I	O	
Economic component														I	O
Application III: Salmonid Spawning Habitat															
Physio-chemical component															
Watershed Model (SWAM, SSAMIV, & SWRRB)	I		O	O		O									
Instream water temperature model	I	I				S									
Substrate composition model						I	O								
Biological component															
IFIM - Habitat suitability sub-model					I	I		I	I	O					
Mortality model												I	O		
Population Model													I	O	
Economic component														I	O

Key to table: I - Input to model; O - Output from model

Key to headings:
- U - Upstream management input
- Q - Stream discharge
- V - Stream velocity
- D - Stream depth
- T - Stream temperature
- S - Sediment transport
- B - Bed (or substrate) composition
- A - Weighted usable area
- M - Fish mortality
- # - Fish population
- $ - Net value of fish population in dollars

assesses how farming to the edge of the stream banks affects commercial and sport fisheries downstream. The third is very complex; it explains the local effects that various soil and water conservation measures, applied over the entire watershed, can have on commercial and sport fisheries downstream.

Application I: Aquatic Habitat

The major effect of irrigation withdrawal on a stream is the change in the amount of flow in the stream and how that change affects the habitat. The parameters involved are limited to certain instream physical processes (velocity, depth, and temperature) and the suitability-of-use of the resulting habitat with respect to these processes. The effect of a change in flow can be assessed using a hydraulic model and an energy-balance model to predict the change in velocity, depth, and water temperature as functions of discharge. The IFIM and instream water temperature models then can combine these hydraulic parameters with suitability-of-use criteria to produce usable habitat as a function of flow. This information can then be used by resource managers to determine the amount of withdrawal that provides optimal use of water for both in and out-of stream uses.

These two models have been used for many studies involving stream withdrawals as well as reservoir storage and operations. The results have been the basis for negotiating minimum stream flows at many locations throughout the nation (Theurer and Bayha 1980, Theurer et al. 1984).

Application II: Juvenile Salmonid Rearing Habitat

Theurer et al. (in press) report that the simple replacement of riparian vegetation in a small (500 square mile [1,300 km^2]) upstream agriculture watershed in the Columbia River basin will restore its juvenile rearing habitat. This is expected to increase the number of juveniles for steelhead and chinook by two and one-half times. The increased number of juvenile salmonids would have a net economic value of nearly \$1.1 million per year due to increased commercial and sport fisheries downstream. The \$1.1 million per year, when adjusted for the time that it takes for the riparian vegetation to reach its full shading potential, converts to an estimated present worth of \$6.9 million (1982 dollars). The replacement cost of the riparian vegetation is \$1.5 million and includes the land rights for a 30 foot-wide (9m) buffer strip along each side of the stream.

For this application, the instream water temperature model was used to show that restoring the riparian vegetation is necessary to reduce water temperatures below lethal levels during the summer months. The salmonid-population model developed by Kelley (1982) was used to estimate the expected number of juveniles in the current and restored rearing habitats. The economic models suggested by NMFS (1982), Meyer et al. (1983), and the WRC (1983) were used to determine the net economic benefit of \$5.4 million (\$6.9 million benefit minus \$1.5 million cost).

Application III: Salmonid Spawning Habitat

The SCS, ARS, CSU, and others are working jointly to study the effects of conservation farming on restoring salmonid habitat in an upland watershed in the Columbia River basin. The Tucannon River once supplied large numbers of chinook salmon and steelhead trout to downstream fisheries. Loss of riparian vegetation caused elevated water temperatures and streambank instability. Agriculture has increased in intensity and acreage leading to an average annual cropland erosion of 14 tons per acre (34.5 tons per ha) over 51 percent of the watershed. Conservation farming could reduce this to 3 tons per acre. The land and streambank erosion has resulted in fine sediment intrusion into the redds. The fine sediment intrusion and elevated water temperatures have completely eliminated the spawning and rearing habitat in the lower two-thirds of the river. In addition to restoring the riparian vegetation, Theurer et al. (in press) believe that reducing the cropland erosion is all that would be necessary to also restore the spawning habitat. This would further increase the number of juveniles and result in additional benefits. The amount of additional benefits would be comparable to those for restoring the juvenile-rearing habitat alone (see Application II). The level of conservation farming needed to accomplish this erosion reduction may not be justified economically using onsite benefits (agricultural productivity) alone. Preserved and restored aquatic resources could provide the needed justification.

Analytic models are being developed and synthesized to predict (1) watershed source-area erosion and resulting sediment yield, (2) fine sediment intrusion into the redds, (3) percentage of fry emergence, (4) potential stream carrying capacity for juveniles, (5) number of return spawners, (6) net economic value of increased commercial and sport catches, and (7) the net economic benefits.

A site-specific watershed resource systems model is being developed for the Tucannon River. ARS is adapting SWAM, SSAMIV, and SWRRB to estimate the amount of sediment delivered, by particle size, throughout the mainstem of the river for various combinations of soil and water conservation measures. ARS and CSU are jointly developing a fine-sediment intrusion model which will also be applicable to the Tucannon River. SCS and CSU are adapting the percentage of fry emergence model of Stowell et al. (1983) from their sand-fraction fine sediments to the silt fraction found in the Tucannon River. SCS, CSU, and others are going to use the salmonid-population model by Kelley (1982), with further field validation, to estimate the expected number of increased juveniles due to restored spawning habitat. SCS is to estimate the onsite effect of erosion on crop productivity. In addition, SCS and others are to develop appropriate economic models to estimate the net economic on-and offsite values (due to reduction in loss of crop productivity and restored salmonid resource), the costs of all conservation measures required to realize the benefits, and the net economic benefits of the recommended conservation measures.

What Can Be Done

The authors believe that the inclusion of aquatic and other offsite resource values into a total economic analysis of both on-and offsite effects of increased levels of conservation farming will be sufficient to economically justify preserving and restoring agricultural and aquatic resources. Local sponsors, in cooperation with SCS, could develop work plans whose total benefits exceed costs and thereby justify increased conservation farming efforts applied with federal cost-sharing and technical assistance. With approval from Congress, SCS could be authorized to cost-share in the recommended measures and provide technical assistance to the sponsors. For example, the Tucannon River study could result in a restored salmonid resource and a protected agricultural resource base for future generations; and a prototype model for future studies.

What Must Be Done

It is becoming clear to conservationists that mutual cooperation and support is needed to accomplish the common goal. The only way to relate upstream land use, sometimes occurring high in the mountains, to downstream aquatic resources, sometimes as far away as the ocean, is through models of watershed resource systems.

Literature Cited

Alonso, C. V., and D. G. DeCoursey. 1985. Small watershed model. *In* Proceedings Natural Resources Modeling Symposium, Pingree Park, CO, October 16-21, 1983. 7pp.

Bardecki, M. J. 1984. What value wetlands? J. Soil and Water Conser. 39(3):166-169.

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Infor. Pap. 12. FWS/OBS-82/26. U.S. Fish and Wildl. Serv., Washington, D.C.248 pp.

______, and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Infor. Pap. 3. FWS/OBS-77/63. U.S. Fish and Wildl. Serv., Washington, D.C. 39 pp.

Chevalier, B., C. Carson, and W. J. Miller. 1984. Report of engineering and biological literature pertaining to the aquatic environment: with special emphasis on dissolved oxygen and sediment effects on salmonid habitat. ARS project no. 5602-20813-008A. USDA Agr. Res. Serv., Ft. Collins, CO. 250 pp.

Crosson, P. 1984. New perspectives on soil conservation policy. J. Soil and Water Conser. 39(4):222-225.

Dysart, B. C., III. 1984. Watersheds, water, and trout: a more appropriate system for today's agenda. September 1984. Keynote address, Wild Trout III Symposium, Yellowstone National Park. 12 pp.

Fausch, K. D., and M. G. Parsons. 1984. A review of models that predict standing crop of stream fish from habitat variables. Paper presented at the annual meeting Colorado-Wyoming Chapt., Amer. Fish. Soc. March, 1984.

Grenney, W. J., and A. K. Kraszewski. 1981. Description and application of the stream simulation and assessment model version IV (SSAMIV). FWS/OBS-81/46. U.S. Fish and Wildl. Serv., Washington D.C. 199 pp.

Haas, J. W. 1980. Managing natural resources in the 1980's. *In* Proc. Unified River Basin Management, May 4-7, Gatlinburg, TN. American Water Resources Assoc. 7 pp.

______. 1984. Remarks at the national SCS conference. National Bulletin No. 440-5-1. USDA Soil Conserv. Serv., Washington, D.C. 12 pp.

Helms, W. T. 1984. Members call for western division action on standardization. Fisheries 9(2):10-11.

Kelley, D. W. 1982. Ecological investigations on the Tucannon River, WA. USDA Soil Conserv. Serv., Spokane, WA. 112 pp.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 2980. Atlas of North American freshwater fishes. Publ. No. 1980-12 of the North Carolina State Biological Survey. 854 pp.

Lotspeich, F. B. 1978. Biological significance of fluvial processes in the lotic environment. Corvallis Environmental Research Laboratory, Office of Research and Development, U.S. E.P.A., Corvallis, Oregon.

Meyer, P. A., W. G. Brown, and Ching-Kai Hsiao. 1983. An updating analysis of differential sport fish values for Columbia River salmon and steelhead. National Marine Fish. Serv., U.S. Dep. of Commerce, Washington, D.C. 44 pp.

Nehring, R. B. 1979. Evaluation of instream flow methods and determination of water quantity needs for streams in the state of Colorado. Report to the U.S. Fish and Wildl. Serv., Cooperative Instream Flow Service Group, Contract Number 14-16-0006-78-909. Colorado Division of Wildlife, Denver.

NMFS. 1982. Net economic values for salmon and steelhead from the Columbia River system. Prepared by P. A. Meyer and edited by R. O. Koski. NOAA Technical Memorandum NMFS/NWR-3. National Marine Fish. Serv., U.S. Dep. of Commerce, Washington, D.C. 26 pp.

Norton, V., T. Smith, and I. Strand. 1983. Stripers: The economic value of the Atlantic coast commercial and recreational striped bass fisheries. Publ. No. UM-SG-TS-83-12. Univ. of Maryland, College Park. 56 pp.

Paragamian, V. L. 1981. Some habitat characteristics that affect abundance and winter survival of smallmouth bass in the Maquoketa River, Iowa. Pages 45-53 *in* L. A. Krumholz, ed. The Warmwater Streams Symposium. American Fisheries Society, Bethesda, Maryland.

Smith, R. E., and W. G. Knisel. 1985. Summary of methodology in the CREAMS2 model. *In* Proceedings Natural Resources Modeling Symposium, Pingree Park, CO, October 16-21, 1983. 4 pp.

SRI. 1979. A conservation planning and evaluation methodology. Prepared by P. A. Owen, J. Crawford, P. McNamme, and F. L. Offensend. International Project No. 7971. Stanford Research Institute, Menlo Park, CA. 59 pp.

Stowell, R., A. Espinosa, T. C. Bjornn, W. S. Platts, D. C. Burns, and J. S. Irving. 1983. A guide for predicting salmonid response to sediment yields in Idaho batholith watersheds. USDA For. Serv., Intermount. Reg., Ogden, Utah. 85 pp.

Theurer, F. D. 1985. Evaluating impacts of soil and water conservation measures. *In* Proceedings Natural Resources Modeling Symposium, Pingree Park, Co, October 16-21, 1983. 6 pp.

Theurer, F. D., and K. Bayha. 1980. Instream fishery resources in unified river basin management. *In* Proceedings Unified River Basin Management, May 4-7, Gatlinburg, TN. American Water Resources Assoc. 12 pp.

Theurer, F. D., K. A. Voos, and W. J. Miller. 1984. Instream water temperature model. Instream Flow Infor. Pap. 16. FWS/OBS-84/15. U.S. Fish and Wildl. Serv., Washington, D.C. 340 pp.

Theurer, F. D., I. Lines, and T. Nelson. In press. Interaction between riparian vegetation, water temperature, and salmonid habitat in the Tucannon River. American Water Resources Assoc. 32 pp.

U.S. Fish and Wildlife Service. 1981. Ecological Services Manual—standards for the development of habitat suitability index models. ESM 103. U.S. Fish and Wildl. Serv., Division of Biological Services., Washington, D.C.

Williams, J. R., and A. D. Nicks. 1985. SWRRB, A simulator for water resources in rural basins: an overview. *In* Proceedings Natural Resources Modeling Symposium, Pingree Park, CO, October 16-21, 1983. 6 pp.

WRC. 1983. Economic and environmental principles and guidelines for water and related land resources implementation studies. U.S. Water Resources Council, Washington, D.C. 136 pp.

An Economic Perspective on the Effects of Federal Conservation Policies on Wildlife Habitat

Linda L. Langner
USDA, Economic Research Service
1301 New York Ave, N.W., Washington, D.C. 20005

There is an increasing awareness that agriculture has extensive impacts on wildlife. The first section of this paper briefly reviews how changes in agriculture have impacted wildlife and tries to assess the current status of habitat diversity on farmlands. An economic framework is then used to illustrate the conflict between farmers and society regarding wildlife on agricultural lands, and how this conflict influences policy choices. The remainder of the paper focuses on the potential impact of federal soil conservation programs on wildlife, including technical assistance, subsidies, and land retirement programs.

Agricultural Impacts on Wildlife Habitat

During the settlement of America the impacts of agriculture on wildlife were largely favorable as clearings in forests and new food sources were added to create a more diverse landscape. However, an increasing demand for food service worldwide has resulted in the intensification of American agriculture. Agricultural technology to meet increased demands has altered the structure of farms and production practices. Field sizes have increased, large acreages are planted in monocultures, and fertilizer, pesticide, and herbicide use has increased. Marginal lands have been brought into production, often converting land previously providing wildlife habitat. New technology also has the potential for creating positive impacts, with conservation tillage being one example. However, in the future further conversion and intensification is expected, mostly at the expense of natural ecosystems (National Academy of Science 1982).

Diversity on Agricultural Lands

Practices that have brought land into production, such as the draining of wetlands and the destruction of hedgerows and woodlots, have had a serious impact on the diversity of farmland habitat. These impacts have varied by region since, in regions of little natural diversity, agriculture may improve diversity. Diversity is important for providing the various needs of individual species, such as food and cover, and also for attracting a variety of species. An indication of the existing habitat diversity can be determined using the Conservation Reporting and Evaluation System (CRES) data collected by the Soil Conservation Service (SCS) in 1983. The CRES data was collected on a national sample of farms participating in 1983 SCS and/or Agricultural Stabilization and Conservation Service (ASCS) programs involving technical assistance and cost-sharing to farmers for conservation practices. The distribution of acres on which conservation practices were applied is shown in Table 1 by both major land use and farm production region.

The CRES data included estimates of the distance to various vegetative types in proximity to the sample points. The vegetative types included were cropland,

Table 1. Distribution of acres impacted by conservation practices by land use and farm production region, 1983. (ha in parentheses below acres)

Region	Cropland	Hayland & pasture	Rangeland	Forestland	Total
Appalachian	768,983 (311,200)	738,619 (298,912)	0	60,566 (24,510)	1,568,168 (634,622)
Corn Belt	1,692,693 (685,016)	324,177 (131,192)	0	45,786 (18,529)	2,062,655 (834,736)
Delta States	1,586,382 (641,993)	636,749 (257,686)	32,605 (13,195)	341,755 (138,305)	2,597,492 (1,051,179)
Lake States	991,716 (401,337)	25,241 (10,215)	0	20,449 (8,275)	1,037,046 (419,682)
Mountain	622,630 (251,972)	313,343 (126,807)	7,020,186 (2,840,999)	2,026 (820)	7,958,273 (3,220,633)
Northeast	599,082 (242,442)	244,898 (99,108)	0	111,250 (45,022)	915,230 (370,384)
Northern Plains	2,084,567 (843,603)	388,567 (157,249)	1,951,436 (789,726)	21,210 (8,583)	4,445,811 (1,799,175)
Pacific	1,172,851 (474,641)	175,606 (71,066)	241,941 (97,911)	33,040 (13,371)	1,623,438 (656,989)
Southeast	834,387 (337,668)	348,387 (140,989)	0	323,631 (130,970)	1,506,576 (609,696)
Southern Plains	6,195,519 (2,507,264)	3,419,323 (1,383,766)	18,973,756 (7,678,489)	256,233 (107,337)	28,844,832 (11,673,215)
National	16,508,982 (6,681,020)	6,615,029 (2,677,036)	28,219,924 (11,420,321)	1,215,947 (492,081)	52,559,881 (21,270,458)

Source: Expanded Conservation Reporting and Evaluation System Data, 1983.

hayland, pasture or range, forestland, water bodies, and wetlands. Given the limited data, a simple assumption was made that, on cropland, vegetative changes had to occur within 1,320 feet (402m) to be of any benefit to wildlife. For purposes of comparison, diversity was considered excellent if there were at least three vegetative changes within 1,320 feet of the sample point; diversity was good if there were two vegetative changes, fair if there was only one change, and poor if there were no changes. In Table 2, the percentage of total cropland acres that fell into the four categories is shown for the nation and for the ten production regions.

Nationally, 37 percent of the cropland acres had no vegetative changes within 1,320 feet, with only 11 percent having three or more vegetative changes. The regional variation is considerable. The highest proportion of acres with excellent diversity occurred in the Appalachian and Northeast regions, where agriculture is the least intensive. The Southern Plains, Mountain, and Pacific regions show the poorest diversity, with between 48 percent and 60 percent of the acres falling in the poor category. However, this is at least partially a reflection of the natural diversity in some of these areas. The Corn Belt and Northern Plains, regions of intensive agriculture, fall between these two extremes.

These results imply that nationally, diversity in proximity to cropland is low. This is probably a result of a loss of diversifying features from agricultural impacts in some regions, but merely a consequence of natural conditions in others. The decrease in diversity caused by agricultural practices can be explained with simple economic concepts.

Economics of Wildlife on Agricultural Land

Wildlife are dependent on private lands to a large extent. Since the largest proportion of private land in the U.S. is devoted to agriculture, farmlands provide essential wildlife habitat. Wildlife provides value to society in a variety of forms. Individuals who hunt, fish, or trap benefit through consumptive use; birdwatchers and photographers benefit through nonconsumptive use. Other values include option value and existence value. Despite these benefits to the general public, farmers have little economic incentive to manage their lands for wildlife.

The farmer seeks to maximize net returns. To do so, the farmer relies on market signals, mainly prices, to make management decisions. Input prices and output prices determine which crops to plant and what production practices are most profitable. There are no prices associated with wildlife, which in effect signals a zero value to the farmer. Without comparable signals the farmer cannot incorporate the value of wildlife into the decision-making process.

This is a classic case of market failure. Although wildlife is valuable to society, the farmer is generally incapable of capturing that value. This results in a stock of wildlife on agricultural lands that is less than socially optimal. This problem is illustrated by a study on the economics of conversion of wetlands to agricultural production (Hammack and Brown 1974). This study concluded that wetlands in the prairie pothole region are more valuable to society as waterfowl production areas than they are in agricultural production. These results were based solely on the value of the waterfowl produced for hunting and did not consider other benefits provided by the wetlands. Society would benefit if there were more wetlands, and therefore more waterfowl, and less land in production.

Table 2. Percentage of cropland acres in habitat diversity categories by farm production region, 1983.

Rating	Appalachian	Corn Belt	Delta States	Lake States	Mountain
Excellent	48.32	18.63	10.46	24.93	1.68
Good	30.01	27.07	19.46	27.34	17.80
Fair	16.36	31.53	34.83	29.75	32.28
Poor	5.31	22.77	35.25	17.97	48.25

Rating	Northeast	Northern Plains	Pacific	Southeast	Southern Plains	National
Excellent	41.96	10.15	1.21	32.66	2.91	11.30
Good	28.02	30.42	8.05	30.85	15.31	21.02
Fair	23.86	31.60	30.52	21.56	29.86	29.65
Poor	6.16	27.47	60.23	14.92	51.92	37.07

Source: Expanded Conservation Reporting and Evaluation System Data, 1983.

There are a variety of economic solutions to the market failure problem, including compensation, subsidization, taxation, and regulation. These solutions are well-described elsewhere (Bishop 1981). Of particular interest here is the effect that conservation programs have on wildlife habitat.

Soil Conservation and Wildlife Habitat

The United States Department of Agriculture (USDA) has a long history of soil conservation programs that have the potential to benefit wildlife. Federal conservation programs are designed for a variety of goals, with the primary goal being soil conservation. Both SCS and ASCS provide technical assistance and cost-sharing assistance to farmers for applying conservation practices, many of which also enhance habitat.

Cost-Sharing and Technical Assistance

The Agricultural Conservation Program (ACP) is administered by ASCS to provide farmers with cost-sharing funds for conservation practices. In Table 3 a list of selected practices is shown from the 1983 ACP program. These practices were selected as being beneficial to wildlife. Only three of the practices relate directly to wildlife: permanent wildlife habitat, shallow water areas for wild waterfowl, and interim wildlife food and cover. Together these three accounted for less than 1 percent of the 1983 funds. All the selected practices together accounted for 37 percent of the 1983 ACP budget, which totalled approximately $175 million (USDA 1984).

The CRES data can be used to determine which conservation practices were most widely applied in 1983. Of the approximately 120 practices listed by SCS as eligible for assistance, those listed in Table 4 are considered to be beneficial to wildlife when applied to cropland. Table 4 lists the total number of acres the practices were applied

Table 3. Federal expenditures on selected conservation practices in the 1983 Agricultural Conservation Program.

Practice	Cost-shares (000 dollars)	Percentage of total budget
Permanent vegetation cover establishment	$29,797	17.03%
Stripcropping systems	1,991	1.14
Grazing land protection	8,176	4.67
Windbreak restoration or establishment	2,799	1.59
Cropland protective cover	6,765	3.87
Permanent vegetative cover on critical areas	2,767	1.57
Reduced tillage systems	3,455	1.97
No-till	7,913	4.52
Stream protection	170	.10
Permanent wildlife habitat	489	.28
Shallow water area for wild waterfowl	419	.24
Streambank stabilization	299	.17
Interim wildlife food and cover	10	.01
Total	65,050	37.16

Source: USDA, 1984.

Table 4. Selected conservation practices applied to cropland acres, 1983 (ha in parentheses below acres).

Practice	Acres	Percentage of total acres[a]
Conservation cropping system	7,851,601 (3,177,464)	48%
Crop residue use	7,129,943 (2,885,416)	43
Conservation tillage	4,939,608 (1,999,009)	30
Cover and green manure	1,009,708 (408,619)	6
Upland wildlife habitat management	353,291 (142,973)	2
Stubblemulching	300,967 (121,798)	2
Stripcropping	250,583 (101,408)	1.5
Grassed waterway or outlet	237,018 (95,919)	1.5
Field windbreak	131,322 (53,145)	<1
Grasses and legumes in rotation	110,758 (44,823)	<1
Critical area planting	77,438 (31,338)	<1
Filter strip	14,138 (5,721)	<1
Wetland wildlife habitat management	46,653 (18,880)	<1
Field border	8,851 (3,582)	<1
Hedgerow planting	0	0

[a]Percentages can sum to greater than 100 percent because more than one practice can be applied to a sample unit.
Source: Expanded Conservation Reporting and Evaluation System Data, 1983

to and the percentage of total cropland acres.

Despite the variety of practices available to farmers, only three were applied to a large proportion of the acres. Nationally, conservation cropping systems (rotation systems to maintain soil productivity that may include grass and legumes), crop residue use, and conservation tillage were the most widely applied of all the practices. These three practices were also the most widely used in five of the ten production regions. In the Pacific region, stubblemulching was more widely applied than crop residue use; in the Southern Plains, contour farming (nonbeneficial to wildlife) was more common than conservation tillage. In the Lake States, Northeast, and Southeast regions, cover and green manure crop usage replaced conservation cropping systems as the third most frequent practice.

The practices most widely used enhance habitat, but other practices that would be highly beneficial to wildlife were not widely applied. Field borders, windbreaks, streambank protection, and wetland wildlife habitat management were applied on less than 1 percent of the acres, while upland habitat management was applied to 2 percent. No hedgerows were planted. This implies that the farmer is applying practices that are expected to increase returns. Practices most beneficial to wildlife divert lands from production and therefore decrease returns.

All conservation programs involve trade-offs between a variety of variables, including erosion control, wildlife habitat, farm income, and production levels. In the next two sections several conservation options and their potential impacts on erosion, wildlife habitat, income, and production control are considered.

Subsidies and Regulations

A study by Miranowski and Bender (1982) in the Iowa River Basin considered three soil conservation options: (1) a no-till per acre subsidy, (2) a subsidy per ton of reduced soil loss, and (3) a per acre soil loss restriction. All three options reduced erosion and improved wildlife habitat, but the extent of the impact varied by option. The soil loss restriction option was most effective at improving habitat quality and reducing erosion; however, it also decreased net farm income the most. The no-till subsidy was the least effective at reducing erosion and improving habitat, but decreased farm income the least. The general subsidy struck a balance between the other options.

The soil loss restriction was most effective at improving wildlife habitat because of the impact on land use changes. This option created the greatest shift in land use, as land was shifted into less erosive crops. The authors concluded that land use changes (i.e., changes in diversity) had more impact on improving habitat than management practices, although this result may not generalize to other regions. One of the drawbacks of all the options is their temporary nature. Therefore, it is also useful to examine an option that could offer multi-year protection as well as improve diversity.

Land Retirement

Land retirement programs have usually had two goals: production control and soil conservation. Unfortunately, during their 50-year history, land retirement programs in the U.S. have not been particularly successful at either. The diversion of marginal lands and increased planting by nonparticipating farmers has hampered production control, while the lack of cover restrictions on diverted acres resulted in little erosion control and consequently little wildlife habitat (Berner 1984).

Any land retirement program that provides land with good cover would generally be expected to benefit wildlife. But the net impact of land retirement on wildlife habitat depends on the design of the diversion program. For example, a multi-year program would be preferred to an annual program because the permanence of the vegetation, once it is established, provides year round cover. Whether an annual or multi-year program, there will be regional differences in the impacts on habitat quality.

The possible variations in effect can be illustrated using the results of a study on land diversion options done by Webb and Ogg (1984). This study proposed a 5 to 10 year diversion program, with all diverted acres to come from lands currently producing major agriculture program crops. Three options were considered. The first was a set-aside program following the 1978 set-aside pattern, chosen as a fairly representative program in recent years. The second option was a program that would retire acres in the same geographic proportions as the 1978 program, but would target retired acres to critically erosive and fragile lands. Finally, the third option was a conservation reserve which would retire lands according to their erosiveness. The 1978 pattern option is designed primarily for production control, the conservation reserve primarily for erosion control, while the targeting option attempts a balance between the two.

Each of the set-aside options diverts approximately 17 million acres (6.9 million ha). The distribution of diverted acres by region is shown in Table 5. The distribution for the 1978 pattern and the targeting option are identical by definition, although the actual acres removed would vary. The differential regional effects on diversity can be estimated on the basis of the results of existing habitat diversity presented earlier. It is being assumed that diverted acres in permanent vegetation would increase a region's diversity. Under the 1978 pattern the Northern Plains would have the most diverted acres. Two areas of relatively low diversity, the Southern Plains and Mountain regions, would have a relatively large number of diverted acres. Conversely, two areas with high diversity, the Northeast and Appalachian regions, would gain few diverted acres. This results in a pattern of increasing diversity where it appears to be most needed.

The conservation reserve option retires the largest share of acres from the Corn Belt, with the Northern Plains region getting the second largest share. This would mean gains in diversity in two regions of highly intensive agriculture. However, the shares increase over the 1978 pattern for the Appalachian region and the Northeast, neither of which are suffering from low diversity. The Southern Plains, Mountain, and Pacific regions would gain few diverted acres, which means little positive impact in regions that currently have very low diversity.

These results show that land retirement programs will have differential effects on habitat, depending on the pattern of diversion. More importantly, the basic method to control erosion may not be the most optimal for wildlife habitat. Although the conservation reserve option is the most effective at reducing erosion, it may not be as beneficial to wildlife in terms of increasing diversity where it is most needed as the 1978 pattern option. Of course, ultimately the success of diversion for wildlife depends on the adequacy of the cover provided.

Conclusions

Conservation programs are definitely beneficial to wildlife. However, these positive impacts are largely a secondary effect, since the programs are not designed to provide farmers with the incentives to manage their land for wildlife. Practices beneficial to wildlife could be made more attractive to farmers by such techniques as increasing cost-share ratios, but the scope for this type of activity would be limited by budget constraints. Land diversions that are targeted to control erosion are likewise beneficial to wildlife, but the optimal pattern of diversion for erosion control will not necessarily coincide with the optimal pattern for habitat enhancement.

Soil conservation programs cannot be expected to have major impacts on wildlife habitat. Programs designed specifically for wildlife are more appropriate vehicles. An example is USDA's Water Bank Program, which pays farmers to keep wetlands out of production. Nonfederal programs may have more flexibility. State and local zoning regulations are effective means of preventing the conversion of valuable

Table 5. Distribution of acres for land retirement options by farm production region.

Region	1978 program		Conservation reserve	
	1,000 acres	Percent	1,000 acres	Percent
Appalachian	264	1.5	1,762	10.3
Corn Belt	2,791	16.2	6,293	36.6
Delta States	56	0.3	1,174	6.8
Lake States	1,528	8.8	727	4.2
Mountain	1,910	11.2	1,206	7.0
Northeast	208	1.2	742	4.4
Northern Plains	6,637	38.4	3,169	18.5
Pacific	397	2.3	348	2.0
Southeast	273	1.6	697	4.1
Southern Plains	3,201	18.5	1,045	6.1
Total	17,265	100.0	17,163	100.0

Source: Webb and Ogg (1984)

habitat, such as wetlands and bottomland hardwood forests, to agriculture. Another possible mechanism is granting preferential tax treatment on land devoted to wildlife habitat.

Programs involving subsidies and compensation are all vulnerable to fluctuating budgets. A more promising route to explore is the development of mechanisms by which farmers can realize a return on an investment in wildlife habitat, particularly by increasing the use of paid access to private lands for hunting or other forms of wildlife recreation. This is not new, but neither is it widespread. The extensive leasing of land for hunting in Texas serves as a potential guide. Another common occurrence is the renting of wetlands for waterfowl hunting. No matter what technique is chosen to attempt to improve wildlife habitat on agricultural lands, further research on determining wildlife values is crucial in determining socially optimal choices.

In closing, it should be recognized that this paper has focused on only one aspect of the problem: the on-site effects of agriculture on wildlife. The off-site impacts are equally important. Runoff of sediment and chemicals from agricultural lands has a serious impact on aquatic habitats. A complete analysis of the effects of conservation programs on wildlife habitat should incorporate both on-site and off-site impacts.

Acknowledgements

I would like to thank the following people for helpful comments on an earlier draft: Daniel Colacicco, Anthony Grano, John Miranowski, George Pavelis, Carl Thomas, and Shwu-Eng Webb.

Literature Cited

Berner, A. H. 1984. Federal Land Retirement: A land management albatross? Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:118-131.

Bishop, R. C. 1981. Economic considerations affecting landowner behavior. *In* R. T. Dumke, G. V. Burger and J. R. March, eds. Wildlife management on private lands. LaCrosse Printing Co., Inc, LaCrosse, WI. 576 pp.

Hammack, J., and G. M. Brown, Jr. 1974. Waterfowl and wetlands: towards bioeconomic analysis. Resources for the Future, Johns Hopkins University Press, Baltimore. 95 pp.

Miranowski, J. A., and R. L. Bender. 1982. Impacts of erosion control policies on wildlife habitat on private lands. J. Soil and Water Conser. 37(5): 288-291.

National Academy of Science. 1982. Impacts of emerging agricultural trends on fish and wildlife habitat. National Academy Press, Washington, D.C. 303 pp.

United States Department of Agriculture. 1984. Agricultural Conservation Program: 1983 Fiscal Year statistical summary. April, 1984. ASCS, Washington, D.C.

Webb, S. H., and C. Ogg. 1984. Economic analysis of acreage retirement options to protect critically erosive and fragile lands. Paper presented at the National Symposium on Erosion and Soil Productivity, New Orleans, December 10-11, 1984.

Forested Lands: Management for Multiple Benefits

Chairman:
CHARLES E. ALLEN
Wildlife Programs Manager
St. Regis Paper Company
Lufkin,Texas

Cochairman:
HUGH C. BLACK
Wildlife Program Manager
USDA Forest Service
Washington, D.C.

Multiple-Use on Western Private Industrial Timberlands

Lorin L. Hicks
Plum Creek Timber Company, Inc.
999 Third Avenue, Suite 2300
Seattle, Washington 98104

Introduction

The 14.6 million acres(5.9 million ha) of privately owned commercial forestland in the West are as diverse as the region itself. Industrial timberlands extend from coastal rain forests to dry ponderosa pine *(Pinus ponderosa)* grassland, and from lowland lodgepole pine *(Pinus contorta)* to high elevation whitebark pine *(Pinus albicaulis)*. Public expectations from this land base are equally diverse. In addition to a supply of wood and wood products, managed forests are expected to provide grazing, watershed, recreation, wildlife, aesthetic views, and other multiple uses.

In this paper I will examine current and projected multiple-use demands on industrial timberlands in the West. Opportunities and limitations for private landowners to meet these demands will be discussed as well as recommendations to increase private landowner participation in western resource allocation issues.

Multiple-Use Concept on Private Lands

The concept of multiple-use on private lands is different from that applied on public lands. Multiple-use on private lands could be defined as "maintaining public expectations to the extent possible while meeting economic objectives." Industrial timberland owners must generate sufficient income to cover costs and provide a reasonable return on investment in order to stay in business. They must also satisfy social and legal responsibilities to maintain other "amenity" values as a cost of doing business, often without any direct economic return to the landowner. The task of meeting these requirements is difficult and, as regulations and demands increase, the job is not expected to get easier. Beyond the commercial utilization of forest products, recreation and wildlife management are two multiple-uses which comprise much of the public demand and professional attention on industrial timberlands in the West.

Recreational Use on Private Lands

U.S. Department of Interior surveys indicate that 76 percent of America's population over 12 years of age use forests for recreation. U.S. Forest Service recreation statistics for 1983 suggest that much of this use occurs in roaded timberlands, with wilderness amounting to only 5 percent of the total. While actual figures are not available, a substantial amount of recreation use occurs on western industrial timberlands.

Numerous private industrial forestlands are open to the public, although recreational use is not actively encouraged due to problems of fire danger, theft, vandalism, damage to roads, and potential liability for injury. Camping sites are provided as well as tours to explain forest management operations. Leases and permits are normally issued to the public for such uses as woodcutting and outfitting for hunting and fishing. Companies have cooperated with state and federal agencies in the development of designated Wild and Scenic Rivers and recreation areas to insure public access for water-oriented activities.

Not only is the present public use of managed forests high, but future demands for this type of recreation are expected to increase due to the "greying" of the American population following the post-World War II "baby boom." By the year 2000, the U.S. population is expected to increase 28 percent. However, the over-65 segment will increase 56 percent and comprise 14 percent of all Americans (Bjorklund 1984). As the aging process continues, more people will pursue recreational activities in managed forests with roaded access. Industrial timberlands will be expected to accept at least a portion of this increased public use.

Wildlife Management on Private Lands

Management of resident big game and endangered species is an important activity on western industrial forest lands. Timber companies in this region are involved in road closure programs to increase big game security habitat and provide diverse walk-in hunting opportunities. They are also involved in the development of interagency endangered species recovery plans, regional habitat management guidelines, and a wide variety of wildlife publications of use to managers on public and private lands.

Industrial landowners have contributed financially to research projects investigating the effects of forest management practices on elk *(Cervus elaphus)*, white-tailed deer *(Odocoileus virginianus)* and moose *(Alces alces)* in the West. One of these projects, the Montana Cooperative Elk-Logging Study, has completed 15 years of research on one of the West's premier game species. Industrial forestlands have also been the site for big game introductions and transplants to increase hunting opportunities. It should be recognized that the cost incurred by industrial landowners of producing and maintaining fish and wildlife resources on western industrial timberlands are not included in the price of a hunting or fishing license.

Land exchanges provide an opportunity for private landowners to transfer high-quality habitat to public ownership. Plum Creek Timber Company recently purchased 1,000 acres (405 ha) of key elk winter range threatened by subdivision in Montana. This parcel was then exchanged to the U.S. Forest Service for commercial forestland in other areas.

Wildlife management on private lands often requires coordination with state and federal agencies to achieve mutual objectives. A pertinent example from the West includes industry participation in the Washington-Oregon and the Montana bald eagle working groups, which use an interagency approach to facilitate research and management of this species. In another example, the U.S. Forest Service and Plum Creek Timber Company have worked together in managing a grizzly bear movement corridor in the Swan Valley of western Montana. By synchronizing forest management activities in the area, seasonal feeding sites and migration routes for grizzlies should be maintained with a minimum of human disturbance.

Multiple-Use Demands Versus Benefits to Private Landowners

Although demands for multiple-use benefits are high on western timberlands, there is a large difference between what the public expects and what they appear willing to pay for. Western recreationists have developed a tradition of considering all forestlands open to the public regardless of ownership. The large amount of public land and land ownership patterns are primary reasons why industrial landowners in the West are limited in their abilities to generate income from multiple-use management on their properties.

In the Rocky Mountains, 75 percent (43.2 million acres [17.5 million ha]) of the commercial forest land base is in public ownership with industry controlling only 4 percent (2.1 million acres [850,000ha]) of the total (Beuter 1980). Many industrial forest managers have at least a portion of their property in a "checkerboard" alternate-section ownership pattern stemming from old railroad land grants. Consequently, western landowners are expected to manage essentially public resources on private lands. Private landowners need to be convinced that their involvement is actually needed to achieve multiple-use objectives. It must be demonstrated that the large amount of public land already managed for multiple-use in the West cannot meet public expectations. Benefits to the private landowner from cooperating in these activities must also be demonstrated.

Grizzly Bear Management: A Multiple-Use Issue

The current status of grizzly bear *(Ursus arctos)* recovery efforts illustrates the need for a clearly defined program to involve private landowners in multiple-use issues. Grizzly bear management is a uniquely western resource allocation issue involving both public and private land managers. Over $2 million a year are spent on the grizzly, making it one of the most expensive members on the federal list of threatened and endangered species. Nearly 160,000 acres (65,000 ha) of Plum Creek Timber Company property might be considered occupied grizzly bear habitat.

However, grizzly bear management at this time is a confusing array of obscure objectives and mixed signals. On the Flathead National Forest in northwestern Montana, nearly 1.85 million acres (750,000 acres) or 78 percent of the forest has been proposed as Management Situation I, where grizzly bear habitat management will take priority over all other multiple uses. Yet in the same national forest, grizzly bears are still legally hunted as a game species.

In the Yellowstone ecosystem, where recent data strongly suggest that the grizzly bear population is declining (Knight and Eberhardt 1984), 18 percent of Yellowstone National Park has restrictions on human visitation to provide security areas for grizzlies. However, construction is now being completed on expanded, year-round resort facilities at Yellowstone Lake, in the heart of the grizzly bear range.

Seemingly conflicting actions of this type involving public agencies tend to increase controversy surrounding the grizzly and alienate land managers who, by virtue of their land ownerships or personal philosophies, must be involved in grizzly bear recovery efforts. What is clearly needed at this time is a logical definition of the problem and well-planned strategies for solution involving state, federal, and private interests to achieve multiple-use objectives. Recovery of the grizzly bear will require costs to society which must be displayed to the public. Certainly, all diverse interests need to be playing on the same "team."

Conclusions and Recommendations

Multiple-use values are being provided on industrial timberlands in the West under physical, social, and economic regimes quite different from other regions of the country. Projected figures indicate that multiple-use demands on industrial timberlands will increase in the future. It is unrealistic to expect maximum levels of amenity values on private lands without economic incentives to provide a return to the landowner.

The following recommendations should be considered when the involvement of private landowners in multiple-use allocation issues in desired:

1. Develop a clearly defined problem statement and goals for resolution of the problem.
2. Demonstrate or display the needs and benefits of private landowner involvement.
3. Involve private landowners early in the process to avoid confusion and allow adequate time for participation.

Literature Cited

Bueter, J.H. 1980. Timber in the United States: a strategic resource for the twenty-first century. Working paper for the National Conference on Renewable Natural Resources. (Washington, D.C., Nov 30-Dec 3, 1980) 39 pp.

Bjorkland, N.E. 1984. Forest recreation on managed timberlands. Amer. Forests 90(9):10, 52-54.

Knight, R.R., and L.L. Eberhardt. 1984. Projected future abundance of the Yellowstone Grizzly Bear. J. Wildl. Manage. 48(4):1434-1438.

USDA Forest Service: Management, Research, and Cooperative Forestry for Multiple Benefits

James G. Dickson
USDA Forest Service
Southern Forest Experiment Station
Wildlife Habitat and Silviculture Laboratory
Nacogdoches, Texas

Early History

Since its inception the USDA Forest Service has managed federal land for multiple use and products, and has provided multiple forestry services through land management, research to provide information, and cooperative forestry to aid in the management of other land. The Sundry Civil Act of 1897 established the forestry reserves. This legislation referred specifically to timber and water, but federal foresters never felt constrained to its narrowest interpretation. Other uses were recognized and managed early. B. E. Fernow and Gifford Pinchot, early chiefs of the Division of Forestry, were instrumental in gaining acceptance for managing national forests for multiple products. Pinchot regarded the nation's forests as means to fulfill varied needs of America's people. A 1902 policy manual covering the reserves allowed for timber, water, agriculture, mining, roads, grazing, and construction of schools and churches. Cooperative forestry was a large part of the thrust of early federal forestry. Efforts to initiate forest management of public and private land were applied extensively. Research also was an integral part of the history of federal forestry. A research arm of the Division of Forestry was established the year after Pinchot became chief. The conservation movement was underway.

The early twentieth century saw federal forestry expansion. In 1901 the Division of Forestry became the Bureau of Forestry, and in 1905 the forest reserves were transferred from the Department of Interior to the Department of Agriculture and the Bureau of Forestry became the U.S. Forest Service.

In this period managing federal land for multiple products and providing multiple forestry services was confirmed and expanded. National Forests were administered by the general tenet that questions of conflicting interest must "always be decided from the standpoint of the greatest good of the greatest number in the long run" (Steen 1976).

Cooperative forestry was expanded in 1911 with passage of the Weeks Law. This legislation is known for authorizing purchase of forests in watersheds of navigable streams, and it also authorized federal matching money to states for forest protection. This played a major part in developing forest fire protection as well as control of insects and disease. Cooperative forestry was expanded in 1924 with passage of the Clark-McNary Act. The goal was to have a combined federal-state-private effort to improve forests on private lands. It also authorized federal matching funds to qualified states for fire protection and to address the land tax problem.

Research grew and became more independent. In 1910 the Forest Products Laboratory was opened. Chief Graves set up a Central Inspection Committee in 1912 with silviculture, grazing, and products departments. Shortly afterwards, in

1915, the Branch of Research was established with substantial autonomy in operation. By the end of the 1920s, the experiment stations were in place. An important milestone was the passage of the McSweeney-McNary Act of 1928, through which Congress recognized the importance of research and authorized substantial funding.

Later Developments

Succeeding documents substantiated the idea of management of national forests for multiple products. The Copeland Report of 1933 urged multiple use (Steen 1976). In 1947, the Society of American Foresters adopted a policy of giving adequate recognition of all resources and benefits. In 1953, Assistant Chief Edward P. Cliff addressed the American Forestry Association on multiple use as integrated management of all resources on national forests.

By the 1950s there was increased demand for postwar timber, recreation, and other uses of our nation's forests. Competition for resources and the need for a substantial legal basis prompted a call for legislation that resulted in the Multiple Use-Sustained Yield Act of 1960. This legislation stated "the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (Steen 1976). Also reaffirmed was the right to develop mineral resources. This Act of Congress made official policy of what had previously been administrative decisions.

Environmental Awareness

The Multiple Use-Sustained Yield Act and other legislation in the 1960s and 1970s reflected increased public environmental awareness and increasing demand for more goods and services from the Forest Service. Recreation was addressed by various legislations. The wilderness system on National Forests had been established in 1924. With passage of the Wilderness Act of 1964, the 9 million acres (3.6 million ha) that had been set aside on administrative authority were incorporated into the wilderness system, and provisions were made for study and inclusion of other areas (USDA Forest Service 1982). The Land and Water Conservation Fund Act (1965) authorized land purchase for recreation. The National Trails System Act (1968) established a national system of recreational and scenic trails. The Wild and Scenic Rivers Act (1968) provided for river protection in a free flowing condition.

Other legislation and resultant action profoundly influenced how the Forest Service managed for multiple resources. The National Environmental Policy Act of 1969 required federal agencies to consider effects of their actions on the environment. The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) required the Forest Service to prepare long range programs dealing with administration, roads and trails, research, and cooperative programs. The National Forest Management Act (NFMA) (1976) provided for a coordinated land management planning process with full public participation. All of these included all wildlife as integral parts of forest systems. Wildlife was to be included in planning and managed for maintenance at viable levels.

Cooperation and research were strengthened during this period also. The Cooperative Forestry Assistance Act of 1978 authorized technical assistance, cost sharing, and resource protection programs on nonfederal forest lands through cooperative agreements. The Forest and Rangeland Renewable Resources Research Act of 1978 authorized a forestry research program in resource management, environmental protection, forest products utilization, and resource assessment.

The late 1970s and early 1980s brought Administration attention to commodity values from National Forests (Frome 1984). Recent annual receipts from timber sales have been erratic, depending on the market. Revenues from mineral activities have increased. From fiscal year 1979 to 1981, receipts from mineral activities increased about 50 percent annually, and from 1981 to 1983 were up 6 percent.

Multiple Services

Multiple services for better forests and for the betterment of people have current emphasis as well as a rich tradition. An inspection of the annual report for fiscal year 1983 (USDA Forest Service 1984) details the varied activities and multiple services the Forest Service provides to the forest community. For the year, expenditures totaled $2.06 billion. Operation of the National Forest system represented 83 percent of total expense, research—6 percent, state and private forestry—4 percent, and 7 percent divided between working capital and the Human Resources Program. Receipts from timber sales, mineral leasing, grazing, and recreation totaled almost a billion dollars. Cost reductions were accomplished throughout the organization. Personnel were reduced for the third straight year and some units and services were combined. Distributed information processing systems were installed and tested. The Emergency Jobs Appropriations Act set up $85 million to create employment while accomplishing needed work. The number of fulltime employees totaled 41,850 fulltime equivalents. The Equal Acres Program assisted more than 4,000 minority landowners.

The Forest Service manages and protects 191 million acres (77.3 million ha) in the National Forest System. In the National Forest System, priority was placed on developing cost-effective programs. Some 9.2 billion board feet of timber, with a value of $650 million, was sold. A decision was made to extend some timber contracts. Over 30,000 mineral cases were processed. Recreation revenue increased. Fire wood cutting continues to be popular. An interagency Grizzly Bear Committee was formed. Cannabis growth on National Forests dwindled. There were more than 14,000 grazing permittees. Grazing receipts were lower because of a congressionally dictated fee formula. Over 200,000 acres (81,000 ha) were reforested. Timber stand improvement was accomplished on over one-half million acres (200,000 ha). Visitor days on National Forests numbered 228 million.

For research, fiscal year 1983 programs provided new technology and supported international forestry. Research is conducted through eight regional Forest and Range Experiment Stations and the Forest Products Laboratory. Approximately 850 scientists are stationed at 75 locations. Increased emphasis was put on research involving old-growth wildlife habitat and integrated pest management. Research thrusts included genetic engineering and tree genetics, acid deposition, biological control of pests, improved tree utilization, and continued research on watershed, wildlife and fish habitat, range, recreation, timber, and biomass energy (USDA Forest Service 1984).

Increased productivity on nonindustrial private lands, protection from fire, insects, disease, and technology transfer were programs emphasized by State and

Private Forestry (USDA Forest Service 1984). Specific activities included: Treating 2 million acres (809,000 ha) of land for insect control; publishing "The Truss-Framed Construction Manual"; aiding in improved wood utilization; issuing 29 state forest resource plans; technology transfer on a wide scale; and completing a national analysis of fire protection and the roles of various agencies.

The Human Resources Program was successful in meeting social goals and accomplishing work of this federal organization. Over 44,000 volunteers contributed $21 million worth of work. The Touch America Project was a new cooperative program for youth. More than 5,000 youth aged 15 to 18 were hired in the Youth Conservation Corps.

Wildlife Management and Research

Because this is a natural resource conference with major focus on wildlife, it is appropriate to give a brief consideration of wildlife management and research in the U.S. Forest Service as illustrations of multiple use. In general, the Forest Service is charged with maintaining viable populations of plant and animal species, promoting recovery for threatened and endangered species, and providing habitat for species with high demand, such as game animals (Nelson et al. 1983). Goals and means to accomplish goals are detailed in RPA. The NFMA requires that wildlife be considered in each forest plan for each administrative unit, that habitat for animals be maintained, and that management indicator species be monitored. Each Forest Service Region is establishing and maintaining a computerized wildlife habitat relationships data base as part of a National Wildlife and Fish Habitat Relationships Program. Public input comes through review of Environmental Impact Statements and Forest Plans.

Land capabilities and Forest Service management activities have resulted in a wealth of wildlife on public land. In the East, most of the habitat for many threatened and endangered species, such as red-cockaded woodpecker, Kirtland's warbler, peregrine falcon, bald eagle, and eastern timber wolf, is federal land (Hoekstra et al. 1981). The wild turkey has experienced a dramatic comeback in the United States. Today, there are over 2 million wild turkeys, many on National Forests. In the West, extensive habitats for large ungulates and carnivores are found primarily on federal land. During the mid-1970s, western federal land provided more than two-thirds of the harvest of eight big game species (pronghorn antelope, bighorn sheep, black bear, brown bear, elk, moose, mountain goat, and mule deer) (Hoekstra et al. 1981).

The mission of wildlife research is within the mission of Forest Service research—to develop the knowledge and technology required to enhance the economic and environmental value of all of America's 1.6 billion acres (647 million ha) of forest and related lands. The emphasis of most wildlife research is directed toward obtaining information for the National Forest System to aid in management decisions and to develop the National Wildlife and Fish Habitat Relationships program. The Forest and Range Renewable Resources Research Act of 1978 specifies wildlife investigations of multiple products, vegetation support of fish and wildlife, improving wildlife and fish habitat, and activities concerning threatened and endangered wildlife. Research in the eight experiment stations can be generally categorized: (1) development of new methods and systems of monitoring wildlife; (2) community and habitat response to land management; (3) species-specific studies; and (4) application of ecological concepts to management of wildlife and fish (Dickson et al. 1985).

Some examples of current research include investigations of wildlife community-habitat relationships: In old-growth Douglas-fir stands in the West, in riparian and ponderosa pine habitat in the Southwest, in shrub-herb rangeland in the Great Basin, in the Rocky Mountains, in the South, and in the Northern Plains. Examples of studies of species or species groups include those defining ecological roles of: small mammals in Alaska, salmonids in Oregon, the spotted-owl in Oregon and Washington, great grey and flammulated owls in Oregon, the red-cockaded woodpecker in the South, Kirtland's warbler in Michigan, eastern timber wolves in Minnesota, and the Puerto Rican parrot in Puerto Rico (Dickson et al. 1985).

Conclusions

The Forest Service has a long tradition of multiple-use management of National Forests and providing multiple services for a variety of benefits. This has been influenced by the public, special interest groups, and legislative mandates. The future should hold increased demands for limited goods and services from the Forest Service. An increasing population will demand more timber, quality water, recreation, meat from livestock, and wildlife. A high level of professional and social skills will be necessary to provide a mix of products to meet most of the varied demands of a larger and more educated populace.

Summary

Managing federal land for multiple products and offering multiple services for better forest management has been associated with USDA Forest Service since its inception. This policy has been strengthened by public interest and recent legislation such as the Multiple Use and Sustained Yield Act of 1960, the National Environmental Policy Act (1969), the Renewable Resources Planning Act (1974, 1976), and the National Forest Management Act of 1976. To meet these mandates the Forest Service has undertaken new initiatives in management, research, cooperative forestry, and human resources development. To illustrate one facet of multiple use, Forest Service wildlife management and research is introduced. A national Wildlife and Fish Habitat Relationships program is being developed to manage vertebrate wildlife communities. Land management planning, which includes wildlife, is being implemented by each Forest Service management unit. Major emphasis in wildlife research covers: Monitoring techniques, wildlife in special habitat (e.g., old growth, riparian zones), special wildlife (such as endangered wildlife), and testing ecological concepts. The future should hold increased demands from more people for limited goods and services from the Forest Service.

Literature Cited

Dickson, J. G., J. P. McIlwain, and F. A. Stormer. 1985. Nongame wildlife management and research in the U.S. Forest Service. Pages 6-13 *in* W. C. McComb, ed. Proc. Workshop on Management of Nongame Species and Ecological Communities. Univ. of Kentucky, Lexington (In Press).

Frome, M. 1984. The Forest Service (Second Edition). Westview Press. Boulder, CO. 312 pp.
Hoekstra, T. W., J. W. Thomas, M. R. Lennartz, and D. P. Worley. 1981. Managing of federal lands for production and use of wildlife and fish. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46: 336-344.
Nelson, R. D., H. Black, Jr., R. E. Radtke, and J. Mumma. 1983. Wildlife and fish management in the Forest Service: a goal oriented approach. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:87-95.
Steen, H. K. 1976. The U.S. Forest Service, a history. Univ. of Washington Press, Seattle. 346 pp.
U.S. Department of Agriculture, Forest Service. 1982. What the Forest Service does. U.S. Government Printing Office, Washingtion, D.C. 31 pp.
______. 1984. Report of the Forest Service—fiscal year 1983. USDA Forest Service, Washington, D.C. 161 pp.

Management of Wildlife Resources on Large Private Forestland Holdings in the Southeastern United States

Roy L. Lassiter, Jr.
Tennessee Technological University
Cookeville, Tennessee 38505

Introduction

This report is based on a study supported by a grant from Resources for the Future, Inc., which had the objectives of determining:[1]

1. who gains access to the wildlife on large private timberland holdings in Alabama, Florida, Georgia, and Tennessee and the terms through which access is achieved;
2. the relative importance of the various access arrangements, problems associated with each form of arrangement, and possible future changes in the distribution of acreage among the various access arrangements;
3. the extent to which forestlands are explicitly managed so as to maintain or enhance the production of wildlife and the impact of current forest management practices on wildlife populations; and
4. the magnitude and significance of payments made to forestland owners for access (e.g.,hunting rights leases, permits, etc.) and the consequences of these payments on the management of forest and wildlife resources.

This paper will deal with some of the more significant wildlife and forestry policies affecting wildlife with some reference to the impact of income received from providing access for the management of resources. More specifically, the paper will address the use of wildlife specialists by the firms, the explicit inclusion (or lack thereof) of wildlife in forest planning and in operating practices, attitudes of woodlands personnel toward the feasibility of maintaining or enhancing wildlife populations, general wildlife and forest practices, and even-age management practices affecting wildlife.

Data

The data employed were obtained from forest managers/owners using interview and mail surveys. Sixty-two firms were interviewed. Of these, 40 had holdings in only one of the states, 16 operated in two states, and 6 owned lands in three states. Because of differences in the characteristics of holdings and operations among the states, a separate questionnaire was completed for each state in which a firm owned forestland (a total of 90 questionnaires). The interview survey firms owned, or controlled access to wildlife, on 17.2 million acres, (7 million ha) in the four states (Table 1). Forty of the firms were classified as Forest Industry and 22 were Other Private firms.

[1]*See,* Roy L. Lassiter, Jr., *Access to and Management of the Wildlife Resources on Large Private Timberland Holdings in the Southeastern United States,* Cookeville, Tennessee; Tennessee Technological University, College of Business Administration Monograph No. 1, forthcoming.

Table 1. Number of sample firms and acreage controlled by these firms by type of survey and type of firm, 1983.

Type of survey and firm	Number of firms	Number of operations in in four states	Acreage on which firms control access to wildlife
Interview survey			
Forest industry	40	66	15,351,888 (6,212,755ha)
Other private	22	24	1,860,434 (752,899ha)
Mail questionnaire	125	—	2,675.536 (1,082,762ha)
Total	187	90	19,887,858 (8,048,017ha)

Mail questionnaires were sent to 248 firms and 125 useable questionnaires were returned. The 125 mail survey firms controlled access to wildlife on 2.7 million acres (1.1 million ha) which they owned or leased from others.

Management Indices

Dealing with the number, size, and diversity of firms included in this study precluded identification and analysis of the detailed management policies and practices of individual firms. However, an examination of the literature of forestry and wildlife management suggests that there are key indicators which will provide a general picture of the extent to which wildlife are explicitly included in the management of forest resources. A listing of all of the questions pertaining to wildlife management on the interview questionnaire is not feasible here, but they are derived from the following list of general questions, which represent the indices employed in this study.[2]

1. Is the professonal expertise of wildlife biologists used in overall forest planning by the firm?
2. Does the firm include wildlife in its planning, policies, and programs?
3. What is the firm's attitude toward the maintenance and enhancement of wildlife populations under various access arrangements?
4. What are the firm's practices relating to the maintenance of inventories of wildlife and vegetation suitable for wildlife, and the maintenance of records of wildlife harvested, trapped, or otherwise removed?
5. Does the firm maintain openings for wildlife and seed these openings and woods roads with vegetation for wildlife?
6. Does the firm use prescribed burning and herbicides in forest management?
7. Does the firm leave mast trees and high site index hardwoods in even-age harvests?
8. Does the firm establish streamside management zones?
9. Does the firm regard it economically feasible to reduce the size of clearcuts and to disperse age classes into small non-contiguous plantings?

[2]Selected citations supporting the bases of these questons are given in Roy L. Lassiter, Jr., Ibid, pp. 30-32

It must be recognized that the priorities assigned to the management of wildlife resources will be affected by the attitudes of those in decision and policy making positions in the firms. These attitudes ranged widely among the interview sample firms. A few firms regarded the production of wildlife as an integral part of business operations. For the remainder of the firms, attitudes ranged from those who regarded wildlife as a trust associated with the ownership of land, to those who were essentially neutral, to those who held negative attitudes which primarily arose from the problems associated with public access.

Access Arrangements

In part, the management of wildlife resources is determined by the arrangements through which access to these wildlife is obtained. For example, state wildlife specialists presumably influence the management of wildlife on those lands contained in state wildlife management areas. The distribution of the forestlands controlled by the sample firms among various means through which access is obtained (or denied) is provided in Table 2. Of the 19.9 million acres (8 million ha) on which the sample firms controlled access to wildlife, hunting rights were leased to others on nearly one-third of the acreage, 26 percent of the acreage was either open to the public with no permission being required or through a free permit, and a fee was charged for a permit on 11 percent of the acreage. Owners of the land which was closed indicated that most of it was available for hunting rights leases.

Management of Wildlife and Forest Resouces

In practice it is difficult to separate wildlife and forest management practices because the two are interrelated. Many wildlife management practices affect the production of wood products, and forest management practices affect wildlife habitats. Furthermore, other factors may affect both. For example, the size, shape, and proximate locations of clearcuts are influenced by topographic characteristics; or state water quality statutes may require the establishment of streamside management zones. Both affect wildlife habitats and the production of wood products. It is beyond the scope of this paper to explore the complex, multi-dimensional trade-offs or externalities which are inherent in the management of the natural environment.

Table 2. Acres of forestland owned by and leased with access to wildlife controlled by all sample firms by specified access arrangement, 1983.

Specified access arrangement	Total acres in 1983	
State wildlife management areas	3,274,174	(1,325,025ha)
Open: No Permission or permit required	2,754,673	(1,114,788ha)
Open: Permission or permit		
Required	4,696,939	(1,900,804ha)
Free	2,499,776	(1,011,634ha)
Charge	2,197,163	(889,170ha)
Access rights leased	6,569,760	(2,658,716ha)
Open only to owners, employees, or guests	1,233,509	(499,189ha)
Closed to all parties	1,358,803	(549,894ha)
Total	19,887,858	(8,048,417ha)

Rather the method is to employ key indicators or practices, undertaken for whatever reason, which positively or negatively affect forest wildlife.

Use of Wildlife Specialists

The extent of use of wildlife specialists is at least a partial indicator of the commitment to the management of wildlife resources.[3] Among the sample firms (or branches of firms) 133 did not make any use of wildlife specialists in firm operations (see Table 3). These firms accounted for 47.9 percent of the 19.9 million acres (8 million ha) controlled by the sample firms. However, it should be recognized that some 2.1 million acres (849,849 ha) of the firms not using wildlife specialists were in state wildlife management areas where, presumably, state agency specialists had some impact on wildlife management. Sixteen firms (or branches) used wildlife specialists as fulltime employees of the firm. The importance of government agency specialists is emphasized by the fact that 57 firms controlling slightly over one-third of the total acreage made some use of specialists from that source. It is obvious that the use of paid consultants specializing in wildlife is not nearly as widespread as is the use of forester consultants.

Inclusion of Wildlife in Firm Planning and in Operations

The detail available from the mail survey was obviously limited. For that reason the balance of this paper will deal with the interview survey firms as a group and, in some cases, with the Forest Industry firms sub-set. The inclusion (or exclusion) of wildlife in firm planning and in operating policies and practices is an indication of

Table 3. Use of wildlife specialists by sample firms (or branches) by type of specialist, type of survey and firm, and acreage of forestland controlled, 1983.

	Type of wildlife specialist used:				
Type of survey and firm	Full-time employee	Paid consultant	Government agency	None	Total
Interview survey					
Forest Industry					
No. of firms	9	3	21	33	66
Acreage	2,684,407 (1,086,352ha)	499,251 (202,042ha)	5,296,022 (2,143,247ha)	6,872.208 (2,781,114ha)	15,351,999 (6,212,800ha)
Other Private					
No. of firms	1	0	10	13	24
Acreage	305,000 (123,430ha)	0	602,374 (243,775ha)	953,060 (385,694ha)	1,860,434 (752,899ha)
Mail Survey					
No. of firms	6	6	26	87	125
Acreage	79,300 (32,092ha)	64,313 (26,027ha)	834,108 (337,555ha)	1,697,815 (687,089ha)	2,675,536 (1,082,762ha)
Total					
No. of firms	16	9	57	133	215
Acreage	3,068,707 (1,241,875ha)	563,564 (228,069ha)	6,732,504 (2,724,577ha)	9,523,083 (3,853,896ha)	19,887,858 (8,048,417ha)

[3]It is recognized that many professional foresters have some training in wildlife management. However, the use of professional wildlife personnel presupposes a stronger commitment to wildlife resources.

Table 4. Number of forest industry interview survey firms by inclusion of wildlife in forest plans and policies, and acreage controlled, 1983.

Inclusion of wildlife in forest plans and policies	Number of firms	Acreage controlled
Provisions for wildlife incorporated in plans and policies	36	10,015,328 (4,053,103ha)
Provisions for wildlife *not* incorporated in plans and policies	28	5,224,860 (2,114,448ha)
Total	64[a]	15,240,188[a] (6,167,551ha)

[a]Excludes two firms which did not express judgements on the maintenance of wildlife populations.

Table 5. Number of forest industry interview survey firms (or branches) by judgement regarding the maintenance of wildlife populations and acreage controlled, 1983.

Judgement of possibility of maintaining or enhancing wildlife populations under Specified conditions of public access	Number of firms	Acreage controlled
Possible to maintain or enhance wildlife populations with free public access and public access for fee	33	7,583,295 (3,068,883ha)
Possible to maintain or enhance wildlife populations with public access for fee, but *not* free public access.................	23	4,699,074 (1,901,688ha)
Not possible to maintain or enhance wildlife populations with either free public access or public access for fee.............	8	2,962,319 (1,198,821ha)
Total	64	15,240,188[a] (6,167,551ha)

[a]Excludes two firms which did not express judgements on the maintenance of wildlife populations.

the firm's commitment to its wildlife resources. Thirty-six of the firms indicated that wildlife were explicitly included in firm planning and operating policies and practices (see Table 4). These firms controlled 10 million acres (4 million ha). On the other hand, 28 firms, with 5.2 million (2.1 million ha),did not make such provisions for wildlife.

Judgements Regarding the Maintenance of Wildlife Populations

The maintenance or enhancement of wildlife populations has economic consequences for the firm and thus the judgements were sought in terms of the conditions of public access. Over one-half of the Forest Industry firms were of the opinion that it was possible to maintain or enhance wildlife populations with either free or public access gained through levying a charge. (see Table 5). These firms controlled 45.8

percent of the acreage. On the other hand, eight firms with 19.4 percent of the acreage hald the judgement that wildlife populatons could not be maintained under any condition of public access. The balance of the firms, with 30.8 percent of the acreage, held the opinion that wildlife populations could be maintained or enhanced only if the public were charged for access.

General Wildlife and Forest Management Practices

Few firms used practices directed toward managing both the quantity and quality of the wildlife populations. Only 8 of the 90 firms (or branches) maintained inventories of wildlife and only two of these attempted to estimate the characteristics of wildlife populations (see Table 6). Eleven of the firms required users to provide characteristics of big game taken, but none maintained records of forest wildlife removed from their lands. Two firms had established and were maintaining inventories of vegetation suitable for wildlife.

Thirty-three firms, which controlled 6.3 million acres (2.5 million ha) reported that they established and maintained openings for wildlife, and 28 of these firms made plantings for wildlife in these openings (see Table 7). Fifty-three firms seeded woods roads with vegetation suitable for wildlife, although the reasons for this practice were based more on erosion control than for the benefit of wildlife. Prescribed burning was employed by 73 of the firms (or branches) on 15.5 million acres (6.3 million ha), or 89.9 percent of the total acreage controlled. Herbicides were regularly used by 64 firms controlling 89 percent of the acreage.

Even-Age Management Practices

Of the 90 firms (or branches), 73 used even-age management to some extent. Forty-two of these firms reported leaving mature mast trees in even-age harvests, 46

Table 6. Specified wildlife management practices of interview sample firms by classification of firms, 1983.

Specified wildlife management practice	Classification of firms: Forest industry	Other private	Total
Number of firms			
Maintaining an inventory of game and nongame wildlife	4	4	8
Maintaining an inventory of game and nongame wildlife including population estimates and population characteristics	0	2	2
Requiring users of company lands to provide characteristics of big game taken	7	4	11
Maintaining a record of forest wildlife taken from company lands by any method of removal	0	0	0
Maintaining an inventory suitable for wildlife	2	0	2

Table 7. Specified wildlife and forest management practices employed by interview sample firms or branches, number of firms and acres of forestland owned and leased, 1983.

	Number of firms and acres of forestland owned and leased in four states:	
Specified practice	Number of firms	Acres owned and leased
Establish and maintain openings for wildlife	33	6,251,504 (2,529,921ha)
Make plantings for wildlife in openings	28	4,040,824 (1,635,281ha)
Seed wood roads with vegetation suitable for wildlife	53	11,503,021 (4,655,157ha)
Regularly use prescribed burning	73	15,468,805 (6,260,070ha)
Regularly used herbicides	64	15,320,914 (6,200,220ha)

left dead or overage trees, 48 left high site index hardwoods in converting hardwoods to pine, and 64 established streamside management zones (see Table 8). Only 23 firms with 5.9 million acres (2.4 million ha) (32 percent of the acreage of firms using even-age management) reported using all four of these practices.

The size and shape of clearcuts and the dispersal of age classes are considered to be important factors affecting wildlife habitats. In order to assess firm practices they were asked to specify the practices which would be used on a forest compartment (600-1,000 acres[243-405 ha]) suitable for a single age class. Thirty-five of the firms indicated that it would be their practice to regenerate the compartment to a single age class and 38 responded that they would regenerate the compartment to more than one age class (see Table 9).

Only 10 of the firms which would regenerate the compartment to a single age class were of the opinion that it was economically feasible to disperse age classes into smaller non-contiguous age classes, while 19 of the 38 firms using more than one age class felt that dispersal of age classes was economically feasible.

It would be expected that the income derived from wildlife would have an impact on the management of forest resources. This impact can be illustrated by a simplified transformation function illustrating the trade-offs between wood products and wildlife (see Figure 1). When the price derived from wildlife is zero, or negligible, few resources would be devoted to its production. The "optimum" production of both forest products and wildlife would occur where a line with a slope equal to the ratio of prices of the two products is tangent to the transformation curve.

For the bulk of the interview firms, it was very difficult to identify the impact of income from wildlife on wildlife and forest management practices. However, for those firms receiving the highest incomes the effects are more apparent. For example, when the 10 firms receiving the highest total and per acre incomes are separated from the rest of the sample, differences in practices and policies are evident (see Table 10). For example, greater proportions of the firms with the highest gross income from wildlife incorporated wildlife in firm plans and policies, left mature

Table 8. Number of interview survey firms using even-age management by specified practice, type of firm, and all acreage controlled, 1983.

	Type of firm					
	Forest industry		Other private		Total	
Specified practice	No. of firms	Acreage controlled	No. of firms	Acreage controlled	No.of firms	Acreage controlled
Firms which:						
Leave mature mast trees	40	9,168,427 (3,710,370ha)	2	365,000 (147,712ha)	42	9,533,427 (3,858,082ha)
Leave dead or overage trees	41	10,890,050 (4,407,094ha)	5	490,000 (198,298ha)	46	11,380,050 (4,605,392ha)
Leave high site index hardwoods	41	9,670,470 (3,913,524ha)	7	630,000 (254,955ha)	48	10,300,472 (4,168,498ha)
Establish streamside management zones	56	15,701,381 (6,354,192ha)	8	616,064 (249,315ha)	64	16,317,445 (6,603,507ha)
Use all four practices	21	5,539,993 (2,241,980ha)	2	365,000 (147,712ha)	23	5,904,993 (2,389,691ha)

Table 9. Even-age management regeneration practices on a forest compartment and economic feasibility of alternative practices by interview sample firms in four southeastern states by number of firms, total acreage owned by and leased to these firms, and classification of firms, 1983.

	Regeneration practices and possible practices on a forest compartment (600-1000 [243-405ha] acres) suitable for a single age class:					
	Practice to regenerate in single age class		Regard it economically feasible to regenerate into more than one age class		Regard it economically feasible to disperse age classes into smaller noncontiguous plantings	
Classification of firms	Number of firms	Total acres owned and leased	Number of firms	Total acres owned and leased	Number of firms	Total acres owned and leased
Forest industry	30	8,768,118 (3,548,369ha)	23	5,923,130 (2,397,031ha)	7	2,229,579 (902,288ha)
Other private	5	212,829 (86,130ha)	3	172,829 (69,942ha)	3	172,829 (69,942ha)
Total	35	9,000,947 (3,642,593ha)	26	6,095,959 (2,466,973ha)	10	2,402,408 (972,230ha)

	Practice to regenerate into more then one age class		Regard it economically feasible to disperse age classes into smaller noncontiguous plantings	
	Number of firms	Total acres owned and leased	Number of firms	Total acres owned and leased
Forest industry	32	7,279,019 (2,945,746ha)	15	2,913,466 (1,179,050ha)
Other private	6	498,231 (201,629ha)	4	487,780 (197,399ha)
Total	38	7,777,250 (3,147,375ha)	19	3,395,246 (1,374,002ha)

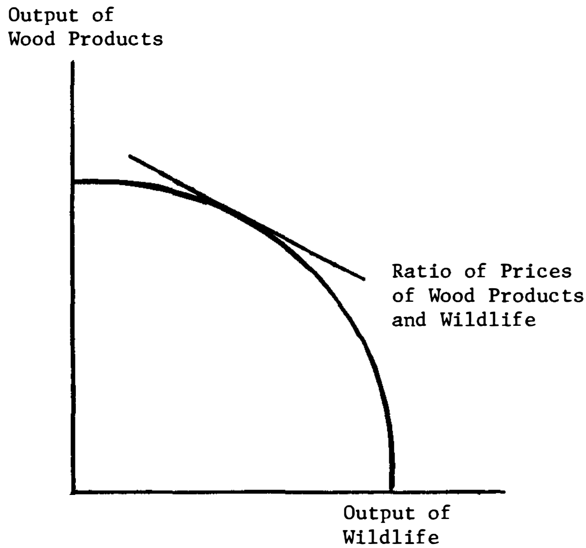


Figure 1. Hypothetical relationship between the production of wood products and wildlife.

Table 10. Specified practices or judgements of interview survey firms in four southeastern states by level of gross income received for providing access to wildlife, 1983.

Specified practice or judgement	Percent of designated firms following specified practice: Ten firms with highest total gross income from wildlife	Ten firms with highest gross income per acre from wildlife	All other firms
	(percent)	(percent)	(percent)
Incorporate wildlife in forest plans and policies	90	40	53
Even-age management practices:			
Leave mature mast trees	80	80	54
Leave high site index hardwoods	70	80	65
Regeneration of forest compartment:			
In single age class:	40	30	49
Economically feasible to regenerate to more than one age class	50	100	77
Economically feasible to disperse age classes	50	67	29
In more than one age class:	60	70	51
Economically feasible to disperse age classes	50	57	50

mast trees and high site index hardwoods, regenerated forest compartments into more than one age class, and regarded it as being ecomically feasible to disperse age classes than was the case for the balance of the firms.

Conclusions

1. Overall the intensity of the management of wildlife resources by the sample firms is low, although it is higher than might be expected given the limited incomes which many of the firms derived from wildlife.
2. While it was beyond the scope of this paper, there were substantial differences in public access arrangements and the management of wildlife and forest resources among the states of Florida, Georgia, Alabama, and Tennessee.
3. A number of forest management practices are highly beneficial to wildlife, but are not "chargeable" to the production of wildlife. Examples of these practices are prescribed burning and the establishment of streamside management zones.
4. Although some firms used wildlife specialists as either employees or as consultants, in only a very few firms do these specialists have significant input into forest planning or in the definition of operating policies and practices. For those firms which regard the production of wildlife as an integral part of the business, wildlife specialists have substantial impact on firm operations.
5. Although not explicitly dealt with in this paper, it became evident in the study that the incomes which could be derived from providing access to wildlife were substantial and increasing. The long term effects of this income potential will be to alter the attitudes of woodlands managers, to intensify the management of wildlife, to reduce the amount of land to which the public has free access, and to alter the combinations of wood products and wildlife produced.

Public Use of Large Private Forests in Arkansas

Carlton N. Owen
Potlatch Corporation, Warren, Arkansas, 71671

T. Bently Wigley
University of Arkansas at Monticello, 71655

Danny L. Adams
The Ross Foundation, Arkadelphia, Arkansas, 71923

Introduction

Forests occupy 49 percent of the land base in Arkansas and are important to the state for a variety of uses, including economics, recreation, wildlife, and timber. Of the state's forestland base, 82.5 percent is privately owned.

Forested acreage in Arkansas declined from 20.7 million acres (8.4 million ha) in 1959 to 16.6 million acres (6.7 million ha) in 1978, a decline of 19.8 percent (Troutman and Breshears 1981). Meanwhile, the population of Arkansas rose from approximately 1.7 million in 1960 to 2.3 million in 1980, an increase of 28.0 percent.

From 1960 to 1980, sales of Arkansas resident hunting and fishing licenses increased 64.2 percent, from 466,000 to more than 765,000. In 1980, almost one-half million persons spent more than 9 million man days hunting in Arkansas (U.S. Dep. of Interior 1982a). More than 895,000 residents and non-residents spent 15,277,200 user days fishing. Over two-thirds of the state's population took part in non-consumptive wildlife-related activities.

Recreational use of forestland, especially private lands, has led to landowner-recreationist conflicts. Many private landowners have management objectives that may be hampered by public users. In turn, recreational users may perceive the management practices of private landowners as detrimental to their recreational pursuits.

Both landowners and recreational users are concerned about continued public access to privately owned lands and protection of the forest resource (Blood and Baden 1984). This study was undertaken to identify problems, policies, and programs associated with public use of large privately owned forestlands from the landowner's perspective. It suggests opportunities and solutions beneficial to both landowners and recreational users.

Methods

A list was assembled of corporate and individual private landowners, each owning more than 1,000 acres (405 ha) of forestland in Arkansas. It was compiled from Arkansas Forestry Association members, Certified Arkansas Tree Farmers, consulting foresters, lands cooperatively managed by major forest industry companies, and tax records from 23 of the 75 Arkansas counties.

A mail survey was adapted from Kluender (1978). It contained questions pertaining to ownership size, reasons for owning forestland, public use policies, and public use of forestlands. Additional open-ended questions were used to evaluate problems experienced by landowners and their feelings toward existing land-use legislation. The survey and a self-addressed return envelope were mailed (first-class) on June 20, 1984. A reminder post card was mailed on August 1, 1984, to all non-respondents. The final mailing, August 14, 1984, consisted of another copy of the survey and a self-addressed envelope. Statistical analyses were done using SPSS-X (SPSS, Inc. 1983) and significance was accepted at the 0.05 probability level.

Results and Discussion

Of 352 questionnaires mailed, 223 (63.4 percent) usable responses were received. Six (1.7 percent) were returned as non-deliverable. Individual landowners responded at a 55.8 percent rate (129), while 77.7 percent (94) of corporate landowners returned usable surveys.

Private Forest Ownership

Of the 5,098,511 forested acres (2,064,174 ha) tallied from the survey responses, 94.7 percent (4,830,126 ac; 1,955,517 ha) were owned by forest-industry or other corporations (Table 1). The remaining 268,385 acres (108,658 ha) were reported by individual owners. This survey covered almost one-third of the forestlands in Arkansas.

Most corporate and individual landowners (88.7 percent) stated that the primary reason for owning and managing their forestlands was timber production. Wildlife management, observation, and hunting was the most commonly cited secondary reason for ownership (36.0 percent), while investment ranked next (30.7 percent). Other uses cited in this survey as reasons for ownership were profit, stewardship, recreation, buffer to other operations (primarily mines), livestock grazing, tax shelter, inheritance, and minerals.

These rankings are comparable to those of an unpublished Southern Forest Institute landowner survey of four southern states, including Arkansas. In that study, timber management was also the most common reason given for owning forestland. Outside of the Southeast, timber management is not always a dominant ownership goal (Birch 1982, 1983, Birch and Dennis 1980). If private lands are to be fully utilized by the public for recreational and wildlife-related purposes the landowner must be given incentives to adjust ownership goals (Leopold 1933).

Public Use Policies

Nearly 85 percent (4,316,928 ac; 1,747,744 ha) of all respondents' lands were open to unrestricted public use (Table 1). Unrestricted use was permitted on a higher proportion of corporate-owned lands than on lands owned by individuals (85.1 percent versus 77.2 percent).

Values for unrestricted public use found in this survey are among the highest in the nation. Numerous studies indicate that significant percentages of private rural lands in the U.S. have some type of user access restriction (Birch 1982, 1983, Wildlife Management Institute 1984). A 1982 national survey by the Future Farmers of America indicated that at least 46 percent of private land is posted and up to 80 percent of private lands in some northeastern states is closed to public use (Wildlife Management Institute 1984). Another nationwide study of private nonindustrial

Table 1. Sampled privately owned forestlands [acres (percent)] in Arkansas by ownership and public use policy.

Public use policy	Corporate		Individual		Total	
Open	4,801,110	(99.4)	260,015	(96.9)	5,061,125	(99.3)
	(1,942,961ha)		(105,225ha)		(2,048,186ha)	
Unrestricted	4,109,879	(85.1)	207,049	(77.2)	4,316,928	(84.7)
	(1,663,227ha)		(83,790ha)		(1,747,017ha)	
By permission	98,907	(2.0)	37,436	(14.0)	136,343	(2.7)
	(40,026ha)		(15,150ha)		(55,176ha)	
Leased	458,353	(9.5)	15,387	(5.7)	473,740	(9.3)
	(185,491ha)		(6,227ha)		(191,718ha)	
Cooperative area	133,951	(2.8)	63	(0)	134,014	(2.6)
	(54,208ha)		(25ha)		(54,234ha)	
Closed	29,016	(0.6)	8,370	(3.1)	37,386	(0.7)
	(11,742ha)		(3,387ha)		(15,130ha)	
Total	4,830,126	(100.0)	268,385	(100.0)	5,098,511	(100.0)
	(1,954,703ha)		(108,612ha)		(2,063,316ha)	

forest owners reports that fully two-thirds of these lands are not open to public use (Cordell and Stevens 1983).

The proportionate acreages reported as open to unrestricted use in this survey should not be extrapolated to forest landowners with smaller acreages (< 1,000 acres; 405 ha). Landowners in Oklahoma with fewer than 75 acres (30 ha) were less willing to allow public use of their lands than were those holding larger tracts (Thorwardson 1977). Similarly, in Ohio, owners with fewer than 10 acres (4 ha) were more likely to post their property than were owners of larger acreages (Birch 1982). If the same holds true in Arkansas, where the largest single ownership group is comprised of individuals owning 300 acres (121 ha) or less (Troutman and Breshears 1981), public use of a greater proportion of these unsurveyed lands may be resticted.

A small number of owners reported a "use by permission" policy. Of the 136,343 acres (55,200 ha) in this category, 72.5 percent were owned by corporations and the remaining 27.5 percent were owned by individuals. A greater percentage of individuals than corporations, however, sought such restrictions (Table 1).

Less than one percent of all lands were listed as "totally closed," where landowners allowed no public use (Table 1). Most were associated with industrial plants, house sites, or mines, and thus were restricted for safety and liability reasons.

Cooperative agreements with public agencies were rare. This survey yielded no individual owners and only four corporate respondents who had entered cooperative agreements with the Arkansas Game and Fish Commission. These corporations committed 133,951 acres (54,231 ha) to Cooperative Wildlife Management Areas (Table 1). The potential for committing additional acreage to long-term public use was recognized in Arkansas' outdoor recreation plan, which stated that, "the Game and Fish Commission shall be urged to negotiate more wildlife management agreements with timber companies in Arkansas" (Arkansas Dep. of Local Services 1980). To achieve even a portion of this potential the Commission would need to pursue innovative approaches that would aid corporate landowners in reaching their objectives while also allowing compatible and regulated public use. A similar potential exists with individual owners, but logistics of such programs would be complicated by the diversity of owners, scattered holdings, differing management philosophies and ownership objectives.

The most controversial recreation management option is the "leasing" of hunting or other recreational privileges to groups or individual users. This survey found that Arkansas' corporate landowners leased 9.5 percent of their holdings while individuals leased 5.7 percent. Among all leases, 93.8 percent were for exclusive hunting uses; deer hunting (88 percent) was the most significant species use.

Economic Returns

The need for landowners to be compensated for wildlife management has long been recognized (Leopold 1933, Kimball 1963, Decker et al. 1979). Such programs are rapidly expanding in most southern states (Halls 1975, Burger and Teer 1981), either through club leases or fee leases operated by state wildlife agencies. At the present time, user fees are generally uncommon on Arkansas' private forestland. More than half (59 percent) of the lands leased by individuals were without an annual fee, while 4.2 percent of the leased corporate lands were in free leases (Yoho 1981). Gottschalk (1977) stated "free hunting" is a concept which promotes the illusion that buying a hunting license guarantees both game and a place to hunt, and denies the landowner an incentive for maintaining habitat.

When individual landowners did lease for a fee, however, it was often at a slightly higher price than corporate leases. Of the 13 individual landowners who leased, annual fees ranged from \$.25 to \$5.00 per acre and averaged \$1.36. Corporations (n = 9) charged from \$.50 to \$3.50 ($\bar{x}$ = \$1.22). In both cases, \$1.00 was the most common fee. One corporate and one individual landowner said annual fees were equal to taxes.

Special-Use Programs

Thirteen corporate owners reported programs designed to regulate firewood cutting, three of which involved charges for permits (\$3 to \$20). Only three grazing leases were reported, with a maximum fee of \$6 per animal unit year. Two special-use leases (a riding arena and a roadside park) were recorded.

A total of 534 campsite or cabin leases were recorded, of which 92.0 percent were on corporate land. Individuals charged for cabin site leases in three cases, and for camping in one. Corporate owners were more likely to charge fees for such public uses. Annual fees ranged from \$10 to \$100, with \$50 and \$75 being the most common. Temporary camping charges were uncommon, but ranged from \$10 to \$50.

Respondents reported 22 miles (35 km) of nature trails (72.8 percent corporate) and 8 roadside parks (all corporate). Forty-nine public access boat launching ramps (91.8 percent corporate), 8 public fishing lakes (7,200 ac; 2,915 ha) and 15 developed camping sites were also available for public use.

Public Uses

Landowner's perceptions of public uses varied only slightly by ownership. Both corporate and individual landowners ranked hunting as the most common public use (Table 2). Hunting was also found to be the most popular use in Louisiana (Hu et al.

Table 2. Public use of privately-owned forestlands in Arkansas, ranked by corporate and individual forest landowners (1 = most common use).

Public use	Corporate		Individual	
Hunting	3.22[a]	(80)[b]	2.56	(102)
Trash dumping	9.03	(55)	9.67	(62)
Firewood gathering	9.59	(47)	9.30	(57)
Fishing	10.33	(43)	11.21	(42)
3-wheel vehicle use	10.51	(39)	9.97	(47)
4-wheel vehicle use	10.51	(38)	10.48	(44)
Sight-seeing	10.66	(40)	13.17	(38)
Trapping	11.48	(39)	11.76	(41)
Camping	11.55	(36)	11.18	(44)
Hiking	12.85	(29)	13.09	(33)
Grazing	12.97	(30)	13.64	(25)
Wildlife/plant observation	12.99	(26)	13.05	(30)
Boating	13.84	(22)	13.95	(30)
Photography	14.27	(20)	14.21	(25)

[a]Average rank weighted for frequency of response.
[b]Number of respondents ranking land use out of 93 corporate respondents and 114 individual respondents.

Table 3. Problems associated with public use of privately-owned forestlands in Arkansas, ranked by forest landowners (1 = most common problem).

Problem	Corporate		Individual	
Litter	3.67[a]	(74)[b]	3.79	(90)
Illegal firewood cutting	5.45	(57)	5.12	(75)
Road damage	5.72	(47)	5.25	(61)
Arson	5.92	(55)	7.36	(48)
Timber damage	5.98	(52)	5.42	(68)
Trespass	6.58	(46)	7.02	(48)
Vandalism	7.19	(42)	7.69	(44)
Interference with landowner or agents	7.46	(34)	6.91	(39)

[a]Average rank weighted for frequency of response.
[b]Number of respondents ranking each problem out of 93 corporate respondents and 114 individual respondents.

1979) and the most common activity permitted by nonindustrial forest owners nationally (Cordell and Stevens 1983). Hunting requires a great deal of land per recreationist (Decker and Brown 1979). Sixty-eight percent of all hunting time nationwide is spent on private lands (U.S. Dep. of Interior 1982b), with some studies rating use as high as 75 percent (Jackson and Anderson 1982). Since Arkansas' total land base is more than 90 percent privately held, hunting time on private lands in Arkansas would most likely exceed the nationwide average.

Corporate landowners ranked trash dumping as the second most common use, firewood gathering third, and fishing fourth (Table 2). Firewood cutting was ranked second by individuals, followed by trash dumping and 3-wheel vehicle use. These results are similar to those found by Kluender (1978). In his study of public use of industrial forests in the Southeast, he too found hunting to be the principal use, with trash dumping ranked second. Firewood cutting was not considered a common use in his study. A recent nationwide study, however, projects a 5.0 percent annual growth in residential firewood useage. In the eastern U.S., 90 to 96 percent of all firewood comes from private land (Skog and Watterson 1983).

It is important to note that both 3- and 4-wheel vehicle use are frequently associated with hunting, further magnifying the importance of hunting as a use. Other uses rated by landowners included camping, boating/canoeing, grazing, hiking, photography, sightseeing, trapping, and wildlife/plant observations.

User-Associated Problems

Respondents were asked to identify significant problems associated with public use, in order of cost or value lost (Table 3). Both groups perceived litter and trash disposal to be the number one problem, and it also ranked high as an identified common public use (Tables 2 and 3). Similarly, both groups concurred that illegal firewood cutting and road damage ranked second and third respectively. Timber damage and interference with their activities were ranked fourth by individuals. Corporations ranked arson as fourth and timber damage as fifth. Trespass and vandalism both ranked low.

Rankings of problems associated with public use, as identified by this study, were similar to those found by Kluender (1978). In that study, trash disposal, road damage, firewood cutting, interference, and timber damage ranked from most to least significant.

Policies to Control User-Associated Problems

Landowners reported numerous approaches to addressing user-related problems. Corporations most frequently noted attempts to identify trash dumpers and/or erect no-dumping signs. Programs designed to control access (posting, road closing, etc.) were cited most often by individuals, and were second with corporate landowners. Periodic tours of areas, firewood-permit programs, personal contact with users, contacting authorities, or simply ignoring problems were used more frequently by corporations. Other programs identified by both landowner groups included leasing to clubs for protection, policies prohibiting nails in trees, removing deer stands and signs, painting of boundary lines, maintaining good relations with neighbors, no-camping policies, and road maintenance.

Planned Changes

Plans to expand existing recreation-use programs or adopt new ones were cited by fewer than 25 percent of either ownership class. Corporate owners stated such intentions more often than individuals (24.0 percent versus 10.6 percent). An additional 5.1 percent of corporate owners and 1.9 percent of individuals would expand public-use programs under the proper conditions.

Of owners planning changes, 12 corporations and seven individuals were considering starting or expanding leasing programs (8.5 percent of all respondents). Other plans included posting, limiting access, litter disposal projects, education directed at users, more cooperative management areas, and reduced grazing and firewood programs. One innovative individual planned to make a fishing lake out of a 20-acre (8 ha) beaver pond.

In Louisiana (Hu et al. 1979), most forest landowners with existing leasing programs planned to lease additional lands. The most common reasons given were to: (1) promote better community relations; (2) maintain and strengthen title to land ownerships; and (3) shift recreational responsibilities to leasees.

Legislative Needs

Sixty-eight percent of private forest landowners responding to this survey were not satisfied with existing private property rights legislation. This feeling did not differ significantly by ownership category.

The need for a "clear," "adequate," and "enforceable" trespass law was the most frequently cited legislative deficiency (54.6 percent of all respondents). Better trash-dumping laws and improved liability protection were desired by 3.6 percent and 2.6 percent of the respondents respectively. Arson and vandalism were also cited as areas needing legislative improvement.

Much of the conflict between users and landowners is due to the unclear relationships between landowners and wildlife ownership. Although wildlife is a "public" resource and does not belong to the owner of the land, the owner does have the exclusive right to hunting opportunities, subject to the right of the state to prohibit or regulate such hunting. It is because of this exclusive right inherent in land ownership that a state cannot, within constitutional limits, authorize a person to enter another's premises for the purposes of hunting without the landowner's permission (Kramer 1982). A clear understanding of these rights is frequently lacking among users and occasionally in agencies that manage wildlife resources.

Complicating the issue of private property rights in Arkansas is the fact that forest landowners do not have the basic protection of the state's "posting" or access control laws. The Arkansas civil code specifically excludes forested lands from protection by posting, the only land category so excluded. Thus, an Arkansas forest landowner must use the state's criminal trespass code, which is difficult to apply. Such laws may leave landowners looking upon wildlife resources as a nuisance that will lead to more abuse rather than a resource worthy of management attention and consideration (Gottschalk 1977).

Trash dumping and littering laws were considered to be generally adequate. However, inadequate enforcement, lack of solid waste disposal options, and public attitudes have tended to allow problems to continue.

Several respondents expressed concerns about user liability. However, recreational landowner liablility laws are in place. A 1965 code, which was amended in 1983, appears to provide the liability protection needed. Much of the remaining fear expressed by landowners may be more perceived than real, a reflection of publicity surrounding suits against landowners and the enormous settlements often awarded.

Conclusions

Owners of large (> 1,000 ac; 405ha) forested holdings in Arkansas have traditionally provided free and unrestricted access to their lands for public recreational use. Nearly 90 percent of the lands represented in this survey remain open today, yet the trend is toward more controlled access programs. This trend is being fueled by abuse by receational users, legislative inadequacies, and economic pressures.

Unlike most other southern states, Arkansas has an opportunity to influence the direction and complexion of changes that are in progress. Opportunities remain to encompass all user groups and assure continued access to private land. First, however, users of all types must develop positive (non-abusive) habits and images. Secondly, users and government agencies alike must recognize, as Aldo Leopold did in 1933, that the private landowner is custodian of wildlife produced on his land and, as such, must be duly compensated. That compensation may be economic or it may take the form of social recognition, rewards, or in-kind services to aid the owner in reaching his ownership objectives. Legislative remedies to strengthen weak or unclear access control and landowner rights laws are also needed.

Much is being done to achieve these ends. The abuse problems can and are being addressed by attempting to curb unethical user behavior. One way to address this is through "statewide ethics conferences" of landowners, concerned users, and managers. In other states, these programs have evolved into full-fledged campaigns such as Missouri's SPORT and Virginia's Operation RESPECT. Hunter education courses, such as the one in Arkansas, and even trapper education courses, such as those held in Kansas, aid in the process.

To work toward social recognition needs, the state of Colorado has developed a "Landowner Recognition Project," designed to recognize and reward private landowners who allow public use of private property. The program combines education of users, stronger trespass control, and reduction of abuses with awards and recognition.

In-kind service or assistance to landowners is also working to improve relationships between users and landowners. In Tennessee, a group of sportsmen recently helped a farmer clear rocks from a new field. In return, the landowner waived the group's lease fees for dove hunting on his property.

Individuals from Leopold to Zane Grey have recognized the need to give legislative and other necessary protection and support to landowners who actually pay for production of wildlife and other recreational opportunities on their lands. Broad-based organizations such as the National Wildlife Federation, National Rifle Association, Wildlife Management Institute, and the National Association of Conservation Districts recognize that if landowners are to be encouraged to manage resources for public consumption then they must be protected and duly compensated.

Unlike many states, Arkansas has a rich diversity of outdoor recreational opportunities, and at present an unparalled access to such opportunities, even on private land. If that trend is to continue, a new bond of cooperation and support must be developed between users and private landowners.

Acknowledgements

The authors gratefully acknowledge the Board of Directors of the Arkansas Forestry Association (AFA) for supporting this effort. Special thanks are due Doyle Shook, Bill Tomlinson, Dale Oliver, Tony Melchiors, David Urbston, and Charles Self, our fellow AFA Wildlife Resources Committee members. The editorial assistance of Dick Kluender and Jim Sweeney is appreciated. Thanks are also given to the University of Arkansas at Monticello, Department of Forest Resources for computer time and data analysis. To the more than 200 individuals and corporations who graciously responded to our request for information, we sincerely express our appreciation.

Literature Cited

Arkansas Dep. of Local Services. 1980. Arkansas Outdoors: the 1979 state-wide comprehensive outdoor recreation plan. Arkansas Dep. Local Serv., Little Rock. 154 pp.

Birch, T. W. 1982. The forest-land owners of Ohio—1979. Resour. Bull. NE-74. U.S. Dep. Agric., For. Serv., Broomall, Pa. 84 pp.

_____. 1983. The forest-land owners of New York. Resour. Bull. NE-66. U.S. Dep. Agric., For. Serv., Broomall, Pa. 90 pp.

_____, and D. F. Dennis. 1980. The forest-land owners of Pennsylvania. Resour. Bull. NE-66. U.S. Dep. Agric., For. Serv., Broomall, Pa. 90 pp.

Blood, T., and J. Baden. 1984. Wildlife habitat and economic institutions: feast or famine for hunters and game. Western Wildlands 10(1):8-13.

Burger, G. V., and J. G. Teer. 1981. Economic and socioeconomic issues influencing wildlife management on private land. Pages 252-278 *in* R. T. Dumke, G. V. Burger, and J. R. March, eds. Wildlife management on private lands, proceedings of a symposium. Wis. Chap., The Wildl. Soc., La Crosse, Wis. 576 pp.

Cordell, H. K., and J. H. Stevens, Jr. 1983. A national survey to determine public outdoor recreation opportunities on nonindustrial private forest and range lands. Pages 327-333 *in* Proc. Symp. nonindustrial private forests: A review of economic and policy studies. Duke Univ., Durham, N.C. 398 pp.

Decker, D. J., C. P. Dawson, and T. L. Brown. 1979. Expanding hunter's access to private lands: potentials, problems and research needed. Trans. NE Sec. Wildl. Soc. 36:160-168.

Decker, D. J., and T. L. Brown. 1979. Hunting in New York: participation demand and land access. New York Fish and Game J. 26:101-131.

Gottschalk, J. S. 1977. Wildlife habitat-the "price-less" resource base. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 42:237-245.

Halls, L. K. 1975. Economic feasibility including game habitats in timber management systems. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 40: 168-174.

Hu, S., C. L. Shilling, R. W. McDermid, and R. D. Owens. 1979. Recreational use policies of large forest landowners in Louisiana. Forestry Note No. 127. Louisiana State Univ., Baton Rouge, La. 3 pp.

Jackson, R. M., and R. K. Anderson. 1982. Hunter-landowner relationhip: a management and educational perspective. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47: 693-704.

Kimball, T. L. 1963. For public recreation: private development of hunting and fishing. J. Soil and Water Conserv. 18: 44-53.

Kluender, R. A. 1978. Public use of industry lands in the Southeast-summary. Amer. Pulpwood Assoc., Jackson, Miss. 18 pp.

Kramer, B. M. 1982. Legal aspects of use and development of wildlife resources on private lands: Colo., Kans., New Mex., Okla., Tex. Great Plains Agric. Co. Publ. No. 103, Tex. Tech. Univ., School of Law, Lubbock, Tx. 70 pp.

Leopold, A. 1933. Game management. Charles Scribner's Sons, New York. 481 pp.

Skog, K. E., and I. A. Watterson. 1983. Survey completion report—residential fuelwood use in the United States: 1980-81. U.S. Dep. Agric., For. Serv., Forest Prod. Lab., Madison, Wis. 55 pp.

SPSS, Inc. 1983. SPSS[x] User's Guide. McGraw-Hill Book Co., New York. 860 pp.

Thorwardson, N. K. 1977. Landowner constraints on Oklahoma hunting opportunities. M.S. Thesis. Oklahoma State Univ., Stillwater. 73 pp.

Troutman, F. H., and S. G. Breshears. 1981. Forests and the Arkansas economy. Ind. Res. and Extn. Cent. Publ. No. D-17. Univ. of Arkansas, Fayetteville. 69 pp.

U.S. Dep. of Interior. 1982a. 1980 national survey of fishing, hunting, and wildlife-associated recreation. U.S. Govt. Print. Off., Washington, D.C. 75 pp.

U.S. Dep. of Interior. 1982b. 1980 national survey of fishing, hunting, and wildlife-associated recreation. U.S. Govt. Print. Off., Washington, D.C. 156 pp.

Wildlife Management Institute. 1984. Improving access to private land—a path to wildlife. Wildlife Management Institute, Washington, D.C. 15 pp.

Yoho, N. 1981. Private forest industry programs and potentials for wildlife management. Pages 218-226 *in* R. T. Dumke, G. V. Burger, and J. R. March, eds. Wildlife management on private lands, proceedings of a symposium. Wis. Chap., The Wildl. Soc., LaCrosse, Wis. 576 pp.

Multiple-Use Management on Tennessee Valley Authority Lands

Ronald J. Field
Wildlife Resources Development Program,
Tennessee Valley Authority,
Norris, Tennessee 37828

Donovan C. Forbes
Forest Resources Development Program,
Tennessee Valley Authority,
Norris, Tennessee 37828

Larry M. Doyle
Forest and Openland Section,
Land Between the Lakes,Tennessee Valley Authority
Golden Pond, Kentucky

Introduction

The Tennessee Valley Authority (TVA) was established by an act of Congress and signed into law by President Franklin D. Roosevelt on May 18, 1933. Known as the TVA Act, this legislation charged the agency with "the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory...." More specifically, the act directed TVA to provide flood control, navigation, electrical power production, fertilizer development, reforestation, agricultural and industrial development, and to "aid further the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin" (Tennessee Valley Authority Act of 1933).

The agency operates across an 80,000 square mile (207,200 square kilometers), 201-county region encompassing portions of Kentucky, Virginia, North Carolina, Georgia, Alabama, Mississippi, and Tennessee. The Power program, which constitutes approximately 97 percent of TVA's budgeted operation, has a generating capacity of some 32,080 megawatts of electricity from 29 hydro, 16 fossil fuel, 2 nuclear, and 1 pumped storage generating units (TVA 1984). Within the region, TVA is directly responsible or shares responsibility for the stewardship of approximately 1 million acres (405,000ha) of land and water surface under its fee simple ownership or control. Six hundred fifty four thousand acres (265,000 ha) of this area are inundated by TVA's 9 mainstream and 23 tributary dam projects. Roughly 74 percent or 255,000 acres (103,200 ha) of the remaining 346,000 acre (140,000 ha) area is wholly or partially forested and under active forest management. This forested land is managed by TVA to encourage multiple use of nearly all tracts by the public. Through the teamwork among several independent units or programs within the agency, this goal is being achieved.

The Land Use Planning Process

TVA has incorporated several processes in its land management activities to ensure that multiple-use management is a standard operating procedure. In 1966 the agency's Land Between The Lakes (LBL) operation began to gather data through the establishment of Continuous Forest Inventory (CFI) plots designed to measure forest and habitat changes. In 1968 the first detailed resource management plan was prepared. It was formally revised in 1970 and again in 1984. Portions of the plan may be revised more frequently, however, as new techniques become available which will aid in reaching the stated multiple-use objectives of recreation, environmental education, resource management, and economic development of the region.

Another of these processes is an elaborate reservoir-by-reservoir land use planning program initiated in 1979 to develop future land use strategies for 300,000 acres (121,400 ha) of reservoir lands. This process evaluates the capability and suitability of each tract of agency-owned land adjoining a mainstream reservoir for a variety of natural and economic resource development uses. Data is compiled on natural, social, and economic resources of the reservoir area. This information is obtained from the general public, outside agencies and organizations, and all TVA programs or offices that are involved in land management or development.

Regional reservoir management sources, local land use issues, and nominations for potential uses of individual tracts are identified through this process. For example, lands may be nominated for forest management, wildlife management, natural area management and public recreation, open space, water access, historic preservation, primitive camping, group camps, commercial recreation, off-road vehicle (ORV) use areas, residential or industrial development, or appropriate combinations of the above.

In the first of a two-phase process, each tract is analyzed to determine its capability to support the proposed uses based on engineering and physical resource characteristics of the site. Attributes such as access to navigable water, soil type, slope, railroad availability, and road accessibility are determined and are plotted for reference on computer generated maps.

Once the land's capability has been determined, the suitability of each site for the remaining proposed uses is determined in the second phase of the planning analysis. This step takes into account such factors as adjacent land uses, reservoir management goals, public values, visual quality, and environmental considerations such as wetlands, endangered species, archeological resources, and air and water quality. These data are integrated and a preliminary land use allocation is proposed in an initial draft of a reservoir land management plan. This draft is circulated for public and agency review. It is subsequently revised, conflicting uses resolved, and a final plan adopted. This final plan designates compatible multiple program uses such as forestry, wildlife, and recreation on appropriate tracts. Single programs such as industrial development or commercial recreation are given lead responsibility in special cases where other uses may not be compatible. The planning horizon for land management plans is approximately ten years, at the end of which time they are reviewed and revised if necessary. To date, three of the agency's nine mainstream reservoirs have been completed and a fourth is underway.

Land Use Planning at LBL

The lands planning process is intensively practiced on a 170,000 acre (68,826 ha) managed segment of TVA land called Land Between The Lakes. The tract occupies a peninsula which is approximately 8 miles (12.9 kilometers) wide and 38 miles (61.3 kilometers) long and represents approximately 60 percent of TVA's managed forest lands. The peninsula separates the TVA Kentucky Lake impoundment from the Lake Barkley Reservoir operated by the U.S. Army Corps of Engineers. The tract was designated in 1963 by President John F. Kennedy as a national demonstration for outdoor recreation, environmental education, and resources management. LBL supports heavy public use at a rate of over 2 million visits annually. The management of this area for purposes such as environmental research, backpacking, agriculture and timber production, camping, fisheries and wildlife management, endangered species restoration, ORV use, and historical and cultural interpretation, to name a few, necessitates implementation of comprehensive multiple-use planning. Through this process seemingly conflicting uses such as 30,000 use days per year in a 2,350 acre (950 ha) off-road vehicle riding area; 250,000 annual user days of deer, turkey, and other hunting; and a closed access eagle sanctuary are compatibly accommodated.

The initial 1968 resource management plan for LBL was developed by a team of TVA specialists in cooperation with state forestry and wildlife agencies in both Kentucky and Tennessee. It was subsequently reviewed by resource management staff from Virginia Polytechnic Institute and State University, Louisiana State University, and later by the Sierra Club, the National Wildlife Federation, and the National Audubon Society. The plan is periodically updated to accommodate new resources management techniques.

For convenient management of the forest and open land resources, LBL has been divided into 65 compartments which range from 1,060 to 3,800 acres (429 to 1,538.5 ha) in size. Portions of nine or ten of these are actively managed each year on a seven-year rotating schedule. Agricultural cropping is conducted on an annual basis in all compartments with tillable land.

Cooperative agreements with the Kentucky Department of Fish and Wildlife Resources and the Tennessee Wildlife Resources Agency enable TVA and these agencies to effectively manage fish and wildlife on LBL. Forest fire control on the area is provided under contract with Kentucky and Tennessee state divisions of forestry.

A total of 245 woods openings ranging from 3 to 10 acres (1.2 to 4 ha) in size have been developed throughout LBL to provide food and cover required by a variety of wildlife species. Water holes have been developed in association with woods openings and in other key areas. A total of 500 waterholes, in addition to those already present in 1963, has been constructed.

Where suitable cover was lacking, pine cover plantings ranging from 5 to 20 acres (2 to 8.1 ha) in size have been established at one-half mile (0.8 km.) intervals throughout the area. Pine trees are also planted to heal severely eroded areas.

Timber stand improvement (TSI) involves killing and/or removal of trees having little potential wildlife, recreational, or timber value. More desirable trees remain to provide improved timber stands with increased food for wildlife.

Timber is harvested annually on land areas averaging about 30 acres (12.2 ha) in size. Approximately 3,000 acres (1,220 ha) are harvested annually using group selection, shelterwood cuts, and thinnings. When strategically distributed in small blocks throughout a compartment, timber harvest provides a variety of habitats that are beneficial to many wildlife species.

Special precaution is taken to leave two to four active den trees per acre for wildlife. To further benefit wildlife and to prevent erosion, timber harvest logging roads are disced, limed, fertilized, and seeded to grasses.

Agricultural land is farmed under local contract on a crop-share basis and by TVA personnel. Farmers leave up to 20 percent of the crops for wildlife food and cover, or provide equivalent services such as planting special food plots or bushhogging. In calendar year 1984, over 5,000 acres (2,023 ha) received agricultural treatment. Portions of utility rights of way are also planted to food crops and/or maintained in natural vegetation beneficial to wildlife.

To produce additional wildlife food and cover, reverting fields that are unsuitable for crops are treated once every four years by bushhogging, discing, or controlled burning to maintain early plant seral stages.

Resource specialists determine conditions and develop specific land use prescriptions for small tracts within each compartment. Determination of forest conditions considers size, volume, vigor, and growth while determination of wildlife habitat conditions considers water availability, cover, den trees, and open land requirements. Land use prescriptions may include such practices as cover plantings, woods openings, timber stand and wildlife habitat improvement, water holes, erosion control, fire access trails, food plots, agricultural cropping, ecological study areas, and timber harvest.

Compartmental Forest Prescriptions

Only a small portion of TVA's lands have been subjected to formal land use planning processes but all of the agency's forested lands, including open lands scheduled for reforestation, are involved in systematic multiple use management practices. One of the more successful management tools used is a descriptive-prescriptive procedure initiated in 1981. This forest prescription system provides for a periodic review of all agency forestlands on a ten-year rotational cycle. The process identifies needs, prescribes actions, assigns priorities, and is the precursor to management plan implementation. Review is undertaken by a multidisciplinary staff team consisting of representatives from several agency programs and is initiated by the Forest Resources Development staff. A series of critical areas or compartments are annually selected to be reviewed. The size and number of compartments selected for review in any given year are approximately equal to one-tenth of the agency's forested landholdings exclusive of LBL, thus establishing a ten-year review cycle.

Compartments are scheduled for prescription work one year, with implementation occurring during the following year. These units are not continguous, but are scattered throughout a wide area of TVA district. This ensures that benefits such as wildlife habitat modification will be dispersed over a broader area; firewood residue resulting from management actions will become available to a broader segment of the general public; and opportunities will be available to more buyers in timber or pulpwood sales.

All compartment prescription work is undertaken after an onsite evaluation by foresters with the assistance of or review by wildlife biologists. This permits optimum retention or development of wildlife habitat to be incorporated in the prescription aspect of the procedure. Each timber stand within a compartment that undergoes a site inspection and prescription is assigned a high, medium, or low implementation priority. This determines whether implementation should be scheduled for the current or some later cycle. All prescriptions including those at LBL are ultimately reviewed by the environmental education, recreation, wildlife, cultural resources, land use planning, land management, and environmental review staffs prior to their implementation. When appropriate, review is also undertaken by industrial or economic development personnel within the agency.

When a timber harvest is scheduled as a result of the compartmental prescription process, wildlife biologists determine what practices should be effectively integrated in cutting regimes to maintain or improve wildlife habitat. In many cases, intermediate or thinning cuts are prescribed for a stand. These cuts are beneficial from a silvicultural standpoint because of the resulting reduction in competition among trees and improved quality and growth of the remaining trees within the stand. Reduced levels of competition can significantly contribute to increased mast production among hardwood species such as oaks (Shaw 1971), thus measurably enhancing the value of the stand for mast consuming species of wildlife as well as timber growth.

Regeneration cuts or clearcuts are recommended for areas where the objective is to harvest all or a portion of the timber in a stand and replace it with a new forest stand of the same or a different type (Hawley and Smith 1960). Cuts of this nature are managed to benefit both timber and wildlife by limiting the size of the clearcuts in two ways. Cutting in each compartment is limited so that timber on at least one-half of each management unit is retained in stands of age classes 40 years and older. This is designed to ensure adequate production and availability of hard mast for species which utilize it as a major diet component. The second requirement for regeneration cutting is that no more than one-eighth of each unit be regenerated during any 10-year implementation cycle. This practice results in a "stair step" production of browse material for deer, thus assuring the availability of low growing browse during each 10-year cycle. Such practices are also beneficial from a timber harvest standpoint since they ensure a long-term continuous economic return of the timber investment rather than a boom and bust enterprise.

TVA does not manage forestland as intensively as landowners who are principally concerned with maximizing profit from wood products. For instance, on most commercial forest lands, malformed, overmature, or cavity-containing trees, which often provide amenities for wildlife or subjects of value to photographers and environmental educators, are removed in order to increase the productivity and market value of remaining trees. On TVA forestlands, provisions for the protection of at least some of these den trees are included in timber harvest prescriptions. Where such an action is appropriate and feasible, timber harvest plans require the retention of a minimum three trees per acre if present, which contain cavities suitable for use by mammals, wood ducks, or other species.

An additional practice involving the establishment of small openings is employed in the management of TVA forestlands, especially the Land Between The Lakes area. This practice is designed to benefit wildlife and the general public through increased recreational opportunity. Openings of two to five acres (1 to 2 hectares) are scattered throughout portions of the agency's forestlands. They are created through clearcutting at the rate of roughly 12 acres per square mile (1.8 ha per km^2) of forest. Their presence provides availability of nesting or brood rearing habitat for gallinaceous birds such as ruffed grouse, quail, and turkeys: supplemental herbaceous food for species such as deer and rabbits; and primitive camping sites for informal public recreational use.

Management of Dewatering Areas

A significantly different method of multiple use management for TVA forest lands occurs on the 15,000 acres (6,073 ha) of mainstream reservoir dewatering areas on Wheeler and Kentucky Lakes in Alabama and Tennessee. These 10 units were built in conjunction with initial reservoir impoundment in the mid-1940s. They consist of low-lying areas adjacent to the reservoirs which contain a series of ditches, dikes, and levees to permit the control of water levels within the individual units. This is accomplished through the operation of gates and pumps. Initially designed to control the incidence of mosquito borne malaria, the units now provide substantial benefits in timber production, wildlife and fisheries management, public recreation, rail and highway protection, flood storage, and commercial farming, as well as vector control.

The units are designed to allow water levels to fluctuate with the reservoir level during winter months from November through February or March, then are "dewatered" or drained in the spring using gravity flow or pumps. The water is held below the reservoir level throughout the summer and fall to permit tree growth, agricultural production, and to protect real property and capital investment. The spring drawdown also effectively eliminates shallow water breeding sites for mosquitos, thus fulfilling the function for which the units were developed initially. Reflooding of the areas in early winter provides an abundance of natural food and unharvested agricultural crops for wintering waterfowl and other wildlife. The seasonal flooding of these areas provides outstanding opportunity for sport and commercial fishing, both within the units and below the spillways, and the spring drawdown permits the maintenance of thousands of acres of valuable bottomland hardwood wetlands.

Use of Color Infrared Photography

The discovery of large acreages of water stressed timber in three of the dewatering units in 1982 led to the incorporation of new technology in the management of these lands. Several factors, including sedimentation of drainage ditches and increased beaver activity, reduced the efficiency of water removal in the spring. This resulted in standing water inundating new forest growth and roots of large trees during the growing season, causing severe water stress and mortality. In order to efficiently evaluate the nature and extent of the problem, agency wildlife biologists and foresters adopted the use of high-altitude color infrared photography in combination with ground truthing to identify and characterize these problem sites (Fowler et al. 1985). Data gathered in this fashion were delineated on topographic maps and used to develop and implement a management plan for ditch renovation, timber removal, beaver control, and site restoration. Most of this work was accomplished using funds provided by the 1983 Jobs Bill.

Transfer to the Private Sector

The success TVA has experienced with multiple-use management on its own lands has prompted the agency to promote similar management strategies among private landowners in Mississippi and Alabama. Agency foresters have introduced a program through which several landowners having small, individual, but relatively contiguous tracts can join private timber and wildlife management organizations headed by a professional consultant who manages the combined landholdings for income generation. This income is provided through a variety of sources, including timber production, but can also include hunting on a fee or lease basis and firewood sales resulting from timber stand improvement practices.

Conclusion

The TVA Act clearly charges this agency with managing its land and water for a wide range of purposes, explicitly including the use, conservation, and development of natural resources. Increased user pressure on public lands for a variety of activities has created the need for systematic management in order to reduce conflicts among the numerous user groups. Experience has demonstrated within TVA that sound planning is the most effective method of managing lands to encourage and ensure their compatible use for multiple purposes. This is of particular importance when unusually intense user pressure from such conflicting interests as off-road vehicle users and deer or turkey hunters are to be effectively managed on a limited area such as LBL. This planning, however, can only be an effective tool if it involves the participation of all user groups. Such participation creates a mutual understanding and a vehicle for cooperation among all participants. Subsequently, viable plans for large tracts of public land emerge and can be maintained by those responsible for sound stewardship.

The 20 years of experience in successful multiple-use management at LBL and expansion of the process across other TVA lands represent a clear commitment on the part of the agency to provide maximum land use benefits for the public. The approach used by TVA has proven to be an effective method of resource management and can be used as a model approach for the management of other lands in the public or the private sector.

Literature Cited

Fowler, D.K., W.K. James, and D. Becker. 1985. Use of infrared photography to identify bottomland hardwood stands damaged by standing water. (In preparation).

Hawley, R.C., and D. M. Smith. 1960. The practice of silviculture. Sixth ed. John Wiley and Sons, New York. 525 pp.

Shaw, S.P. 1971. Wildlife and oak management. *In* Oak Symposium Proceedings. Northeastern Forest Exp. Station, Upper Darby, Pa.

Tennessee Valley Authority. 1984. TVA Handbook. TVA, Knoxville, Tn. 261 pp.

Tennessee Valley Authority Act (PL 48-58, 18 May 1933).

Aspen Management — An Opportunity for Maximum Integration of Wood Fiber and Wildlife Benefits[1]

Gordon W. Gullion
Department of Fisheries and Wildlife
College of Forestry, University of Minnesota
St. Paul, Minnesota 55108

Introduction

Over a large portion of the continent, quaking aspen *(Populus tremuloides)* or "popple"is probably more important to more species of North American wildlife than any other forest tree. Fortunately, it is also becoming increasingly important as a raw material for industry. Logging practices which are most conducive to regeneration of highly productive aspen stands also produce the highest quality wildlife habitats.

Quaking aspen is the most widespread forest tree on the North American continent (Strothmann and Zasada 1957), and has the third most extensive natural distribution of any tree on Earth, surpassed only by Scots pine *(Pinus sylvestris)* and the Eurasian aspen *(Populus tremulus)* in the Old World (Jones in press). The range of quaking aspen extends from central Mexico, southern Missouri, and western Virginia north to near the treeline in northern Canada and Alaska. It occurs in at least 31 of the United States and all the Canadian provinces. In eastern North America the big-tooth aspen *(Populus grandidentata)* has a more limited distribution, occurring from Iowa, Minnesota, and southeastern Manitoba east to the Atlantic Coast, and from Tennessee and North Carolina north to central Ontario, Quebec, and Nova Scotia.

In altitude, aspen ranges from nearly sea level in Maine and the Canadian Maritime Provinces, to over 11,000 feet (3,300 m) in the central Rocky Mountains in Colorado. It tolerates a wide range of soil pH, will grow on quite moist sites, and on sites too droughty to support other trees. Aspen is a pioneering species, often being the first perennial or woody vegetation to become established on mine spoils in Appalachia, on iron mine waste dumps and taconite tailings in northern Michigan and Minnesota, on cuts and fills along highway rights-of-ways in Pennsylvania and New York, and on log landings, skid trails, and severely burned sites in the Rocky Mountains (personal obs.).

The established seedling tree, or "ortet" sends out stolon-like roots to occupy surrounding vacant ground. Within a decade an aspen ortet begins producing adventitious root sprouts, or "ramets", the beginning of a clone (Barnes 1966). The rate of spread from the ortet may exceed a foot (30.5 cm) a year. I have an aspen in my front yard in Cloquet, Minnesota that was producing ramets 44 feet (13.4 m) from the ortet at 10-years of age.

Most of the aspen is in Canada, but in 1977 there were 26.3 million acres (10.6 million ha) of aspen and aspen-birch type in the United States outside of Alaska

[1]Paper No. 14472 Miscellaneous Journal Series, Minnesota Agricultural Experiment Station, St.Paul, 55108. 55108.

(U.S. Forest Service 1982). Aspen and birch *(Betula* sp.) commonly occur together in eastern forests, and many inventories combine the two as an aspen-birch type. There are 13.2 million acres (5.34 million ha) of aspen in the three Lake States of Michigan, Minnesota, and Wisconsin, where it occupies 26 percent of the commercial forest land (Brinkman and Roe 1975), and another 7.1 million acres (2.9 million ha) of aspen in the mountainous west (Green and Van Hooser 1983). One-sixth of the aspen in the lower 48 states is in Colorado, where it occupies over 25 percent of the commercial forest land. Hutchison (1968) gives the figure of 2.4 million acres (974,000 ha) of aspen on commercial forest land in Alaska, but that does not include productive-reserved or noncommercial forest land. Nearly 67 percent of the 119 million acres (48.2 million ha) of forest land in interior Alaska is noncommercial (U.S. Forest Service 1958), so the total aspen acreage is somewhat larger than Hutchison's figure.

In addition to the acreages on which they are dominant, the aspens are a part of many other forest types north of the 40th parallel in eastern forests, and throughout the western mountains. Fowells (1965) lists aspen as a major component of 4 and a minor component of 30 other forest types recognized by the Society of American Foresters. In the Lake States aspen comprises 7 percent of the growing stock in conifer types and 13 percent in other hardwood types (Perala 1977). If treated properly, aspen can be restored to dominance when it comprises only 14 percent of the stand composition (Gullion, unpublished).

Aspen's Status is Changing

Until recently forest managers have usually regarded aspen as a "weed" tree and more effort has gone into eradicating aspen than encouraging it (Ritter 1981). Although it has been and continues to be a "low value" forest product, aspen has long been an important part of the forest economy in the Lake States.

For the past 19 years (1964-1982) the annual harvest of aspen has represented 45.6 percent of all pulpwood cut in the three Lake States, with 38.35 million cords (99.90 million m^3) of aspen cut as compared to 45.82 million cords (119.36 million m^3) for all other species combined (Blyth 1969,1975, Blyth and Smith 1979,1984). The aspen harvest exceeded all softwoods combined by over eight million cords (21 million m^3). In 1975 aspen was the most important species harvested for sawlogs, with 162.7 million bd. ft. (813,710 m^3) being cut, as compared to 174.1 million bd. ft. (870,380 m^3) for all softwoods combined (Blyth et al. 1980). Red oak *(Quercus rubra)* and hard maple *(Acer saccharum, A. nigrum)* were the only other species whose harvest volume exceeded one-half the volume of aspen cut.

Recent advances in wood technology have changed the status of aspen. Prominent among these has been the development of the wafer or oriented-strand board, a reconstituted wood product using chipped aspen to produce a construction board designed to replace plywood.

This has encouraged commercial interest in aspen to an unprecedented scale. In Minnesota, for example, as recently as 1975 there was concern that as much as one-third of the aspen resource could be lost through natural succession by conversion to other forest types (Brinkman and Roe 1975). Now there is concern that Minnesota's aspen resource is insufficient to meet projected demands (Rockel et al. 1983). In

1983 the aspen harvest of 1.6 million cords (4.17 million m^3) reached the estimated annual allowable cut in Minnesota.

Rockel et al. (1983) have projected an annual demand in Minnesota for 1.89 to 2.25 million cords (4.92-5.87 million m^3) of aspen by the year 2000, and 2.762 to 4.097 million cords (7.19-10.67 million m^3) by 2030. The net growth of aspen in this woodshed is about 1.6 million cords (4.17 million m^3) per year. Among these projections is the estimate that from 132 to 136 thousand cords (344-354 thousand m^3) of aspen will be used for fuelwood in the year 2000. In 1980 114,000 cords (297,000 m^3) of aspen were consumed as fuelwood in Minnesota, and aspen represented about 24 percent of the fuelwood consumed in 1979-1980 (Minnesota DNR 1981).

Currently both the Superior and Chippewa National Forests in northern Minnesota are reviewing their management plans. Within a few weeks of this conference they are having public hearings to discuss modified long-range plans. These plans will shift emphasis from softwood management to increased aspen regeneration. This change is expected to reduce the Superior National Forest's management costs by some $36 million (13 percent) for the next 15 years, with increased benefits amounting to $10 million during the same period (Beal 1984). There is concern that the Superior Forest will be unable to meet the projected demand for aspen in about 30 years.

Aspen is an important product in the other five National Forests in the Lake States. In these forests the current aspen acreage is about 776,000 acres (314,000 ha), a 32,000 acre (12,950 ha) decrease from the 808,000 acres (326,000 ha) inventoried in the late 1960s. Annual harvests of aspen on these Forests have been in the order of 13,000 to 14,000 acres (5,200-5,700 ha).

Starting in the mid-1970s Region 2 of the U.S. Forest Service began intensive review of the status of aspen in Colorado, South Dakota, and Wyoming (U.S.. Forest Service 1976). There, where aspen in the past has been mostly an important visual resource, wildlife habitat, and livestock range, a major commercial demand is developing. If handled properly, this demand will provide the opportunity to rejuvenate many single-aged, "determinate"stands that otherwise will be lost to decadence and type conversion in the next few decades (Schier 1975, DeByle 1976).

Aspen is Different

Unlike most other commercially important forest trees, aspen regenerates as suckers (ramets) from a widespreading root system (Barnes 1966). At closely spaced points along these roots there are primordia capable of developing new trees when conditions are proper (Schier 1973). In a clone these roots form a network, often grafting one to another. The growing tips on the tree produce an auxin hormone (idole-3-acetic acid) which normally inhibits the growth of root suckers. But when the aerial stems are killed by fire or removed by logging, and the hormonal suppression ended, primordia on the roots are able to develop into suckers. The best growth occurs when soil temperatures exceed 70° to 75°F (21°-24°C), and no shade is cast on the developing ramets.

When mature aspen is cut or killed during the dormant season, the systems of a single tree may produce 5 or more suckers per square yard over a radius of 30 to 40 feet (9-12 m), or hundreds of young aspens where one tree grew before. Within a clone, suckers develop at densities that often exceed one per square foot (11/m^2), and new growth commonly extends 20 to 40 feet (6-12m) beyond the periphery of the original stand. Growth usually commences in late spring or early summer and proceeds at a rate of 1 to 2 inches per day (2.5-5 cm/day) reaching heights of 3 to 6 feet (0.9-1.8m) by the end of the first growing season.

A site barren of woody cover in early May is usually fully stocked with a dense, luxurious growth of aspen ramets by mid-August. Growth rates usually slow some in each suceeding year, but on good sites a 6 or 7 year-old aspen stand should have a density of about 5,000 to 7,000 stems per acre (12,300-17,300/ha) and a height of 15 to 25 feet (4.5-7.6 m).

But this quality of regeneration is seldom achieved unless the aspen stand is clearcut. It is important to remove all portions of the clone which might support growing tips that produce the auxin hormone which suppresses the development of root suckers. Also, aspen is intolerant of shade, and grows poorly under other trees. Ecologically, aspen is adapted to periodic destruction by fire, and the nearer our harvest procedures replicate the effects of fire the better the aspen response.

On good Lake States sites it should be possible to harvest two or three rotations of aspen in a century, each harvest being made as stands reach their greatest volume, with least defect.

Loss Through Decadence a Major Concern

Being a seral species, intolerant of shade, and relatively short-lived, the amount of aspen has diminished significantly in the north central forests in the last two decades. Some loss has also occurred in the Rocky Mountain forests, and this is expected to accelerate in the foreseeable future (DeByle 1976). Much of this loss can be attributed to a combination of the effectiveness of wildfire suppression and the lack of economic demand for aspen.

The aspen-birch acreage in eastern forests declined from 23,449 to 19,242 million acres (9.49 to 7.79 million ha) from 1953 to 1977 (U.S. Forest Service 1958, U.S. Forest Service 1982). Most of this decrease was in the Lake States where the 18.45 million acres (7.47 million ha) present in 1953 had declined to 15.64 million acres (6.33 million ha) by 1977. In Minnesota, the 5.399 million acres (2.18 million ha) of aspen on commercial forest land in 1962 had declined to 5.302 million acres (2.14 million ha) by 1977 (Jakes 1980). Similar losses have occurred in Michigan, the aspen acreage declining from 4.2 to 3.4 million acres (1.7 to 1.4 million ha) from 1966 to 1980, and the prospect remains of losing more in the near future (Hamill and Visser 1984).

In Minnesota there is a considerable volume of overmature aspen and there has been a danger of losing one-half million acres (202,000 ha) by natural conversion to forest types of less value to wildlife.

In the Rocky Mountains, much of the 1.22 million acres (493,700 ha), or 17 percent of the resource, that is now classed as sawtimber is approaching the age when accelerated losses can be expected. In addition, there is a considerable acreage that will be lost before it reaches sawtimber size. Although some stands are probably climax on the site (Mueggler 1976), perhaps as much as 80 percent of these aging stands may eventually be lost by conversion to coniferous forests or to brush and grasslands, if not regenerated.

Aspen as Wildlife Habitat

Considering that aspen has been a part of the forest composition for more than 10 million years (at least since the Miocene epoch—Barnes 1975), and is so widespread and prominent across the continent, it is hardly surprising that many species of wildlife have become dependent upon aspen, or at least closely associated with it.

There is probably no other tree in North America that provides as many resources for as many species of wildlife as does aspen. Due to its widespread distribution it is available to a great variety of wildlife, from snowshoe hares *(Lepus americanus)* and moose *(Alces alces)* in Alaska, to western bluebirds *(Sialia mexicana)* in New Mexico, wood ducks *(Aix sponsa)* in Minnesota, wild turkeys *(Meleagris gallopavo)* in Vermont, and beaver *(Castor canadensis)* across the continent.

While it is uncertain as to how much of the difference can be related to aspen, it is interesting to note that the greatest diversity of breeding land bird species east of the Rocky Mountains occurs in the zone across southern Canada and the northern United States where aspen is a prominent part of the forest composition (Gauthreaux 1978). Flack (1976) listed 55 species of breeding birds which appeared to prefer aspen forests in western North America. A recent review of several studies indicates that at least 26 species of birds are probably dependent upon aspen in the Rocky Mountains (Gullion in press).

DeByle (in press) lists 146 species of birds and 56 species of mammals that are known to utilize western aspen stands in some fashion. De Graaf and associates note that among wildlife regularly occurring in New England, 82 of the 252 species of birds, 52 of the 65 species of mammals, and 16 of the 75 species of reptiles and amphibians are associated with the aspen type (De Graaf et al. 1980, De Graaf et al. 1981, De Graaf and Rudis 1981).

In recent publications I have described the importance of aspen to a number of North American game and fur-bearing animals in some detail (Gullion, 1977a, 1977b, 1981, 1984).

Several birds appear on aspen clearcuts the first season after cutting. American woodcock *(Scolopax minor)*, whip-poor-wills *(Caprimulgus vociferus)*, nighthawks *(Chordeiles minor)*, song *(Melospiza melodia)* and white-throated sparrows *(Zonotrichia albicollis)* make use of the open ground and slash left on the site.

Young aspen growth provides important browse for ungulates and livestock. In the Intermountain West, the Rocky Mountains, Michigan, Pennsylvania, New York, and New England this herbivory is often the greatest hinderence to regenerating productive stands of aspen (Smith et al. 1972, Mueggler and Bartos 1977, DeByle 1979, Graham et al. 1963, Marquis and Brenneman 1981).

The stems of a developing aspen stand provide a physical structure which becomes preferred cover for several species, most notably the ruffed grouse *(Bonasa umbellus)* and woodcock (Gullion 1984). This young growth is the favored habitat for a number of songbirds, including chestnut-sided *(Dendroica pensylvanica)* and golden-winged warblers *(Vermivora chrysoptera)*, black-billed cuckoos *(Coccyzus erythropthalmus)*, catbirds *(Dumetella carolinensis)*, common yellow-throats *(Geothlypis trichas)*, rose-breasted grosbeaks *(Pheucticus ludovicianus)*, and others.

The aspens have a soft bark which contains chlorophyll and produces carbohydrates through photosynthesis (Barnes 1966). This bark is utilized by several animals. Aspen bark is the preferred food for beaver wherever it is available. Mice, snowshoe hares, porcupines *(Erethizon dorsatum)*, and elk *(Cervus elaphus)* also feed on aspen bark. Recent work has shown that aspen bark fortified with supplemental nutrients is an acceptable ration for beef and dairy cattle (Kamstra and Shideler n.d.).

Aspen leaves constitute an important summer food for black bears *(Ursus americanus),* blue *(Dendragapus obscurus)* and ruffed grouse, porcupines, deer and other browsing species. Aspen also supports a large insect fauna (more than 300 species-Davidson and Prentice 1968), so it is heavily used by a number of insectivorous birds, including several flycatchers, chickadees, nuthatches , vireos, warblers, bluebirds, and thrushes.

Even after the golden leaves have fallen in autumn they often remain palatable and are fed upon by mule deer *(Odocoileus hemionus)* and ruffed grouse. Aspen functions as a nutrient pump and the fallen leaves provide the richest leaf litter produced in many forests (Daubenmire 1953, Reynolds et al. 1977).This rich litter supports high populations of invertebrates, which make aspen forests a preferred habitat for various insectivores and worm-eating species, especially woodcock (Wenstrom 1973, Godfrey 1974). Hale and Gregg (1976) suggested that the recent and future abundance of woodcock in the northern central states is related to the amount of aspen clearcut in the Lake States.

The stout crutches of major branches provide support for the large nests of goshawks *(Accipiter gentilis)*, ravens *(Corvus corax)*, horned owls *(Bubo virginianus)*, and even bald eagles *(Haliaeetus leucocephalus).*

Heart rot becomes prevalent as aspen trees become older. Perala (1977) notes that aspen in the north central states has significant decay by the age of 50 to 60 years, and Hinds and Wengert (1977) found decay in 50 to 60 percent of the 110-120 year old aspen in Colorado. This provides ample opportunity for excavation of nesting cavities by primary excavators (woodpeckers), and abundant cavities for secondary users (owls, falcons, swallows, ducks, and others). Gilmer et al. (1978) suggested that the abundance of overmature and decadent aspen in the Great Lakes region may be partly responsible for the recent increased numbers of wood ducks in the Central Flyway.

The staminate flower buds of aspen develop in the summer and are especially important as a winter-long food resource for ruffed grouse and Cassin's finch *(Carpodacus cassinii*—Samson 1976). They are also consumed by sharp-tailed *(Tympanuchus phasianellus)* and blue grouse, evening grosbeaks *(Coccothraustes vespertinus)* and purple finches *(Carpodacus pirpureus).* When these buds elongate into flowering catkins in the spring they become an even more important food resource for ruffed grouse (Svoboda and Gullion 1972, Stoll et al. 1980, Gullion 1984), and are also used by black bears, at least in northern Minnesota (Rogers 1977). Since the extending male catkins are often the first sign of new growth in early spring in northern forests, insects are attracted to them and provide feeding sites for the earliest migrating yellow-rumped warblers *(Dendroica coronata),* kinglets, yellow-bellied sapsuckers *(Sphyrapicus varius),* and other hardy insectivores.

Harvesting to Meet Wildlife Needs

Clearcutting is usually the most economic method for harvesting aspen, especially on sites where feller-bunchers or similar machinery can be used. Clearcutting also assures the highest quality of regeneration, needed both to restock the site with a commercially valuable and esthetically pleasing stand, and to best meet the needs of wildlife.

The development of an aspen stand, including the natural thinning which occurs as suppressed stems succumb to shade and competition, provides the structural quality that makes aspen so important to wildlife.

For example, ruffed grouse make little use of aspen regeneration until the sapling density has thinned to about 8,000 stems per acre (19,700 stem/ha). Heavy use of this cover continues until the young pole stand thins to less than about 3,000 stems per acre (7,400 stems/ha). Then the cover becomes too open and the site "goes-by" as ruffed grouse cover (with better data these figures differ from those cited earlier—Gullion 1977a).

Stand development varies depending upon local growing conditions. On a study area near Mille Lacs Lake in central Minnesota, aspen regeneration usually becomes acceptable cover for ruffed grouse 4 to 6 years after clearcut logging and has "gone-by" when the stand is 15-years old (Gullion unpublished). Ninety miles (144 km) farther northeast in the Cloquet area near Duluth it takes 8 to 12 years for an aspen stand to become acceptable ruffed grouse cover, and the stand remains good cover until the developing aspen stand is 20 to 25 years old (Gullion 1970).

Other wildlife has similar specific needs which an aspen stand has to provide if it is to be useful. First and second year regeneration often is growing so rapidly that it produces few, if any branches. Without branches songbirds cannot find support for their nests. But by the third year branches develop and birds nest in the young aspens. Back (1982) found 17 species of songbirds making use of this habitat in Minnesota aspen clearcuts designed to benefit ruffed grouse.

Many species require an intermixture of aspen age classes. The highest density and most stable ruffed grouse populations in Minnesota have been in areas where mature aspen provides staminate flower-buds for winter-long feeding within 100 yards (100 m) of moderately dense sapling cover (Gullion and Alm 1983). Back (1982) reported seven species of songbirds that used the edge of a mature forest as perches while flight-foraging for insects over young aspen regeneration on 5-to-11-year-old clear-cuts.

Not surprisingly, some conflicts between various species' needs arise when managing aspen for wildlife. Ruffed grouse need blocks of moderately dense cover at least one acre (0.4 ha) in size, but not larger than 10 acres (4 ha—Gullion 1984), and Back (1982) found greater songbird diversity in the 10-acre (4 ha) blocks than in smaller blocks. Woodcock appear to do equally well in any of these sizes, providing there are sufficient small openings to serve as singing grounds (Sepik et al. 1981, Gregg 1984). Gregg (1984) believes short-rotation (10-20 year) aspen harvesting would be beneficial to woodcock, but that would be disastrous for ruffed grouse. Conroy et al. (1979) recommended clearcut blocks of 5 to 10 acres (2-4 ha) for snowshoe hares, which both ruffed grouse and woodcock should find beneficial.

To improve white-tailed deer *(Odocoileus virginianus)* range, Wisconsin has treated areas as large as 640 acres (260 ha) and Michigan areas as large as 160 acres (652 ha). The early results of a management evaluation in Michigan (Bennett et al. 1980) showed that deer preferred the smaller blocks over the larger. Minnesota has preferred treating smaller areas, recommending east-west strips not over 100 yards (30 m) wide (Rutske 1969).

The interspersion of permanent openings (1 percent of area) recommended for deer management in Wisconsin by McCaffery et al. (1981) should meet the needs of woodcock as well, but might not be enough to support high density woodcock populations. Forest edges and clearings often increase predation upon ruffed grouse (Gullion 1984).

Peek et al. (1976) believed that clearcuts designed to benefit moose should be at least 200 acres (80 ha) in size, and Jordan and his students (unpublished) are finding that the density of aspen regeneration preferred by ruffed grouse reduces forage production in northern Minnesota to the disadvantage of moose.

Aldous (1938) suggested that aspen be cut frequently to maintain a continuous supply of pole-stage trees for beaver within 100 yards (100 m) of waterways, but to favor wood ducks that might be using the same waterways, Gilmer et al. (1978) suggested that aspen stands within 100 m of waterways be held beyond normal rotation age to allow cavity development.

We cannot do all things for all species and we have to decide which wildlife we wish to favor by our management and accept inevitable trade-offs.

Integration of Wildlife Benefits into Aspen Management

The importance of aspen to a diversity of wildlife at different stages in its growth, together with the increasing importance of aspen as a source of wood fiber provides an unparalleled opportunity to maximize both values by integration of management programs. This is already being done, and has demonstrated significant improvements in wildlife values. But the effort needs to be broadened and intensified as the market for aspen and the pressure on forest wildlife increases.

The three Great Lake States of Michigan, Minnesota and Wisconsin commenced accelerated management of aspen in the late 1960s and early 1970s as a means of reversing long-term declines in white-tailed deer populations (Byelich et al. 1972, Bennett et al. 1980, Haberland 1972). In the 1970s Michigan logged more than 637,000 acres (258,100 ha) on state forest lands in a manner designed to meet wildlife habitat improvement guidelines. Much additional acreage, averaging about 6,700 acres (2,700 ha) of aspen annually was cut on federal forest lands in Michigan. A similar program has been underway in Wisconsin ,where an average of 10,000 acres (4,000 ha) has been treated annually. Aspen harvest on National Forest lands in Wisconsin has averaged about 6,500 acres (2,600 ha) annually. Minnesota treated some 13,000 acres (5,260 ha) in the 1969-71 biennium, and a smaller scale program treated 63,500 acres (25,713 ha) from 1971 to 1980. This is an addition to an estimated 543,000 acres (219,800 ha) of aspen logged commercially in Minnesota from 1962 to 1977 (Jakes 1980). These programs are continuing today.

By 1980 the Michigan white-tailed deer herd had increased to more than one million animals, and the current deer herd in Wisconsin is estimated to number about 900,000 deer (Haberland 1985, in correspondence). In Minnesota, where the deer hunting season was closed statewide in 1971, deer harvest exceeded 132,000 animals in both 1983 and 1984. During the 1984 season more than one-half million deer were harvested in the three Lake States, 14 years after this aspen management began (Michigan, ca. 165,000; Minnesota, 132,000; Wisconsin, 294,800). Not all of this increase in deer numbers has been a result of this management program, but it has certainly played an important role.

What needs to be done!

The pressing need is to improve aspen age class diversity which provides the proper habitat interpersion for the greatest diversity of wildlife, while providing a continuing flow of wood fiber for industry and other purposes.

This means clearcut harvesting of appropriately sized blocks. In most cases schemes treating 10- to 20-acre (4-8 ha) or smaller blocks in a 4-or 5-stage rotation are preferable for wildlife. Eventually such systems will create a diversity of age classes with 10-to-15-years difference between adjacent blocks. Ideally some blocks should be allowed to become decadent to accomodate wildlife requiring the amenities of old forest, and snags should be left standing or created to provide sites for cavity nesters.

Cutting intervals have to be adjusted to the growth-rate of the stands, and harvests should be made before stands become overmature. When overmature aspen stands are cut there is not only a loss of decayed wood but the quality of regeneration and the subsequent stand is likely to suffer.

In Lake States forests optimum harvest rotations are at 35-to 60-year intervals (Brinkman and Roe 1975), but in Colorado cutting should probably be done when stands are 80- to 90-years old (DeByle 1976).

Probably the most troublesome aspect of this story concerns the harvesting of extensive, overmature stands. We have been "backed into a corner" by prolonged inattention to the need for aspen regeneration. As an example, large scale harvesting should have begun in Minnesota at least 20 or 30 years ago. This would have allowed the development of proper interpersion of age classes desirable for maximum wildlife benefits and a steady flow of the product for industry. This was not done and now it becomes necessary to harvest large blocks, with minimal interpersion of age classes, simply to retain aspen on the sites. This will result in a shortage of harvestable stands in the future, and depressions of some wildlife populations.

This is happening on an area where I have been working for 20 years (Gullion 1977a). In 1974 a 4-stage cutting rotation commenced in a 60-year-old mixed northern hardwood stand. Initially cutting was to be done at 10-year intervals, but by 1980 aspen mortality predicated an acceleration of the cutting rate, and the intervals were reduced to 6 years. The second cutting rotation is nearing completion in 1985. The present deterioration of aspen suggests that there will be a greatly reduced aspen component by 1990, when the next cutting rotation should commence. There may be too little aspen alive in the late 1990s to justify a fourth harvest designed to maintain aspen in this forest.

Aspen Management Provides Multiple Benefits for Private Forestland Owners

In the Lake States and northeastern forests aspen management provides an especially interesting management option for the private woodland owner. It is the one easily managed tree that can provide a diversity of wildlife values and the opportunity to watch a managed forest grow from the sprout-seedling stage to harvested mature trees within a lifetime.

A number of studies in different parts of the country have shown that woodland owners often rank wildlife as the primary value they derive from their property

(Noreen and Hughes 1968, Shaw 1970). Oftentimes these individuals hesitate to disturb their woodlands in fear of destroying wildlife values. They fail to recognize that some highly desired wildlife occurs in greater abundance in young, regenerating stands than in older, mature forest. This is especially true of white-tailed deer, snowshoe hares, beaver, ruffed grouse, woodcock, and several species of particularly interesting songbirds.

Conclusion

I have said this before (Gullion 1977b:262), and I will say it again: "This [aspen] ecosystem provides the basic habitat resource for several species of North American wildlife [and an important habitat for many others] across a substantial part of the continent. Unlike many wildlife habitats it does not maintain itself if we simply leave it alone. Maintenance of this ecosystem as a primary wildlife habitat requires periodic and properly dispersed catastrophic destruction to stimulate regeneration." I add, commercial, clear-cut logging, providing a needed raw material for home construction, paper, furniture, crating, livestock feed, and heating fuel is the best way to reap maximum wildlife benefits while preserving the beauty of our nation's aspen resource.

Acknowledgements

This reports on work accomplished by the Forest Wildlife Relations Project 83H, University of Minnesota Agricultural Experiment Station, St. Paul, with additional support from the Minnesota Department of Natural Resources, Division of Fish and Wildlife, The Ruffed Grouse Society, and Mr. James O. Matschulat, of Lyme, Connecticut.

Many persons have contributed to this study during the 30 years it has been underway, including 14 graduate research assistants, 199 forestry students attending classes on the Cloquet Forestry Center, and 40 others who as field assistants, interns, or volunteers have contributed to our data base, or helped in other ways. Special thanks go to Dr. Richard Sauer, Director of the Minnesota Agricultural Experiment Station, Dr. Richard Skok, Dean of the College of Forestry, a succession of department heads, Drs. A.C. Hodson, M.W. Weller, and currently, I.R. Adelman, for the continuing support of this project. Dr. W.H. Marshall initiated this study and provided guidance and support for many years. Mr. Craig Rupp, as Regional Forester, Region 2, U.S. Forest Service, provided the opportunity for involvement in Rocky Mountain aspen management. The dedication of Mrs. Mary Ferguson and her predecessors, Mrs. Mary Kimber and Cindy Mankowski, have played crucial roles in many ways while serving as project secretaries.

Literature Cited

Aldous, S.E. 1938. Beaver food utilization studies. J. Wildl. Manage. 2:215-222.

Back, G.N. 1982. Impacts of management for ruffed grouse and pulpwood on nongame birds. Ph.D. Thesis. Univ. Minnesota, Minneapolis. 96 pp.

Barnes, B. V. 1966. The clonal growth habit of American aspens. Ecology 47:439-447.

________. 1975. Phenotypic variation of trembling aspen in western North America, For. Sci. 21:319-328

Beal, C.G. 1984. Proposed land and resource management plan-Superior National Forest. U.S.D.A. For. Serv. Eastern Region. 200 pp. + 3 appendices.

Bennett, C. L., E. E. Langenau, G. E. Burgoyne, J. L. Cook, J. P. Duvendeck, E. M. Harper, R. J. Moran, and L. G. Visser. 1980. Experimental management of Michigan's deer habitat. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:288-306.

Blyth, J. E. 1969. Pulpwood production in the North Central region by county, 1968. Resour. Bull. NC-8. U.S.D.A. For. Serv. St. Paul, Minn. 22 pp.

________. 1975. Pulpwood production in the North Central region by county, 1973. Resour. Bull. NC-27. U.S.D.A. For. Serv., St. Paul, Minn. 16 pp.

Blyth, J. E., and W. B. Smith. 1979. Pulpwood production in the North Central region by county, Resour. Bull. NC-41. U.S.D.A. For. Serv., St. Paul, Minn. 23 pp.

Blyth, J. E., and W. B. Smith. 1984. Pulpwood production in the North-central region by county, 1982. Resour. Bull. NC-79. U.S.D.A. For. Serv., St. Paul, Minn. 22 pp.

Blyth,J. E., J. H. Whipple, A. J. Boeltler, and S. Wilhelm. 1980. Lake States primary forest industry and timber use, 1975. Resour. Bull. NC-49. U.S.D.A. For. Serv. 39 pp.

Brinkman, K. A., and E. I. Roe. 1975. Quaking aspen: silvics and management in the Lake States. Agric. Handb. 486. U.S.D.A. For. Serv., Washington, D.C. 52 pp.

Byelich, J. D., J. L. Cook, and R. I. Blouch. 1972. Management for deer. Pages 120-135 in Aspen Symposium Proceedings. Gen. Tech. Rep. NC-1. U.S.D.A. For. Serv. St. Paul, Minn. 154 pp.

Conroy, M. J., L. W. Gysel, and G.R. Dudderan. 1979. Habitat components of clear-cut areas for snowshoe hares in Michigan. J. Wildl. Manage. 43:680-690.

Daubenmire, R. 1953. Nutrient content of leaf litter of trees in the northern Rocky Mountains. Ecology 34:786-793.

Davidson, A. G., and R. M. Prentice. 1968. Insects and diseases. Pages 116-124, *in* Growth and utilization of poplars in Canada. Publ. 1205. Canad. Dept. For. 257 pp.

DeByle, N.V. 1976. The aspen forest after harvest. Pages 35-40 *in* Symp. Proc: Utilization and marketing as tools for aspen management in the Rocky Mountains. Gen. Tech. Rep. RM-29. U.S.D.A. For. Serv., Fort Collins, Colo. 120 pp.

________. 1979. Potential effects of stable versus fluctuating elk populations in the aspen ecosystem. Pages 13-19 *in* North American Elk: ecology, behavior, and management. Univ. Wyoming, Laramie. 294 pp.

________. In press. Wildlife values. *In* Aspen: ecology and management in the western United States. Gen. Tech. Rep. U.S.D.A. For. Serv., Rocky Mtn. For & Range Exp. Sta. Fort Collins, Colo.

DeGraaf, R., G. Witman, J. Lanier, B. Hill, and J. Keneston. 1980. Forest habitat for birds of the Northeast. U.S.D.A. For. Serv.,Northeast. For. Exp. Sta., Broomall, Pa. 598 pp.

De Graaf, R., G. Witman, and D. Rudis. 1981. Forest habitat for mammals in the Northeast. U.S.D.A. For. Serv. , Northeast. For. Exp. Sta., Broomall, Pa. 182 pp.

De Graaf, R., and D. Rudis. 1981. Forest habitat for reptiles and amphibians of the Northeast. U.S.D.A. For. Serv. Northeast. For. Exp. Sta. , Broomall, Pa. 239 pp.

Flack, J. A. D. 1976. Bird populations of aspen forests in western North America. Amer. Ornithol. Union, Ornithol. Monogr. No. 19. 97 pp.

Fowells, H.A. 1965. Silvics of forest trees of the United States. Agric. Handb. No. 271. U.S.D.A. For. Serv. , Washington, D.C. 762 pp.

Gautheraux, S. A. 1978. The structure and organization of avian communities in forests. Pages 17-37 *in* R.M. De Graaf, tech. coord., Proceed. of the Workshop:Management of Southern Forests for Nongame Birds. Gen. Tech. Rep. SE-14. U.S.D.A. For. Serv., Asheville, N.C. 176 pp.

Gilmer, D. S., I. J. Ball, L. M. Cowardin, J. E. Mathisen, and J. H. Riechman. 1978. Natural cavities used by wood ducks in north-central Minnesota. J. Wildl. Manage. 42:288-298.

Godfrey, G. A. 1974. Behavior and ecology of American woodcock on their breeding range in Minnesota. Ph.D thesis. Univ. Minnesota, Minneapolis. 318 pp.

Graham, S. A., R. P. Harrison, Jr., and C. E. Westell, Jr. 1963. Aspens: Phoenix trees of the Great Lakes region. Univ. Mich. Press, Ann Arbor. 272 pp.

Green, A. W., and D. D. Van Hosser. 1983. Forest resources of the Rocky Mountain States. Resour. Bull. INT-33. U.S.D.A. For. Serv., Ogden, Ut. 127 pp.

Gregg, L. 1984. Population ecology of woodcock in Wisconsin. Tech. Bull. No. 144. Wisconsin Dept. Nat. Resour., Madison. 51 pp.

Gullion, G. W. 1970. Ruffed grouse investigations—influence of forest management practices on grouse populations. Minn. Dept. Nat. Resour. Game Res. Prog. Rep. 30:104-125

________. 1977a. Forest manipulation for ruffed grouse. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 42:449-458.

________. 1977b. Maintenance of the aspen ecosystem as a primary wildlife habitat. Proceed. Intern. Congr. Game Biol. 13:256-265.

________. 1981. Integration of wildlife production into Great Lakes forestry programs. Pages 28-35 *in* H.C. Black, ed. Effects of forest practices on fish and wildlife production. Soc. Amer. For., Washington, D.C. 52 pp.

________. 1984. Managing northern forests for wildlife. The Ruffed Grouse Society, Coraopolis, Pa. 72 pp.

________. In press. Impact of aspen management on Rocky Mountain wildlife. *In* Proceed: 2nd Biennial Symp. on issues and techniques in the management of impacted western wildlife. Thorne Ecol. Inst., Boulder, Colo.

________, and A. A. Alm. 1983. Forest management and ruffed grouse populations in a Minnesota coniferous forest. J. Forestry 81:529-531, 536.

Haberland, F. 1972. We're out to grow deer food. Wisc Conserv. Bull. 37:3-6.

Hale, J. B., and L. E. Gregg. 1976. Woodcock use of clearcut aspen areas in Wisconsin. Wildl. Soc. Bull. 4:111-115.

Hammill, J. H., and L. G. Visser. 1984. Status of aspen in northern Michigan as ruffed grouse habitat. Pages 123-136 *in* W. L. Robinson, ed. Ruffed grouse management:state of the art in the early 1980s. N. Cent. Sec., The Wildl. Soc. 181 pp.

Hinds, T. E., and E. M. Wengert. 1977. Growth and decay losses in Colorado aspen. Res. Pap. RM-193. U.S.D.A. For. Serv., Fort Collins, Colo. 10 pp.

Hutchinson, O. K. 1968. Alaska's forest resources. Resour. Bull. PNW-19. U.S.D.A. For. Serv. , Portland, Ore. 74 pp.

Jakes, P. J. 1980. The fourth Minnesota forest inventory: area. Resour. Bull. NC-54. U.S.D.A. For. Serv., St. Paul, Minn. 37 pp.

Jones, J. R. In press. The tree: distribution. *In* N. V. DeByle and R. Winokur, eds. Aspen: ecology and management in the western United States. Gen. Tech. Rep. U.S.D.A. For. Serv. Rocky Mtn. For. & Range Exp. Sta. Fort Collins, Colo.

Kamstra, L. D., and F. J. Shideler. n. d. [1980?] Aspen as a livestock feed. South Dakota State Univ. Agric. Exp. Sta., Brookings. 7 pp.

Marquis, D. A. , and R. Brenneman. 1981. The impact of deer on forest vegetation in Pennsylvania. Gen. Tech. Rep. NE-65. U.S.D.A. For. Serv., Broomall, Pa. 7 pp.

McCaffery, K. R., J. E. Ashbrenner, and J. C. Moulton. 1981. Forest opening construction and impacts in northern Wisconsin. Tech. Bull. No. 120. Wisconsin Dept. Nat. Resour., Madison. 40 pp.

Minnesota Department of Natural Resources. 1981. Minnesota residential fuelwood demand study, 1979-80. Minn. Dept. Nat. Resour., St. Paul. 10 pp.

Mueggler, W. F. 1976. Type variability and succession in Rocky Mountain aspen. Pages 16-19 *in* Symp. Proceed: Utilization and marketing as tools for aspen management in the Rocky Mountains. Gen. Tech. Rep. RM-29. U.S.D.A. For. Serv., Fort Collins, Colo. 120 pp.

________, and D.L. Bartos, 1977. Grindstone Flat and Big Flat exclosures-a 41 year record of changes in clearcut aspen communities. Res. Pap. INT-195. U.S.D.A. For. Serv., Ogden, Ut. 16 pp.

Noreen, P. A., and J. M. Hughes. 1968. A study of absentee owners of Pine County, Minnesota forest land. Minn. For. Res. Notes No. 195. 3 pp.

Peek, J. M. , D. L. Urich, and R. J. Mackie. 1976. Moose habitat selection and relationships for forest management in northeastern Minnesota. Wildl. Monogr. 48. The Wildlife Soc., Washington, D. C. 65 pp.

Perala, D. A. 1977. Manager's handbook for aspen in the North Central states. Gen. Tech. Rep. NC-36. U.S.D.A. For. Serv., St. Paul, Minn. 30 pp.

Reynolds, J. W. , W. B. Krohn, and G. A. Jordan. 1977. Earthworm populations as related to woodcock habitat usage in Central Maine. Proceed. 6th Woodcock Symp. , pp. 135-145.

Ritter, L. 1981. The Cinderella tree. Minn. Volunteer. 44:40-44.

Rockel, M., J. Buongiorno, D. C. Lothner, and E. Kallio. 1983. Future consumption of timber grown in northern Minnesota. Res. Pap NC-244. U.S.D.A. For. Serv., St. Paul, Minn. 15 pp.

Rogers, L. L. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Ph.D Thesis. Univ. Minnesota, Minneapolis. 203 pp.

Rutske, L. H. 1969. A Minnesota guide to forest game habitat improvement. Tech. Bull. No. 10. Minn. Div. Game and Fish., St. Paul. 68 pp.

Samson, F. B. 1976. Territory, breeding density and fall departure in Cassin's finch. Auk 93:477-497.

Schier, G. A. 1975. Deterioration of aspen clones in the middle Rocky Mountains. Res. Pap. INT-170. U.S.D.A. For. Serv. , Ogden, Ut. 14 pp.

________. 1973. Origin and development of aspen root suckers. Canad. J. For. Res. 3:45-53.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowner's guide to woodcock management in the Northeast. Misc. Rep. 253. U.S. Fish and Wildl. Serv. and Maine Life Sci. & Agric.. Exp. Sta. 23 pp.

Shaw, S. P. 1970. Forest wildlife responsibilities-what's our problem? J. Forestry 68:270-273.

Smith, A. D., P. A. Lucas, C. O. Baker, and G. W. Scotter. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Publ. No. 72-1. Utah Div. Wildl. Resour., Salt Lake City 32 pp.

Stoll, R. J. , M. W. McClain, C. M. Nixon, and D. M. Worley. 1980. Foods of ruffed grouse in Ohio. Fish and Game Rep. 7. Ohio Dept. Nat. Resour. Div. Wildl., Columbus 17 pp.

Strothmann, R. O., and Z. A. Zasada. 1957. Silvical characteristics of quaking aspen *(Populus tremuloides)*. Pap. No. 49. U.S.D.A. For. Serv. Lake States For. Exp. Sta., St. Paul, Minn. 26 pp.

Svoboda, F. J., and G. W. Gullion. 1972. Preferential use of aspen by ruffed grouse in northern Minnesota. J. Wildl. Manage. 36:1166-1180.

U.S. Forest Service. 1958. Timber resources for America's future. Resour. Rep. No. 14. U.S.D.A. For. Serv., Washington, D.C. 713 pp.

________. 1976. Utilization and marketing as tools for aspen management in the Rocky Mountains. Gen. Tech. Rep. RM-29. Proceed. of the Symposium. U.S.D.A. For. Serv., Fort Collins, Colo. 120 pp.

________. 1982. An analysis of the timber situation in the United States, 1952-2030. Resour. Rep. No. 23. U.S.D.A. For. Serv., Washington, D.C. 499 pp.

Wenstrom, W. P. 1973. Habitat utilization and activities of female American woodcock *(Philohela minor* Gmelin) in northeastern Minnesota during spring and summer. Ph.D. thesis. Univ. Minnesota, Minneapolis. 203 pp.

Economic Values of Wildlife: Opportunities and Pitfalls

Bill H. Tomlinson
Anderson-Tully Company
Vicksburg, Mississippi 39180

We often hear, and have no doubt ourselves presented, papers expounding on the following facts: 19 million people, or approximately 9 percent of the present population, annually hunt in the United States; our nation's commercial forest land, approximately 482 million acres (195 million ha), is expected to shrink at the rate of from one to three million acres (0.4-1.2 million ha) per year due to land withdrawals for wilderness designation, parks, agriculture and suburban development; according to longstanding U. S. Forest Service projections, demand for recreation in this country is expected to double by the year 2020. However we may relate to these statements present and future, the statistics are basically inanimate and have over time become so familiar to us as managers that the impact necessary to stimulate action has, in many cases, dissipated.

As a manager in the field, I am increasingly aware of the truth expressed by today's written facts and projections regarding the future demand for recreation. Resources often considered amenities in some parts of the country are now being recognized as commodities in other areas. Leisure time activities are important to our economy—so important, in fact, that one in every eight dollars in America is spent on recreation (Alcock 1984).

When the wildlife resource is viewed as a commodity rather then an amenity, we begin seeing supply-and-demand economics at various stages of development in our country. Where public hunting lands are in abundance relative to the hunting population and are available on a free and open basis, few hunters are willing to pay for hunting opportunities on public or private lands. However, as the quantity of such land is decreased relative to the hunting population, and as the quality of the hunting experience decreases due to overcrowding, so increases the desire of many hunters, resident and non-resident alike, to find affordable areas which will give them more quality control relative to their recreational experience. Thus the private sector suddenly becomes an important and integral part in the overall picture of wildlife management and recreational opportunity for our nation.

A noted ecologist once stated that any management system will suffice until demand exceeds supply. It is only when scarcity becomes a reality that individuals who manage private resources must be given incentives to consider the preferences of others (Blood and Baden 1984).

Nationwide, 58 percent of the commercial forest land is in private, non-industrial ownership and 14 percent is owned by private industrial owners. Twenty-eight percent is owned by government agencies, 20 percent of the total being federal ownership and 8 percent state and other public ownership (American Forest Institute 1982). While a relatively high percentage of state, federal, and municipal ownership exists in many of the western states, private ownership as a whole controls access to 72 percent of the nation's timberland. Regionally, as in the

Southeast, approximately 90 percent of the commercial forest land is in private ownership. Being even more specific and considering an individual state, in the southern one-third of Michigan, 97 percent of the land is in private ownership, with 90 percent of the state's population and 75 percent of the state's hunters being located in that portion of the state (Blood and Baden 1984). It is on these private lands that some of our greatest wildlife management opportunities and problems exist (unless problems are viewed as opportunities) as we strive to match hunter opportunity with available resources.

How Do We Take Advantage of the Opportunities Available on Private Lands?

In the transactions of the 17th American Game Conference (1930), the following observation was made: "With rare exceptions, the landowner is not yet practicing management. There are three ways to induce him to do so:

1. Buy him out and become the landowner;
2. Compensate him directly or indirectly for producing a game crop and for the privilege of harvesting it;
3. Cede him the title to the game so that he will own it and can buy and sell it just as he owns, buys, and sells his poultry.

The first way is feasible on cheap lands, but prohibitive elsewhere. The second is feasible anywhere. The third way is the English system and is incompatible with American tradition and thought" (Leopold et al. 1930).

In a recent article, two political economists, not biologists, posed the following question: "What system will make landowners produce wildlife along with primary product goals of agriculture, livestock, and timber?" In response to their question, the economists wrote, "The answer may be lease or pay hunting, a system of property rights and private management that provides the most ecologically sensitive and equitable scheme yet designed" (Blood and Baden 1984). Leopold et al. (1930) stated that only the landowner can practice management efficiently. In a recent letter I received concerning my review of some proposed research material, the following statement was made: "There exist today some compelling reasons to believe that big game hunting as a regional commodity satisfies the requirements of conventional economic analysis. Income from hunt leases may, in fact, be used as a basis for such a valuation." (Fred Busch, Department of Forestry, Clemson University, pers. comm. 1985).

Whether or not we agree with these statements, it seems that we will all have to agree with two points: (1) with rare exceptions, the landholder is still not yet practicing wildlife management; and (2) landowners can only be expected to practice wildlife management if they receive just compensation and property rights or trespass protection.

What Is "Just Compensation" When Speaking of Generating Landowner Interest and Considering Wildlife or Other Ecological Values?

The answer to this question is as varied as the regions of our nation and the individuals who populate those regions. Minnesota, for example, has implemented a program whereby a landowner receives tax credits for maintenance of wetland areas.

Counties are reimbursed for lost revenues out of a standing fund appropriated by the state legislature. Public access is not required. They will cost-share up to 100 percent for wetlands development, thereby allowing the landowner to also qualify for a tax credit (Tim Bremicker, Minnesota Department of Natural Resources, pers. comm. 1985). This program is a result of cooperation between the private sector, local government, and the state legislature.

In southern Michigan the Public Access Stamp Program (P.A.S.P.) has been in operation since 1977. P.A.S.P. basically pays rural landowners an annual per-acre fee to allow public hunting on their land. Fees range from $0.50 to $6.00 per acre, depending on the type and location of habitat available (Tom Nederveld, Michigan Department of Natural Resources, pers. comm. 1985). The program was developed for the following reasons: (1) as stated previously, the southern one-third of Michigan is 97 percent privately owned and contains 75 percent of the state's hunters; (2) hunters were looking for alternatives to crowded public lands; (3) landowners were increasingly unwilling to grant hunting access; (4) rising land management costs and values were seriously affecting the state's ability to purchase land and effectively manage it: and (5) rising transportation costs discouraged hunters from traveling long distances (Blood and Baden 1984). A move is currently under way to include the stamp cost in the cost of the regular license, thus avoiding the separate stamp fee. This program again demonstrates what can be achieved when a public agency cooperates with the private sector in working toward a mutually beneficial goal.

Other states, such as North Carolina and South Carolina, have programs whereby a landowner places his lands in a state game management area program category. In return for allowing public access to his lands, the landowner receives a pro rata share of revenues generated. However small the payment may be in light of private leases, it is a step in the right direction toward providing incentives to landowners.

There is no question that many people feel it is their God-given right to be able to hunt on a free and open basis with no monetary encumbrance, save license fees, to taint the outdoor experience. Likewise, some agencies feel that it is the landowner's responsibility to provide public recreation on a free, or at most a token fee, basis. I suggest to you that continuing in that frame of thought may be likened to viewing the world through an opaque looking glass.

I recall an article in a state outdoor magazine several years ago in which the statement was made that the U. S. Forest Service returned their portion of game management area revenues back to the land for wildlife development work. The private landowner enrolled in the same program supposedly took his money and ran. True enough, the payment received by the private sector for keeping their lands open for public hunting was a whopping $0.24 per acre. Private lease fees on similar lands adjacent to the game management area lands were $1.50 to $2.00 per acre per year at that time. The difference in the price received from game management area lands and the private lease value was a foregone cost and represented the actual cost to the landowner of opening his lands to public use. Whether one views the $0.24 per acre as income or the price differential as a cost depends upon the observer. However viewed, it must be said that the landowner has made quite a substantial commitment to the public good.

Without Tax Credits, Direct Payments by State Agencies, Public Leases, Permits, or Other Incentives to Manage for the Public Good, What Options are Left for Landowners Who Wish to Derive Income from Their Land and the Associated Wildlife Resources?

Permit Programs

Landowner-operated permit programs are often time consuming, labor intensive, and rarely provide a high rate of return. With the possible exception of fishing, such programs cannot be successfully implemented without adequate property rights or trespass protection. Rarely can the landowner sell enough permits to make the operation profitable and still retain the quality and attractiveness of the area. Possible exceptions would include permits for fishing, permits issued in conjunction with existing management programs such as flooding rice and soybean fields for ducks, or permits issued where large numbers of animals have to be removed in a short-term, controlled effort.

Commercial Operations

Commercial ventures, while profitable in most cases, also require sizeable acreage (again except for fishing and possibly put-and-take hunting situations) and a large capital investment. These types of operations, if successful, generally require, depending on services offered, several full-time employees. Many successful commercial ventures are developed as off-shoots of the primary product objective, whether it be livestock, timber, or agriculture. These commercial areas are typically well managed, since the success of the operation, and the income, is dependent on providing a quality product that meets the advertised objectives. Competition between commercial operators also seems to influence in a positive way the quality of management and services. Even when open land is widely available and somewhat under-utilized by residents, out-of-state residents are willing to hunt on a pay-as-you-go basis on private lands when someone else is responsible for their success.

Landowner Memberships

If the landowner does not choose to retain ownership of the land, he may sell. Much of the forest land available for sale in the Southeast is not being bought by large corporations, but rather is being purchased for personal hunting purposes by wealthy individuals. For landowners who have insight into the growing worth of wildlife, sales pitches to prospective buyers often include a hard sell concerning wildlife resources, while listing the other land values as secondary. For example, the following advertisement was taken from a Jackson, Mississippi, paper:

Now Offering

Miller Point Rod and Gun Club

*Landowner memberships in an exclusive Mississippi River hunting club
*The finest deer, turkey, and duck hunting available
*Located 65 miles south of Memphis, Tennessee
*Price—$105,000 principals only

Financing Available

Another advertisement taken from the same paper read this way:

> Hunting Land: various tracts—$350.00 per acre and up

Individuals usually purchase the land, then arrange financing. They then recoup the initial investment, and often more, by selling landowner memberships for around $100,000.00 each. I have seen all of the monies required to purchase a $1,200,000.00 tract of timberland accumulated in less than two weeks. These lands, while exclusive, are typically improved and managed for long-term member and wildlife benefits.

Leasing

In this context I will deal only with leases to individuals for private hunting clubs. I have no doubt that, at least in the Southeast, leasing to private clubs will be, and in fact already is, a major factor affecting wildlife resource allocation and land management. I predict that in time, barring the usurping of landowner rights or more substantial landowner incentives, this concept, which may seem distant, will command your attention.

Leasing land for hunting and fishing in the Lower Mississippi River floodplain closely parallels leasing in the lower coastal plain areas of North Carolina, South Carolina, and Georgia. Leasing has been a way of life in the lower Mississippi Delta for over 30 years, and some hunting clubs trace their charter as early as the 1920s and 1930s. Early leases were often issued by word of mouth and a handshake. Occasionally, a written note "to whom it may concern" was supplied. Such early agreements commonly required no monetary transactions.

During the 1950s and 1960s demand for prime hunting areas began to increase. This increased demand can probably be directly tied to large increases in deer populations during that time, as well as the clearing of prime delta timberland for soybean production. As hunter demands increased, formal lease agreements were needed in order to separate designated hunting areas and associated groups. No longer were word-of-mouth agreements possible because of the logistical problem of reduced land availability, increasing numbers of hunters, and the potential for "duplicate" issuance of hunting rights to different people on the same area. Thus, as leasing became more formalized, a "blanket" monetary fee was charged for hunting rights. Some of the earliest leases went for $1.00 per year, while others on a per acre rate began at around $0.02 per acre per year. Fees have increased, slowly, to the current rates.

I am no longer surprised to hear the prices some people are willing to pay in order to establish a hunting club. As early as 1970, a hunting lease was issued on 544 acres (220 ha) of Mississippi Delta soil for an up-front payment of $716,000.00. This ten-year lease, with an option of renewing for another ten-year term, exceeded the purchase price of the land several times over. No improvements, such as hunting lodge, water electricity, etc., existed on the property then, nor do they exist now. Primary huntable species present are deer and turkey.

Hunting leases with large acreage (greater than 1,000 [405 ha]) are commonly yielding $15.00 per acre per year and will occasionally yield in excess of $30.00 per acre. Prices such as these were once thought to pertain only to waterfowl leases. However, these current prices are being paid by residents and nonresidents for deer and turkey hunting opportunities. Small landowners who have lands within existing club boundaries can often name their price. Such areas have what I call a high nuisance value, and clubs will generally match the highest price offered just to prevent encroachment from "outsiders."

For the purpose of comparing hunting lease values, I have separated prices received into two distinct categories: (1) market value; and (2) fair market value.

Market Value Pricing

Management of wildlife resources on a purely supply-demand system typically results in the highest values being paid. This is termed market value, or the price at which both buyers and sellers are willing to do business. Money is the primary consideration, and people are included only because they hold the money. Except as the primary attractor for income, wildlife resources are not typically considered. The bidding process is the most usual way of determining market value pricing.

Positive Aspects of Market Value Pricing

Wildlife values may, in many cases, be high enough to stimulate the landowner to change his mode of operation, whether it be livestock, timber, or agriculture, to benefit wildlife. By using soybean fields to attract waterfowl and timbered areas as sanctuaries for deer and turkey, a landowner often finds that wildlife values may equal or exceed current land-use values. Market values for wildlife may be so great on some areas that they prevent a major change in land use, i.e., converting timberland to rice or soybean fields.

Negative Aspects of Market Value Pricing

Wildlife is often treated as a prostitute of the land, to be used and abused with only money as the bottom line. People who are successful bidders on such lands often find themselves so strapped financially after paying the lease fee that no money is left to improve the property, i.e., camphouse, running water, electricity, road maintenance, wildlife openings, etc. Also, individuals with a high monetary investment on leased lands will often attempt to extract the greatest amount of recreational opportunity possible—an opportunity which is all too often measured in terms of meat in the freezer. As a result, the area's recreational quality and its future worth may be drastically reduced. This is a particular problem if the hunters are certain that, upon lease termination, they will be unable to meet or exceed the anticipated bid price. Thus there is often no incentive to practice conservation measures in the year the lease term is to expire. At best, wildlife management programs are difficult to implement, and unless the lease is for three to five years or more, leaseholders are often not interested in pursuing such programs. Any service or improvement by the landowner is generally expected, not appreciated.

Lease fees which are suddenly and drastically increased to market value rates often select against the hunters who have historically leased the area. Ironically, such people are usually the ones who have worked, protected, conserved, stocked, restocked, and nurtured the resource as surrogate owners and have, over time, been in part responsible for the high worth of the area. These people are usually, though not always, local hunters who will have to scratch to find other places to hunt. The "good" members will usually be absorbed into other existing clubs more suitable to their pocketbooks. Some, especially older members, quit hunting altogether. Most are bitter about the change.

Finally, market value pricing often yields such a public outcry that legislation may be introduced to provide disincentives to the landowner who leases his lands. In Mississippi during the current legislative term, bills have been introduced in both the House and Senate changing the value of lands for tax purposes from timber or agriculture to a commercial designation if such lands are leased for hunting purposes. The Senate version says that such unfavorable tax treatment will occur only if the landowner leases to nonresidents. Such legislation would increase the tax burden on the landowner about 40 percent (Bruce Pierce, Weyerhaeuser Company, pers. comm. 1985). In Louisiana, an assistant district attorney writing on behalf of a police jury asked the attorney general if the police jury could legally pass some form of recreational tax assessing the amount of leases negotiated by large timber companies. The question was also asked whether or not the police jury could additionally require the state wildlife agency to have persons obtaining such leases to acquire leasing and special hunting permits from that agency. In Arkansas, House Bill 833 was introduced in 1981 and, if passed, would have taxed all "hunting rights, leases, or permits granted for a money consideration and/or for profit, which result in the taking or attempted taking of the white-tail deer and other wildlife excepting migratory waterfowl." The bill proposed to tax 20 percent of the first \$0.50 per acre, 80 percent of the second \$0.50 per acre, and 95 percent of all amounts above \$1.00 per acre. Thus, for every dollar per acre charged above the first dollar, the net gain to the landowner would have been \$0.05.

Fair Market Value Pricing

Assessment of wildlife values based on that which is reasonable, equitable, and most accurately represents the true value of the resource is termed fair market value. These values are typically assigned by a knowledgeable assessor(s), and primary consideration is given to not only resource capability, but also the human aspect, an all-important ingredient in any comprehensive and workable resource management system. It is only when demand for the resource is low that fair market value prices equal market value prices. It is only when the land and wildlife resources have been abused and devalued that both fair market and market value pricing is compromised.

Positive Aspects of Fair Market Value Pricing

In a well-structured program, the general hunting public is offered a system of lease pricing which fits most income levels. Like the housing market, there is available a range of prices commensurate with the true value of the area. This type of system is generally conducive to good landowner-leaseholder relationships and makes lands more available to the general hunting public. Fair market value pricing is generally increased in the same manner as are other commodity prices.

Tenants can be expected to make improvements on the land under this pricing system. Lodges may be built and maintained, water wells drilled, electric lines run, caretakers hired, and roads maintained and repaired. Clubs are also prone to be more interested in maintaining or improving the quality of the wildlife resource, since the club has some assurance that they will be able to continue leasing the property. Fair market value pricing in desirable areas usually provides enough income incentives for the landowner to either offer some services or, at the very least, may prevent him from making drastic land-use changes. Any service provided by the leaseholder is appreciated, though not typically expected unless mutually agreed upon as a condition of the lease.

Leaseholders generally understand and accept the philosophy of fair market value pricing more readily than market value pricing. This can be explained in part by reference to what I call the Mercedes-Chevrolet complex. Many of us can not afford, nor do we want a Mercedes. A Chevrolet is better suited to our style and our pocketbooks. But that still doesn't make us bitter to see others driving a Mercedes, nor does it make us despise the company that manufactures them. Likewise, under the fair market value pricing system, clubs who have much, expect much, and pay much are not generally disdained by those majority clubs who are average in nature. I suppose that will be true only as long as the price of the Chevrolet does not change overnight to equal the price of the Mercedes. At that point, one would likely see the majority of the population looking for alternate sources of transportation and a company on the verge of bankruptcy. There are just so many people who can afford a Mercedes.

Negative Aspects of Fair Market Value Pricing

The main disadvantage to the landowner is the immediate loss of money calculated as: fair market value − market value = immediate income loss. The landowner must decide if the disadvantages of market value pricing outweigh the direct loss of revenue when comparing fair market value rates. Additionally, fair market value rates may have to be converted to market value pricing if sale of the land is imminent and maximum wildlife values must be calculated.This is also true if the value of the wildlife resource must be computed against an alternative land use.

Conclusion

Madson (1976) states that the greatest change in wildlife management will occur in the private sector and that private wildlife management will offer the greatest opportunity for future recreation. He further states that private landowners must have economic incentives to increase wildlife management practices. However, the fact that a given amount of *Spartina* can offset the need for tertiary sewage treatment, thereby making an acre of saltmarsh worth approximately $1000.00 per year to the community (Hill 1976), provides little economic incentive to the landowner if he himself can not realize some direct and tangible benefits.

Leopold et al. (1930), in discussing the steps necessary to insure an effective program of game restoration, stated that the landowner must be recognized as the custodian of public game on his land, that he must be protected from the irresponsible shooter, and that he must be compensated for putting his land in productive condition. "Compensate him either publicly or privately with either cash, service, or protection, for the use of his land and for his labor, on the condition that he preserves the game seed and otherwise safeguards the public interest. In short, make game management a partnership enterprise to which the landholder, the sportsman, and the public each contributes appropriate services and from which each derives appropriate rewards. Experiment to determine in each state the merits and demerits of various ways of bringing the three parties into productive relationship with each other."

We have already discussed some states which are addressing this relationship. Colorado addressed the relationship in a report on landowner recognition—a plan to improve communications and relations between Colorado landowners, sportsmen, and the Colorado Division of Wildlife (Anon. 1982). Several states currently employ private land coordinators, who are directly responsible for working with the private sector. Could it be that we are beginning to recognize the wisdom expressed by Leopold and others in 1930? I trust that we are:

I suspect that in some aras of the country, the landowner has evolved in his management of wildlife to a point somewhere between the system of compensation and the European system. Prices for hunting may be routinely set according to species, sex, and size. By and large, though, in the absence of attractive alternative incentives, leasing for the average landowner is the easiest to implement, least expensive, and most profitable.

James Anderson remembers the day when he didn't have to go much further than his back yard to hunt. Duck clubs have been around for a long time, but in the last few years have flourished in size and number. As a result, Anderson has to drive 50 miles (80 km) to find a place to hunt. "It's just bad," he said. "I didn't even go hunting last year." Anderson said he has been arrested more than once for trespassing in areas he once roamed freely (Berry 1984).

Whether this becomes an increasingly familiar story will depend, to a large extent, on our success as managers in providing both attractive economic incentives for the landowner and a reasonable allocation of available resources for the sportsman. If the majority of private landowners decide, due to a lack of alternative economic incentives, to manage their lands on a purely market value system with no regard for the resource, the task of wildlife management will, in their eyes, be reduced to an accounting function whereby bids are taken and winners are chosen. The only interest in the resource will be paid quarterly by the bank. Therein, we will have failed as wildlife professionals.

Our failure will result not from a lack of professionalism or biological expertise. It will result from our lack of vision in evaluating current demands for wildlife-producing lands and in our inability to adequately translate those demands into an imaginative and satisfactory allocation of resources for future generations.

Literature Cited

Anonymous. 1982. A report of the division of wildlife on "landowner recognition." Colorado Div. of Wildl. and Wildl. Comm., Denver. July. 60 pp

Alcock, J. E. 1984. Woodlands management and amenity values—a forester's perspective. Forest Farmer. 43 (3):6-7,23.

American Forest Institute. 1982. Green paper—forest and industry facts. American Forest Institute, Washington, D. C. 4 pp.

Berry, M. 1984. Hunting for room. The Commercial Appeal (Memphis, Tennessee). Sept. 30. p. D11.

Blood, T., and J. Baden. 1984. Wildlife habitat and economic institutions: feast or famine for hunters and game. Western Wildlands. 10 (1) :8-13.

Hill, D. 1976. A modeling approach to evaluate tidal wetlands. Trans. Amer. Wildl. and Natur. Resour. Conf. 41:105-118.

Leopold, A., chairman, et al. 1930. Report to the American Game Conference on an American game policy. (Report of the Committee on Game Policy.) Trans. Amer. Game Conf. 17: 284-309.

Madson, J. B. 1976. What the future holds for the science of wildlife management. Presented at 40th Natl. Wildl. Fed. Annu. Meet., 19-21 March. Louisville, Ky. Appendix A:6-12.

The Role of Environmental Research in Multiple-Use Management of Private Forestlands

James A. Rochelle
Weyerhaeuser Company
Tacoma, WA 98477

M. Anthony Melchiors
Weyerhaeuser Company
810 Whittington Avenue
Hot Springs, AR 71902

Introduction

An environmental research program has contributed to the development and achievement of multiple-use management objectives on Weyerhaeuser Company forestlands. Emphasis is placed on the maintenance or enhancement of the public resources of soil, water, fish, wildlife, and recreational opportunity in conjuction with meeting the Company's economic goals for the management of its commercial forestlands.

Weyerhaeuser Company manages 2.8 million acres (1.1 million ha) of Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) forests in the Pacific Northwest and 3.1 million acres (1.3 million ha) of the loblolly-shortleaf pine (*P. taeda—P. echinata*) forest type in the Southeast. Plantation management of conifers is practiced on most of the ownership; however, selected areas are managed as uneven-aged stands due to site limitations or for certain non-timber values (e.g., riparian zones, wildlife enhancement areas). The fundamental long-term economic objective of Weyerhaeuser Company is to manage its timberlands to assure an appropriate return on investment capital that compensates shareholders for the risks inherent in such ownership. As a major forest land holder, the Company recognizes that environmental values such as clean air and water, recreation, and wildlife habitat must also be addressed within the framework of its primary management objectives.

The purpose of this paper is to describe the evolution of environmental research programs and their role in the management of non-timber resources on Weyerhaeuser Company forestlands.

Multiple-Use Philosophy

Weyerhaeuser Company recognizes the need to serve the public interest in providing for the integration of non-timber resources within its commercial forestry operations. It is long-established Company policy to protect natural resource values on all its forestlands, to provide opportunities for the public to benefit from the broad spectrum of recreational opportunities the lands provide, and to cooperate with public agencies on management and research activities of mutual interest. The Company is committed to being responsive to legitimate public concern related to the integrated management of timber and non-timber resources.

The Company's attitude toward integrated management of all resources on its lands has changed considerably during the last two decades. It has moved from broad corporate policy statements that included objectives such as "... strive to perform in concert and harmony with nature and the public interest ..." to development of site-specific operating guidelines or management recommendations for forest road construction, logging, riparian zones, endangered species, wildlife enhancement programs, public use of Company lands, and others. The multiple-use goals of the Company are to maintain the quality of the managed forest environment for the production of non-timber values and to provide opportunity for public use of those resources.

Historically, the integration of forest management, and certain other resource uses such as game production, have been marked by a fairly high degree of compatibility. Other resource uses have been constraints, to the extent that timber considerations have been deferred in some instances. As our operating experience and technical information base have expanded with time, there has been greater recognition of the broad range of non-timber values that exist and emphasis on seeking opportunities of increasing their compatibility with our primary goals of timber production.

Research Program

Environmental research in Weyerhaeuser Company began in the early 1950s. Initially, emphasis was placed on the influences of pulp mills and other manufacturing facilities on their surrounding air and water environments. A major research effort, focused on point sources of pollution, continues today. Forestry-related environmental research began in the mid-1950s, with emphasis on the control of wildlife damage, which was a major deterrent to forest regeneration in the Northwest. Research focused on development of repellents, habitat manipulation and hunting as damage control methods, and this remained the emphasis until the early 1970s. During this period societal concern for all aspects of the environment had been increasing, as manifested in the passage of several major pieces of environmental legislation. Company management saw the Federal Water Pollution Control Act of 1972, and its section 208 process for state planning and implementation of water quality regulations, as having potentially major impacts on Company forest management operations. At this time a decision was made to expand research efforts into the areas of forest hydrology, water quality, and fisheries to provide technical information that could contribute to the development of state forest practice rules and best management practices. Also, at this time wildlife research emphasis began to shift from animal damage control to addressing relationships between forestry and wildlife, reflecting the expanding public interest in all types of wildlife. Objectives of the research program developed at that time were as follows:

- —Develop a technical data base on the relationship of forest management activities to water quality, stream productivity, and wildlife habitat.
- —Provide a technical base for operating guidelines to maintain stream quality, biological production, and site productivity of Company lands
- —Provide technical information and support to operating regions and Company businesses on issues and regulatory activities relating to forest management and the environment.

These continue to be the primary objectives of the research program, which is carried out with a staff of approximately 15 scientists and technicians, with an annual budget of approximately 1 million dollars. Scientific skills represented on the staff include forest hydrology and geomorphology, geology and soils, aquatic ecology, and fisheries and wildlife biology. Staff are located in both the southeastern and northwestern United States, close to areas of Company ownership.

Role of Research in Multiple-Use Management

We see the primary role of our research program to be one of gathering and assisting in the application of objective technical information on relationships between forest management and non-timber resources. The impetus for conducting research comes from a series of needs that continually face a large forestland owner. These include:

1. Need to maintain the productivity of the forest for both timber and nontimber resources.
2. Need for a technical base on which to make informed management decisions.
3. Need to support established cost-effective forest practices, or determine where changes are necessary.
4. Need to resolve conflicts between resource users.
5. Need to evaluate regulatory actions or proposals.

As an industrial research organization, we are often viewed as serving a special interest. Therefore, our findings are suspect at times, or at least lack the credibility of those of agencies or universities which are assumed to better represent the public at large. We have utilized cooperative research and publication of research findings as two procedures to help overcome this perception. Cooperative research, involving public agencies or universities and conducted in good faith, has three major benefits to any single organization: (1) cost sharing, (2) a research effort that is directed toward mutual goals, and (3) increased credibility and acceptance of findings. Publication, in refereed scientific journals, insures that our findings have undergone peer review and have scientific validity.

Below are provided several examples of how our research effort contributes to addressing the needs outlined above.

Maintenance of Timber/Non-Timber Resource Productivity

Information has been collected annually on the nesting success and productivity of bald eagles on Company lands in Washington and Oregon for the past 14 years. Approximately 66 percent of the 90 nests observed have experienced some type of forest management activity, primarily logging, in the vicinity of the nest. Our observations of these nests indicate continued nesting success at a level of productivity equal to that of nests in undisturbed areas (Anderson, in press). This information is useful for the development of management approaches which will provide for continued existence of productive eagle populations on Company lands while at the same time allow the recovery of a portion of the timber value associated with the nesting site.

Technical Basis for Management Decisions

A cooperative study of habitat use by eastern wild turkeys in managed pine forests in central Arkansas was recently completed by the University of Arkansas (Wigley et al. 1985). This work, funded in part by Weyerhaeuser Company, took place over a 3-year period and involved radio tagging and relocation of a number of birds in each sex and age class. Home range sizes were large, frequently exceeding 10,000 acres (4,047 ha) for individual birds. A wide variety of habitats were used, including natural pine-hardwood stands as well as pine stands ranging in age class from young plantations to sawtimber. Habitat use patterns varied seasonally and by age and sex category. The data collected add significantly to our understanding of turkey-forestry relationships and will prove useful in addressing this species' needs in forest management planning, especially with respect to thinning regimes.

Support of Existing, or Development of Modified Forest Practices

In the Pacific Northwest, removal of streamside vegetation during logging operations was thought to negatively affect salmonid populations. In recent studies, field measurements of fish size and numbers in a series of streams with paired clearcut and old-growth reaches indicated higher salmonid biomasses in the cutover sections (Bisson and Sedell, in press). The increased autotrophic production resulting from more light reaching the stream following canopy removal apparently increased the food supply to the benefit of the fish. These findings indicate opportunities for enhancement of salmonid production through the careful removal of streamside vegetation in some areas. Concurrently, studies indicated that the overzealous removal of large wood from stream channels following logging operations could negatively affect fish habitat, and led to research to develop guidelines for managing this material (Bilby 1984).

Resolution of Conflicts Between User Groups

Relationships between deer and range cattle in managed forests of southeast Oklahoma are the subject of a conflict in which the Company is caught in the middle. Cattlemen are interested in utilizing the forage produced, while deer hunters see the cattle as competitors with deer. Cooperative research is addressing this issue through investigations supported jointly by Weyerhaeuser Company, the Cooperative Fish and Wildlife Research Unit at Oklahoma State University, and the Oklahoma Department of Wildlife Conservation. From this study will come insights on deer-cattle interactions, which will aid in resolving this conflict.

Evaluation of Regulatory Proposals

In the state of Arkansas, point sampling techniques used in 208 water quality assessments predicted sedimentation rates as high as 692 tons per mile per year from forest roads (Arkansas Dep. of Pollution Control and Ecology 1980). These findings were to form part of the basis for development and application of best management practices in the state. A study carried out cooperatively by the University of Arkansas, Weyerhaeuser Company, and the U.S. Forest Service measured rates of 56 tons per mile per year (Beasley et al. 1984). The actual level was less than onetwelfth of the predicted rate, and only a small portion of the forest road sediment reached a stream. While road sediment control constitutes only a portion of the overall 208 assessment, the results of the study will be important as this aspect of water quality planning is developed.

While none of the above examples provide the complete answer to a particular multiple-use question, they each contribute to the technical base available for making informed decisions. This expansion of the data base is viewed as one of the key objectives of our research effort.

The Challenge for Research

Managers of private forestlands can expect steadily increasing demands for active management of non-timber public resources on their lands. In the Northwest, Indian tribes seek "treaty rights" to the maintenance of stream productivity and fish resources on private lands. In the Southeast, livestock interests monitor forage resources and grazing opportunities on commercial timberlands. Growth in human populations across the U.S. in combination with abundant leisure time is resulting in added demands for outdoor recreational opportunity—principally hunting and fishing. Demand for hunting opportunity already exceeds availability in many areas of the Southeast where fee hunting areas and leasing of hunting rights are management options commonly used to control the numbers and distribution of hunters and protect private property. Private and public organizations are seeking a form of "holistic preservation" of private lands—wanting riparian zones left in an untouched natural state to provide non-timber values or resources for public use. At the same time, commodity-oriented individuals are cutting firewood from areas managed to provide habitats for snag- or hardwood-dependent wildlife. Federations, associations, clubs, societies, and local sportsmen organizations are more frequently requesting that their particular species of interest or area of concern be included in management plans for private timberlands.

Often, these requests for management of non-timber resources on private forest lands conflict with the landowner's principal objective or with other multiple-use objectives. It is not uncommon for landowners to be involved in conflict with little direct interest in either side.

While the frequency of conflicts and issues is increasing, so too is the complexity of issues. Today we find ourselves concerned with effects on ecosystems and cumulative effects of forest management on the environment. There is increasing need to study all wildlife rather than just the game animals or endangered species. There is still a very basic need to understand the managed forest—the options and opportunities. More forest land is coming under intensive management with the passing of each year; this trend is not likely to change as demand for timber and non-timber resources continues to rise. Thus, we anticipate an expansion of the technical skills within public and private research organizations to address the increasing complexity of multiple-use management issues.

Research efforts need to emphasize the development of cost-effective methods to integrate non-timber resources into commercial forest management programs. Private forestland managers want to make decisions that are based upon technical information and that will further their principal objective. Where multiple-use options are compatible with the owners' primary land use goals, then those that either produce income for or minimize direct costs are preferred. Thus, research should concentrate on areas where appreciable gains are possible. Cooperative research among private, state, and federal organizations, with the setting of mutual goals and objectives, avoids the pitfalls of adversarial relationships, which seldom produce mutually acceptable results. Our favorable experiences to date have led us to seek out cooperative research opportunities as we consider new or expanded research activities.

It has been our experience that apparent conflicts that exist between various resource uses are often the result of inadequate information on the interrelationships of these uses. These interactions are usually complex, and are often highly variable in time and space. Environmental research can contribute significantly to the development of coordinated management approaches that recognize the range of natural resource values present on private forestlands. Management decisions based on research findings rather than perceptions will be more acceptable to all concerned.

Literature Cited

Anderson, R. J. 1985. Bald eagles and forest management. Forestry Chronicle 61(2): 189-193.

Arkansas Dep. of Pollution Control and Ecology. 1980. Water Quality Management Plan. 208 Continuing Planning Process for non-point sources for FY 1980. Arkansas Dep. Poll. Contr., Little Rock. 29 pp.

Beasley, R., E. L. Miller, and S. C. Gough. 1984. Forest road erosion in the Ouachita Mountains. Pages 202-213 *in* Penn A. Peters and John Luchok, eds, Mountain Logging Symposium Proceedings. Morgantown, West Virginia.

Bilby, R. E. 1984. Removal of woody debris may affect stream channel stability. J. Forestry 82:609-613.

Bisson, P. A., and J. R. Sedell. In press. Salmonid populations in logged and unlogged stream sections of western Washington. *In* W. R. Meehan, T. Hanley, and T. R. Merrill, eds. Proceedings of a symposium on fish and wildlife relationships in old-growth forests. April 12-13, 1982, Juneau, AK. Amer. Inst. Fish. Res. Biologists.

Wigley, T. B., J. M. Sweeney, M. E. Garner, and M. A. Melchiors. 1985. Forest habitat use by wild turkeys in the Ouachita Mountains. Nat. Wild Turkey Symposium 5: 183-197.

Plans and Actions for Fish and Wildlife: Case Histories

Chairman:
DOUGLAS M. CROWE
Planning Coordinator
Wyoming Game and Fish Department
Cheyenne, Wyoming

Cochairman:
HARRY LIBBY
Wildlife Staff Specialist
Wisconsin Department of Natural Resources
Madison, Wisconsin

A Perspective on Planned Management Systems

W. Donald Dexter
Wyoming Game and Fish Department
Cheyenne, Wyoming 82002

Management, whether practiced in a wildlife agency or the General Motors Corporation, is made up of three functions: planning, organizing and controlling. Planning is the foundation upon which the other two management functions rest. In fact, organizing and controlling merely carry out decisions made during the planning process.

Unfortunately, planning has become sort of a dirty word in some quarters; it is said to smack of regimentation; to stifle individual innovation. In other quarters, planning is looked upon as a panacea . . . some sort of snake oil remedy for all organizational ills. The truth is somewhere in between. Planning is no better or worse than the people who do it and the processes developed to support it.

All managers are, in fact, planners. We cannot escape the long-range implications of our decisions. If one is willing to accept this as truth, then the choices relative to planning narrow to just two. It may either be done formally or informally. There are dangers to informal planning since it allows vagueness and inconsistency to interfere with execution. Formal planning produces a decision-making framework which exposes weaknesses and directs emphasis, leading to consistent progress toward identified objectives.

Substantial benefits can be realized by those agencies that organize their operations into a planned management system. Such a system requires the establishment and validation of measurable objectives. It provides a structured process by which the agency pursues these objectives and the mechanism for unity and teamwork on an agency-wide basis. Furthermore, it facilitates control and evaluation, permits planned budgeting, documents administrative decisions, and allows management to proceed in an active, rather than reactive, mode.

There is often a great deal of confusion between producing a plan and implementing a planned management system. Simply stated, "The Plan" documents where the agency expects to be at the end of a given period of time. A management system is the mechanics of how the agency intends to get there. Obviously, the two are interrelated; the plan providing targets at which the management system is aimed and the management system being the actual operations of the agency.

An important question relative to planned management systems is, "who should do it?" The answer is that everyone in the agency should be involved. Planning, to be successful, must become the way an agency does business. The system, once implemented, will encompass all aspects of management operations and any "ivory tower" approach to planning is destined to fail.

Such participative planning should in no way be viewed by senior administrators as a dilution or dissemination of power. Instead, it expands the Director's perception and control by organizing information and viewpoints from throughout the organization. However, the Director and his immediate staff should be involved with, and responsible for, the formulation and implementation of agency objectives, strategies, and procedures.

Conclusion

Every agency, regardless of its charge, needs to develop strategies to direct its future course. Critical decisions on whether to increase data collection, implement new activities, de-emphasize some programs and expand others, etc. are greatly enhanced within the framework of a planned management system.

While it is true that planning will not overcome poor administration, it is also true that no amount of managerial genius or hard work can make up for a lack of planning. Through design and implementation of a planned management system, an agency can reach its full potential for purpose and direction. Planning, however, will fail if it is approached as a static, one-time operation. Properly implemented, a planned management system is an ongoing process of management by objective that accommodates continual change, requires frequent updating, and provides for informed decision making within the ever-changing environment in which we all operate.

Florida's Comprehensive Planning System

J. Davis McElveen
Florida Game and Fresh Water Fish Commission
Tallahassee, Florida

Introduction

In contrast to earlier times, fish and wildlife in twentieth century Florida no longer enjoy the benefits of wilderness, limitd access, and sparse human populations. Five thousand four hundred new residents move to Florida every week, and by 1990, Florida will be our nation's fourth most populous state. The resulting pressures on the fish and wildlife resource are immense. Expanding human populationsd shrink available habitats and the fish and wildlife populations they support, while placing increased demands on the resource for human use and enjoyment.

In 1982, the Florida Game and Fresh Water Fish Commission (GFC) identified the need for a more formalized process for setting agency direction, conducting operations, and evaluating results. The GFC initiated the development and implementation of a comprehensive planning system (CPS) over the next three years. This paper presents critical decisions faced by the GFC in this process and the resulting CPS.

The concept and design of the CPS was to:

1. Develop a realistic planning process that would be implemented and used.
2. Establish priorities and coordinate agency activity in agreed-upon directions.
3. Provide personnel with clear direction and ensure continuity in operations regardless of personnel changes.
4. Inform the public and governmental bodies of agency policies and direction.
5. Provide a means for public evaluation of agency philosophies and operations.
6. Promote action rather than reaction by orienting efforts toward achievement of definite objectives.

The Comprehensive Planning System

The GFC comprehensive planning system is composed of four components forming an integrated system (Figure 1). These components are summarized as follows:

1. Inventory
   The inventory component can be characterized by the question "Where are we?" It compiles data on fish and wildlife populations and users for setting objectives in Component (2) and to evaluate completed operations in Component (4).
2. Strategic Plan
   The strategic plan component can be characterized by the question "Where do we want to go?" It formulates the goals, objectives and strategies that state where an agency wants to be in five years.
3. Operational Plan
   The operational plan component can be characterized by the question "How will we get there?" It "gives life" to the strategic plan and states specifically what will be done in a given budget year. The operational plan is composed of division project documents.

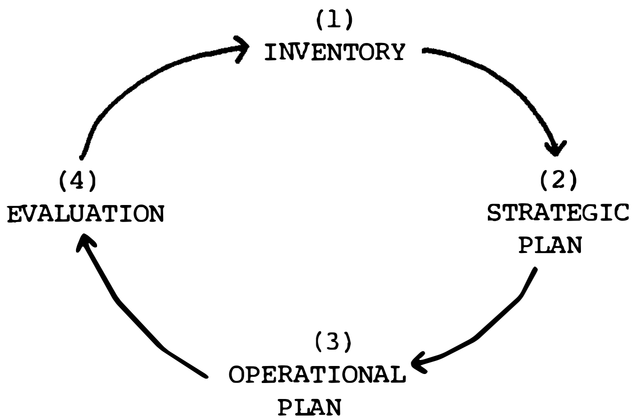


Figure 1. Game and Fresh Water Fish Commission Comprehensive Planning System.

4. Evaluation
   The evaluation component can be characterized by the question "Did we make it?" It "closes the loop" by dertermining how efficient and effective the agency was in meeting objectives. The results of this component update the inventory and form the basis for revisions to strategic and operational plans.

Developing and Implementing the System

Each component of CPS presented difficult decisions to be faced by the GFC. These will be examined in turn and the resulting system components described.

An early decision was whether to develop the CPS so as to qualify for federal funds. Since 1973, the development of comprehensive fish and wildlife planning systems has been an option for receipt of federal Pittman-Robertson (PR) and Dingell-Johnson (DJ) funds and, in come cases, results in a greater federal/state matching ratio. The GFC CPS was very similar to Federal Aid (FA) guidelines for a planning system. However, GFC staff strongly felt that the agency should develop and implement planning to fulfill internal agency needs, regardless of FA considerations.

Inventory and Strategic Planning

Agency Responsibility and Authority. The initial inventory was conducted simultaneously with the development of the first strategic plan. It was felt that sufficient data was on-hand to make strategic decisions. The strategic planning process was designed as a step-down process starting with a single statement of purpose for the agency (the mission) and ending with the specific actions required to attain this purpose (strategies).

The mission statement was conceptualized as a single statement of direction and intent for the agency. Discussions on specific wording centered around the GFC's authority and responsibility, particularly concerning the degree to which the agency controls fish and wildlife habitat.

The Florida Constitution, Article IV, Section 9, sets forth the GFC's authority as

. . management, protection and conservation of wild animal life and fresh water aquatic life." No reference is made to habitat. On the one hand, the GFC recognized habitat as the most critical issue facing fish and wildlife, while on the other, agency constitutional authority rested with the animals themselves. Broadening the scope of the mission beyond the constitutional authority was considered unrealistic. The agency chose, instead, to define its role in habitat as one of "management" in the broad sense of influencing decisions being made about habitat. The result was the following mission statement:

> To manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions which provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Organizing Agency Programs. Approximately six months were spent during 1983 wrestling with the issue of how to organize agency programs. Deliberations centered around what the agency viewed as its end product—fish and wildlife species, fish and wildlife communities, public use of fish and wildlife, fish and wildlife habitat, or some combination of the four.

Initially, a program structure based upon both fish and wildlife species and their uses was developed (Figure 2). Problems became immediately apparent. Of particular note, was that this structure focused too strongly on individual species, while not appearing to consider impacts on other species. Also, the identification of fish and wildlife species and its use as our product created problems. Many staff still felt that the end product should be habitat. These problems led the GFC to restructure programs based on fish and wildlife communities (Figure 3). Communities were defined as those assemblies of fish and wildlife species that have evolved characteristic species composition, densities, and distributions. This structure represented a combination of ecosystem and species approaches to management and thus a greater focus on habitat.

The community-based program structure was conceptually appealing and seemed to provide mechanisms for resolving conflicts between programs more easily. However,

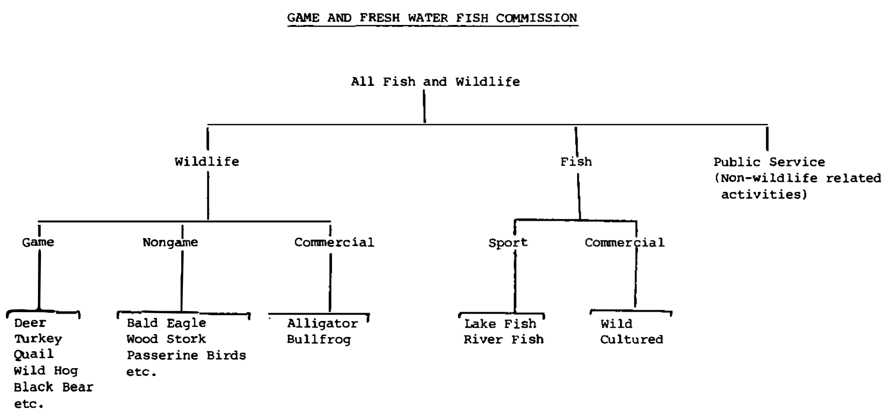


Figure 2. Initial draft program structure of the Florida Game and Fresh Water Fish Commission—May 1983.

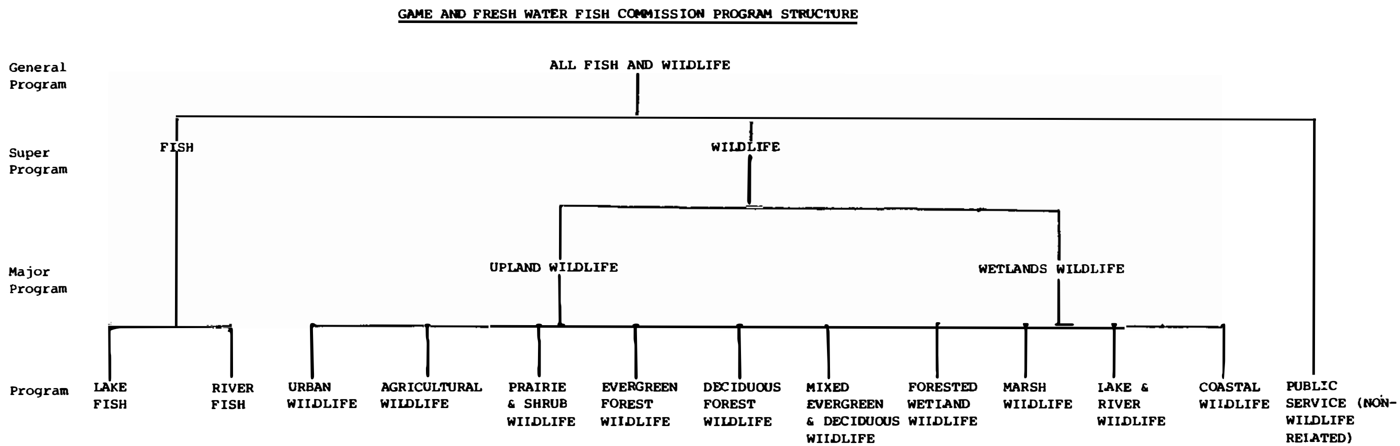


Figure 3. Second draft program structure of the Florida Game and Fresh Water Fish Commission—October 1983.

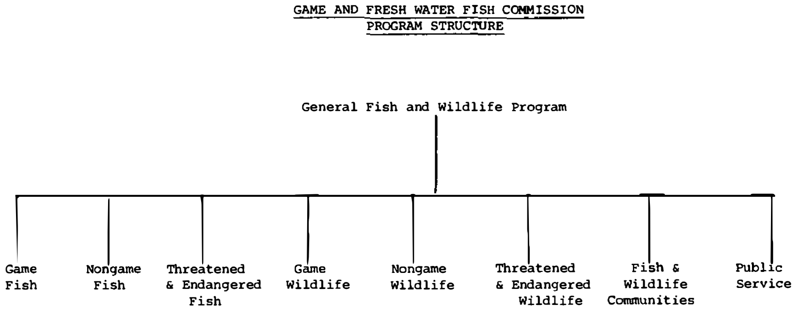


Figure 4. Final program structure of the Florida Game and Fresh Water Fish Commission—July 1984.

in developing the remainder of the strategic plan, difficulty in setting objectives was encountered. To set specific and measurable program objectives required doing so for individual or groups of fish and wildlife species. Secondly, it was difficult to identify with the community concept because the agency had not traditionally managed in this manner. Thirdly, there was no data base on which to set community objectives. All available data was based on individual species, regardless of the community in which they resided.

To overcome these problems, the agency again revised the program structure (Figure 4). This structure reflects the GFC's view of fish and wildlife as individual species and as a part of an ecological community. It also enabled the agency to set specific and measurable objectives for all programs using the existing data base. A difficulty that may arise with this program structure is the Fish and Wildlife Communities program being viewed essentially as a habitat program.

Setting Program Direction. Program direction is set by goals and objectives, which become the focus of a program. These can be stated either in terms of program inputs, such as the number of man-days or the amount of equipment needed to get the job done, or program outputs, such as number of animals harvested. This approach tends to focus attention on what needs to be done, rather than where a program needs to go. The agency decided to begin stating program goals and objectives in terms of the end product of a program, i.e., fish and wildlife and people's use of it (Figure 5).

A second decision remained on program direction: whether goals and objectives should be qualitative or quantitative. Quantified statements would provide better direction and could be evaluated more objectively. Qualitative statements provided vision and inspiration. The agency decided to state goals in qualitative terms as statements of ultimate accomplishment. Objectives would be stated in specific and measurable terms with specific target dates for completion. For example:

*Goal:*To maintain or increase the abundance and distribution to threatened and endangered wildlife to the point they are no longer listed as threatened or endangered.

*Objective:*To maintain current manatee populations (8,000-1,200) and distribution (36 counties) levels through 1987-88.

How to Achieve Objectives. The last step in completing the strategic plan was to develop problems and strategies for each program. Problems were defined as obstacles to the accomplishment of objectives, and strategies the solutions. Though simple in concept, this step also had its difficulties: "What level of problem?" "How to

Problem: The degradation and loss of habitat is a threat to the continued well-being of many game species.

Strategies:

(a) Provide increased technical assistance to landowners to help them benefit game wildlife.

(b) Provide financial incentives to landowners who retain wildlife habitat on their property.

(c) Pursue passage of statutes and regulations that encourage habitat preservation and enhancement.

(d) Review development projects to minimize and mitigate habitat loss and degradation.

(e) Increase enforcement of current statutes and regulations that protect habitat.

(f) Periodically conduct comprehensive assessments of game wildlife habitat.

(g) Inform the public of positive and negative changes in game wildlife habitat.

(h) Determine the habitat needs of game species.

(i) Acquire habitat through purchase, lease or other means.

Figure 5. Example Problem and Strategies from Game Wildlife Program.

organize the problems?" "What's a problem and what's a strategy?"

The various program task forces working on the strategic plan brainstormed a multitude of problems. These were combined and refined into the five to twelve statements that covered all identified problems in a program (Figure 5).

Task forces then developed the strategies for solving each problem statement. Once again ideas were refined into cogent statements of action the GFC should take, or encourage others to take, in order to solve a problem. Any given strategy cannot solve a problem alone, but successful completion of all strategies can (Figure 5).

Operational Planning

Organizing the Operational Plan. With the completed strategic plan establishing program direction, efforts turned to the question "How do we get there?" This would be answered in the annual operational plan.

Two existing types of annual plans were available: (1) annual and five-year FA documents, and (2) state biennial budget documents. Federal aid documents are prepared by three GFC divisions for PR and DJ funds. These documents were organized around projects, and present project objectives, expected results, approaches, specific jobs, and estimated costs. State biennial budget documents are prepared by all divisions and present division needs by line item.

The agency decided to adopt the FA document format for the agency's operational plan. All GFC divisions would prepare these documents, which collectively would entail the operational plan. The outline adopted was as follows:

—project title
—project objective
—study title (if appropriate)
—study objective (if appropriate)
—need
—expected results or benefits
—approach
—jobs (if appropriate)
—procedures
—man-days required
—total estimated cost
—location

Ensuring the Operational Plan Implements the Strategic Plan. Of great concern, was tying projects in the operational plan to the strategic plan. The agency was concerned with ensuring that projects worked toward accomplishing plans set out in the strategic plan, and that the strategic plan would be revised based on experiences gained from the operational plan.

To accomplish this, one page of each project was devoted to providing this information, which states how the project relates to and suggested revisions to the strategic plan (Figure 6).

Selecting Projects for Funding. In any given year, more projects are proposed than can be funded. Thus, projects must be selected that will best accomplish the strategic plan. To accomplish this, programs and problems in the strategic plan are ranked for the next biennial budget cycle. Projects are ranked in order of importance based upon the priority of the programs and problems they address. The higher the priorities addressed, the higher a project scores. The executive director uses this ranking in approving projects for submission to the Legislature for funding. Funded projects are then implemented.

Evaluation

The most difficult phase of a planning system is evaluation of on-going and completed projects. The GFC will begin evaluations during the 1985-86 fiscal year. The approach is to document the costs and benefits of each project and program, in terms of progress toward strategic plan objectives.

Project costs are captured, using the Program Cost Accounting System (PCAS), from two sources: the employee biweekly activity report (70 percent) and invoices (30 percent). Activity reports indicate the project and program under which an activity was conducted (Figure 7). For each activity encompassing two hours or more, employees recorded the number of hours spent and miles driven. This data is entered into a computer for ease of manipulation and retrieval. Project and program cost reports can be generated to assess manpower and vehicle expenditures. Expenditures for equipment and supplies will be captured in future years by coding invoices in a similar manner.

HOW PROJECT/STUDY RELATES TO STRATEGIC PLAN

Fiscal Year 84-85

PROJECT TITLE: Largemouth Bass Investigations

STUDY TITLE: Population Dynamics of Largemouth Bass Resources

DIVISION: Fisheries BUREAU: Research

I. How Project or Study Relates to the Strategic Plan:

Program(s) Addressed: Game fish

Objective(s) Addressed: Largemouth bass: To maintain a catch per unit effort of .2 to .5 largemouth bass per hour through 1987-88.

Problem(s) Addressed: 3. Additional game fish biological, population, harvest and demand data are needed.

Strategy(ies) Addressed: 3(a). Gather biological and population data.

II. Deviation(s) From or Revision(s) to Current Strategic Plan: None.

III. ASSISTANCE NEEDED

This form is designed as part of GFC Operational Planning to enhance communications between divisions/offices on operational matters. Indicate below the assistance, above and beyond current levels, you need from other GFC divisions/offices. Check the divisions/offices that apply and briefly describe the type and amount of assistance needed.

X	Law Enforcement		Administrative Services
	Fisheries	X	Informational Services
	Wildlife		Environmental Services
	Executive Director's Office		Regional Director ____ (Region)

Project Requests A Minimum of Four Man-Hours/Month on-the-water Patrol on Weekend Days for High Visibility of Enforcement on Slot Limit Regulations. Contact Bill Coleman.

Spring Time News Release Requesting Public Cooperation.

Figure 6. Example Project Submission Form.

1. BIWEEKLY ACTIVITIES AND LEAVE RECORDS

2. Division of ______________________ 3. Name ______________

5. Biweekly Period From ______________ To ______________ 19 ___ 6. Social Security No. ______________

8. Employee's Signature ______________ Date ______ 9. Supervisor's Signature ______________ Date ______

(B)							
1. Time In							
2. Time Out							
3. Date							

4. RCC	5. Program	6. Project/Study	7. Activities	7a. Description of Activities (Optional)	8. FRI	SAT	SUN	MON	TUE	WED	THU

Figure 7. Employee Biweekly Activity Report.

Documentation of the benefits derived from programs and projects will not be implemented by the GFC until later in 1985. The challenge is to quantify, in a practical way, as much of the benefits of a program or project as possible. Initially, we expect the majority of benefits assessment to be subjective.

Benefits

As with most planning efforts, the GFC has realized a variety of benefits from the CPS. Chief among these are (1) improved coordination among divisions and offices; (2) better communication within the GFC, with the public, and with other governmental bodies; and (3) clearer direction for agency programs.

Observations of the Planning Process

Three years is the minimum time an agency can expect to develop and implement a CPS. Besides the logistics of a complex process, personnel attitudes must change—a slow process. In many ways three years is about as long as an agency should spend, too. It is difficult to sustain the necessary commitment much longer in that planning responsibilities added approximately 10 percent to the workloads of GFC central office staff during development and implementation.

It is essential to devote one person full-time, preferably housed in the director's office, to develop and implement the format and process for planning. This will allow agency line managers to better focus their input on the content of the plan. Even then, the GFC found that 80 percent of staff effort was devoted to discussions of format and process and only 20 percent to content.

Before beginning planning, GFC staff assumed they shared a common direction for the agency. This was only true to a limited extent. Discussions revealed startling differences of opinion. Even more revealing were striking philosophical differences which created often-conflicting thoughts as to specific courses of action. Through lengthy discussions, staff reached consensus on critical policies and courses of action.

Acknowledgement

Florida's comprehensive planning system was designed based on similar systems developed and refined in other states.The author respectfully acknowledges the assistance and pioneer planning work of the Wyoming Game and Fish Department, the Kansas Game and Fish Department and the Tennessee Wildlife Resources Agency and their planning coordinators Doug Crowe, Verlyn Ebert, and Cliff Whitehead, respectively.

Evaluating Probable Comprehensive Planning Success

Spencer Amend
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526

Introduction

This paper is the outgrowth of discussions with members of the Organization of Wildlife Planners at their last meeting. Comprehensive fish and wildlife planning has been around for a number of years now and has been the object of some attention by most states. In 1970, amendments to the Federal Aid in Sport Fish and Wildlife Restoration acts provided impetus to state interest in comprehensive planning by providing an option for the way states obtain and manage their Federal Aid dollars. Federal Aid specialists established a framework for comprehensive planning and provided many training opportunities and guidelines in an attempt to assist states that wanted to qualify for the comprehensive planning option.

Comprehensive fish and wildlife planning is a process; it is a way of doing business. Comprehensive planning focuses on setting objectives for what the agency does, devising and selecting projects designed to meet those objectives, and measuring progress toward those objectives. Crowe (1983) discussed this process in a highly useful fashion. Comprehensive planning should not focus on the production of a paper plan. Documentation is an important part of planning, but too frequently the focus of planning is on producing "the plan."

"Evaluation" in this paper, has a different meaning than the way it is frequently used in discussions of comprehensive fish and wildlife planning. "Evaluation" usually means answering "Did you get there?" or "How did you do?" questions and is concerned with measuring progress toward objectives. Others in this session undoubtedly will use evaluation in that sense. However, I am using evaluation to mean a process to determine the chance for success in comprehensive planning. It has been said that it takes a long time to determine the benefits of comprehensive fish and wildlife planning. I hope to provide those who may be considering trying comprehensive planning with a diagnostic tool to predict whether or not they are likely to be successful.

Problem

Virtually all natural resource agencies have had experience with something called "planning" in the last dozen or so years. Results have varied considerably, largely because of the different degrees of interest in improving management of the agencies involved. By providing an increased understanding of comprehensive planning, I hope to keep those agencies that are unable to make a reasonable effort from getting involved in the first place. This will save them considerable time, effort, and frustration. I also hope to provide information that helps prevent attempts to use comprehensive planning to create the illusion of doing something, while really seeking only to justify some preconceived game plan.

Planning disciples, those who have benefited from having a planned management system in their agency, sometimes overzealously advocate such an approach to others. When you feel so good about something, and the benefits seem so great, it is human nature to try and help others find the same benefits. However, the costs associated with implementing a planned management system are seldom discussed with the same enthusiasm as the benefits. There are real costs related to comprehensive planning, in dollars and personnel and in institutional change. Agencies sometimes decide to start on comprehensive planning without a clear understanding of the costs involved. This can lead to jolting surprises and unfulfilled expectations. Comprehensive planning is not right for every agency. It is likely that confusion and frustration will result and that bad feelings toward planning will be emphasized throughout the agency unless informed decisions are made about becoming involved in comprehensive fish and wildlife planning and a reasonable implementation effort is made.

Goal

You are fortunate that this is not one of my "Planning is good" sermons; you know, the ones where the person leans down from on high and loudly utters, "If you fail to plan, you are planning to fail." I will restrain myself from such deliverances today. Most people who really need to hear it are not attending this session anyway. In such sermons, three common reasons for planning may be cited: (1) to create the illusion of progress; (2) to justify something that has already been decided; and (3) to improve organizational efficiency and effectiveness. Some agencies become involved with comprehensive planning for one or both of the first two reasons. There are individuals within many organizations who see comprehensive planning as a means to gain something besides improving the way the agency does business.

I want to do several things in this paper. First, I want to identify key items that must be dealt with in any agency in order to successfully implement comprehensive fish and wildlife planning. By "successfully implement", I mean make obvious improvements in the way the agency operates. The costs, in terms of personnel and dollars will vary among agencies and have to be estimated individually, based on whether or not the essential elements are already in place and how much additional effort is required. This paper should help provide an understanding of the costs of comprehensive planning by focusing on the essential elements of a successful application. If an agency is not willing or able to take these steps, they should not attempt comprehensive fish and wildlife planning.

Secondly, I want to identify the actions that an agency will be doing if it is really serious about the successful implementation of an effective planned management system. Some agencies have claimed to get involved with comprehensive planning and have blamed planning when they failed to achieve the benefits of which planning advocates speak. However, what more than likely happened was that the agency really did not understand what was involved in planning and did not give planning a chance to succeed.

Context

The identification of assumptions is a characteristic of good planning. It seems, therefore, only fair that I should identify some of my assumptions in preparing this paper. Clues to some of these assumptions are contained in the previous paragraphs. Other assumptions and admissions of bias that I need to share include:

- There are no definitely right answers in planning; there is no ultimate truth. Planning, planning systems, and their implementation must be adaptive and flexible.
- Planners do not write plans; many self-proclaimed (or agency-annointed) "planners" aren't worth shooting. Many, many people are involved in the planning process; the planning staff coordinates, schedules, reminds, and prods those who really make it happen.
- Planning relies heavily on communication, both within the agency and with outside influences. "Within" means communication and feedback in all directions: up, down, and laterally.
- Good planning and good management are the same thing.
- Planning systems must be simple, not strangled with paper or with regulations, guidelines, or formats.
- Planning should be designed to meet the "reasonable person test": an intelligent, rational person should agree with your point of view, based on a clear, unbiased presentation of the information being considered. If either the approach or the information is too complicated, you cannot expect a person with no previous experience to even understand, much less reach the same conclusions you have reached.
- You will never get it right the first time; you can always make it better. Try it, do it, make mistakes, learn, improve.
- Implementation, action, must be the end point. Planning for implementation should be a driving consideration early.
- All (programs, things) are not created equal; they differ in relative importance; making rational, explicit choices between things in a given category is what planning is all about.
- It is always the ultimate decision maker's God-given right to screw up.
- Make changes slowly, incrementally; extensive dramatic shifts tend to upset an agency, even when the changes are needed.

Methods

Predictions of what may occur in the future are risky; that is why I initially approached this paper somewhat fearfully. After discussions with several people, it seemed reasonable to approach the task of predicting the likelihood of comprehensive planning success or failure through a series of questions that capture the essential elements of good planning. We were unsure exactly how many questions would be needed, but thought that a manageable number probably was possible. We (of course) wound up with a somewhat unmanageable number, but were able to ultimately boil the list down to ten. (It's sort of a rule of thumb among planning types that the maximum manageable number of anything for an administrator is five.)

After identifying all the questions necessary to embody the essential planning elements that I could come up with, I put them into a form where a "yes" answer indicated a good planning system. The next step was to identify just who I wanted to help put priorities on the questions. For the most part, I chose people with experience in effective comprehensive fish and wildlife planning systems. I added several administrators and a number of folks I categorize as just plain good thinkers for balance, and as a lie-detector test on what I was doing.

I sent the initial list of questions to each of the individuals selected, along with information describing my overall purpose. Each person was asked to do three things: (1) determine the relative importance of questions on the list from the perspective of an agency that is getting ready to plan; (2) determine the relative importance from the perspective of an agency that is already involved in comprehensive planning; and (3) add questions that represent essentials of planning not adequately covered in the initial list.

Results

Almost all of the questionnaires were returned (29 of 32). The responses, plus the additional remarks provided, were used to produce the following list of considerations. The first column of numbers indicates the relative importance of the item for agencies about to become involved in comprehensive planning; the second column represents the relative importance of the item to agencies already involved. Although a number of people suggested additional questions, it seemed to me that these ten items adequately encompass the essentials necessary for successful planning.

Top Questions—in Priority Order—for Agencies

Getting Ready to Plan	Already Planning	
1	1	• Do upper level administrators really want to plan? Is the chief administrator willing to demonstrate leadership through the planning process and incorporate it into his management style? Is agency management willing to change the way they do business? Does planning have highly visible support from the chief decision maker, including having the planning unit attached organizationally to the top administrator and giving the unit autonomy to function effectively?
2	2	• Is the planning staff among the most well trained, highly qualified, enthusiastic, and aggressive individuals in the agency? Do they know the agency from the bottom up? Are they essentially free from other duties? Do you have access to computer support people who are familiar with wildlife programs?
3	3	• Are you building/maintaining a management system rather than writing a plan? Does planning identify and focus on those things the agency can do something about? Does the system include honest attention to all four planning questions? (Where are we? Where are we

		going? How do we get there? Did we get there?). Do you have reasonable data on resource distribution, density, and use?
4	8	• Is your system simple enough to meet the "reasonable person test"? (simple equals clear, logical, and understandable). Is the system defined in language recognizable to the "rank and file" rather than in planning jargon? Does the agency have good communication and feedback mechanisms? Does the planning system communicate in terms of what people/projects *produce*, rather than just what they *do*?
5	9	• Does your effort stand to learn from, but not be constrained by, previous agency planning efforts? Is planning and implementation focused clearly on the future and on what you want it to be?
6	7	• Does your planning correspond to the geographic levels at which you manage? Statewide? Regional? Population units?
7	6	• Are agency priorities clear at all organizational levels? Are progress and demonstrated results forthcoming in a timely fashion? Does the system include tracking and measurement of objectives, costs, and outputs in terms/units that can be compared?
8	5	• Is the system "alive"? Are you able to be wrong? Do you encompass shifting political and public priorities? Can you be flexible enough to accommodate legislative or political initiatives into a scheduled program? Are the public and other potential "nay-sayers" involved? Do you look at changing conditions outside the agency's control and assess their impact on the agency? Does the whole process include a healthy degree of controversy?
9	4	• Is planning tied to the budget? Are planning decisions reflected in the budget? Can you shift personnel and money among administrative units?
10	10	• Does the system facilitate better decision making at all levels?

Discussion

It was tempting to try and devise an objective scoring system for evaluating planning systems. In fact, it might have been instructive to do so. However, I was afraid that such an approach would indicate greater precision than exists. Therefore, the following discussion fails to provide "the answer" to evaluating systems. It does, however, contain information about the essential elements that, if followed, will substantially enhance the probability of the smooth, effective implementation of comprehensive planning within an agency.

The idea of building the perfect planning system before implementing it is wrong. An agency should quickly start to implement an acknowledged imperfect system, with a commitment to learning, improving, and encompassing aspects of agency business that may have been left out initially; in short, improvement by cyclic incrementalism. Be wary of anyone who wants to get it perfect the first time. It is impossible to identify all contingencies initially. Build success and confidence in the planning process by early attention to simplicity, logic, clarity, enthusiasm, relevance, and commitment. Maintain the credibility of the process and the people guiding it by underpromising and overdelivering.

One of the biggest challenges to architects of planning efforts is getting the right people involved in the right ways. The planning staff must be free of other duties so that they can get the process underway and guide its progress. Adequate time for all persons involved must be available, and this need must be understood. Top administrators must be visibly supportive and involved in the effort. Organizationally, the planning unit must be attached to the top administrator and must be provided the latitude to function.

The focus and attention must be toward the future, but persons involved must be aware of, and learn from, past planning efforts within the agency. The system must be simple, clear, logical, and understandable, and be attentive to the entire planning cycle: program definition and status; goals, objectives and strategies; priorities and budget; and monitoring progress. Planning must focus on things within the agency's control in order to demonstrate results. Planning levels must be consistent with management levels: if decisions are made about a deer herd at a regional or population unit level, planning must not address only the statewide level. Planning, from the beginning, must focus on what the agency and its people produce, not just on what they do.

Communication is important and should provide a common understanding of what is expected and occurring across all organizational levels. There should be systematic feedback about what others are doing at all levels. The planning staff responsible for coordinating the process should be experienced and motivated. Communication should result in an understanding of priorities and supporting rationale across all organizational levels.

The reasons for the agency becoming involved with planning should be clear. Planning should relate to how the agency does business or result in changing that process. Objectives should be measured. The new system should not take so long to produce demonstrable results that people forget what was promised. The system should include tracking and measurement of objectives, costs, and outputs in comparable terms or be changed to allow these comparisons. Schedules should be clearly specified, and the planning schedule should not be allowed to slip. Don't be too rigid in terms of expecting planning to solve all problems; the system should accommodate outside influences. Progress should be assessed in the same terms throughout the process: the objectives.

Some remaining items are less important. However, smoother implementation of the process will result if they exist. Some degree of controversy is healthy; it indicates more interest than does apathy. Implementation, particularly in the future, is easier when all factions, outside as well as inside, are brought into the process as soon as possible.

The sooner it becomes obvious to people that planning is impacting budget allocations, the better. It is desirable for planning to include an analysis of the alternatives for reaching the same objective and encompass all aspects of what an agency does. Planning is easier and more effective if it is practiced consistently across all agency units or functions, results in more explicit decision-making criteria, and matches decisions with appropriate organizational levels.

Conclusions

As an agency becomes more experienced with comprehensive planning, it should do more things right. I do not believe that the importance of any of the considerations mentioned in this paper diminishes as an agency gets further into planning. The ten items identified continue as valid criteria for predicting planning success throughout the process, although several items increase somewhat in importance at different stages of planning.

If there is any benefit to be derived from this presentation, it will, I hope, be that persons considering a planned management system will carefully evaluate the ramifications of such a move.

The best approach, in my estimation, is one in which the maximum amount of information and understanding is brought to bear on each incremental decision having to do with implementing a planned management system. The approach should be set up in such a fashion that everyone knows what to expect at each step, and it should always be possible to say, "No, we don't want to go any further." This should help avoid the feeling that an agency is trapped into something they do not understand until it is too late. It also should help avoid the necessity of blaming planning failure for what was really an agency's lack of understanding or commitment.

Acknowledgments

I am indebted to a number of people for assistance with both the ideas and the preparation of this paper. Doug Crowe, Verlyn Ebert, Oliver Gasswint, and Ralph Morgenweck each provided helpful suggestions. The 29 people who provided their opinions on the relative importance of planning considerations contributed much of the information used to decide which items are most important. Bill Conlin, Marcia Hall, Gary Hickman, Richard Johnson, Charlie Segelquist, and Pete Taylor provided useful reviews of the manuscript; Cathy Short provided invaluable editorial, as well as substantive, suggestions; and Dora Ibarra patiently typed the several versions in the paper's evolution.

Literature Cited

Crowe, D. M. 1983. Comprehensive planning for wildlife resources. Wyoming Game and Fish Department, Cheyenne, Wyoming. 143 pp.

Managing Wildlife Resources by Objective

Dale Strickland
Wyoming Game and Fish Department.,
Cheyenne, Wyoming 82002

Introduction

Management by objective (MBO) is the label given to a results-based performance appraisal program (Donnelly et al. 1981). When applied to wildlife management, MBO takes on a much broader meaning. It ceases to be merely a way of evaluating employee performance and becomes "a way of doing business" for an entire wildlife agency.

Wildlife agencies have presided over wildlife without clear cut management objectives for too many years. Objectives have often followed the line of we want more critters, we want bigger critters, or we want more bigger critters. Agencies have, by-and-large, managed people by setting limits on harvest and establishing seasons and hunting areas or zones. In the case of upland and small game, populations rose and fell depending on habitat and largely independent of most management decisions. There have been management successes such as quail management in the Southeast, but there have also been failures, such as exotic game bird programs, excluding pheasants. Large animals, such as deer, elk, and antelope, were allowed to increase to high densities and then were controlled by management decisions based on external pressures from private landowners, sportsmen, and managers of other resources. When these external pressures were weak or absent, managers allowed populations to grow beyond the capacity of the habitat, creating disasters such as the Kaibab deer herd.

To our profession's credit, we were in almost every case conservative when making management decisions and, to my knowledge, failed to manage any species into extinction, although we have come very close with bitterbrush *(Pursha tridentata)* on several deer winter ranges in Wyoming. Because of our conservatism and professionalism, we engendered support from sportsmen and the public, which resulted in habitat protection and other positive results for wildlife.

However, increased human populations and their insatiable desire for natural resources have brought about a demand for change in the way we do business. Our management decisions are no longer blindly accepted by an adoring public. We must now justify our actions and operate at an ever-increasing political disadvantage. Wildlife management principles and platitudes that worked with local sportsman groups in the past are less effective today and have little effect on the multinational corporations competing for wildlife habitat.

Strategic Planning

Many states have begun to meet this challenge through comprehensive planning. Planning was defined by Crowe (1983) as "an integrated system of management that includes all activities leading to the development and implementation of goals, program objectives, operational strategies and progress evaluation." The mechanics of the planning process in wildlife management have been described very well in Crowe (1983) and U.S. Fish and Wildlife Service (1973).

The Process in Wyoming

The planning process in the Wyoming Game and Fish Department began by formalizing much of what the agency had already been doing. However, the painful process of documenting goals and quantifying objectives resulted in much needed agency accountability. The identification of problems, and strategies designed to solve those problems, produced a direction for future actions. These actions often required the Department to do something; and, more often then not, identified actions needed by other groups or agencies. That first attempt at strategic planning has evolved into a fairly complex system which includes the strategic plan, operational plan, and evaluation and inventory methods. I would like to spend the remainder of this paper describing how management by objective actually works for terrestrial wildlife in Wyoming.

Objective Setting

Planning in the Wyoming Game and Fish Department works "from the ground up." Objectives are established for a population by the managers of that resource. A population is a reasonably discrete group of animals with less than 10 percent interchange with adjacent groups of the same species. Identification of these populations was a very difficult but necessary first step. Boundaries for population units, including such things as fenced roadways, major rivers, hydrographic divides, and changes in vegetation were established without regard for administrative or political boundaries. Refinement of these boundaries continues as new information suggests change or when new barriers such as fences are erected.

Objectives, first generated as proposals by the biologists responsible for the population, are based on population, hunter use, and habitat data. These objectives are then reviewed by the game wardens responsible for management of the various hunt areas which make up the population. A single population may be made up of from one to more than ten hunt areas. While the biological data may suggest an objective at a certain level, the wardens' knowledge of private landowners' tolerance for animals and hunters, the attitude of the local sportsman, etc., may suggest a change in the objective. Once the drafting of objectives, problems, and strategies is completed, the process of public involvement begins.

Public involvement in the planning process occurs at three levels. The Department measures public attitudes about wildlife and its management with a "Hunter Attitude Survey." The excellent response to these surveys has provided guidance for developing Department management philosophy. For example, some managers in my agency are closet trophy hunters and this personal desire may affect their management decisions. Most managers have the desire to produce some very large trophies to provide a variety of hunting opportunities. In addition, one of the Department's more outspoken critics, the outfitting industry, has constantly pushed for more trophy management. Imagine our surprise when the attitude survey indicated that less than 3 percent of Wyoming's residents considered themselves trophy hunters. By far the largest group, almost 35 percent of the respondents, indicated they hunted for the experience.

In addition to the attitude survey, we survey public opinion at meetings held each time an objective is changed. Special interest groups, including private landowners, federal land management agencies, and sportsman groups, are met with locally. These preliminary meetings are followed by public meetings announced in the media and held at one or two population centers near or within the population boundary. Many managers have even submitted signed statements by landowners verifying agreement with final objectives. By July 1, 1985, all of the more than 200 big game populations will have gone through at least one series of public meetings.

Following public input, the revised elements of the strategic plan are forwarded to division administrators for approval and to the planning section for record keeping.

This process is dynamic. The plan document is reprinted every three years. However, elements of the plan can be changed at any time if the proper process is followed.

Budgeting

The operation of the Department is basically manpower and dollars directed at resource objectives/problems/strategies contained in the strategic plan. The allocation of dollars begins with budget preparation. Wyoming's budgeting process includes two components, the money necessary to carry out ongoing operations and a special projects budget. As I mentioned previously, problems and strategies are identified in the planning process. Sometimes the problems can be solved by information or actions generated by ongoing operations. Often the strategy identified requires additional money and manpower. Funding for these new strategies is acquired through the Department's enhancement process. New ideas are developed into a proposal which is evaluated based on the importance of the problem addressed, whether the objective has been achieved or not, and the feasibility of the proposed approach. Projects are ranked and funded until the money runs out.

Work Scheduling

Armed with a new budget and several funded projects, field personnel prepare work schedules in March and April. Included in this preparation is an evaluation of last year's performance. The work schedule includes personnel assignments and data collection objectives (Figure 1). A computerized program and project cost accounting system allows evaluation of how close personnel came to the mandays allocated to various tasks in the previous year's work schedule. Biologists compiling data collected during the field season can point out missed targets for sample size. This system readily identifies work load inequities and personnel problems.

The remainder of the year, field personnel pursue the tasks identified in the work schedule. Periodic review by field supervisors has been necessary to insure attention to work schedules.

Inventory and Evaluation

Inventory and evaluation are similar in that they are dependent on data collection and analysis. Examples of inventories include:

1. Harvest survey;
2. Sex and age ratio classification;
3. Census;
4. Seasonal distribution;
5. Habitat use;
6. Project impact evaluation.

Wyoming has over 200 big game populations and many more populations of migratory game birds, upland game birds, small game, furbearers, and nongame. Obviously, we cannot collect extensive data on all species. For species other than big game, we generally collect harvest, seasonal distribution, and habitat use data. The latter two sets of information result from periodic observations of these species. The data are stored in a computerized data storage and retrieval system.

DISTRICT 5 ACTIVITY SCHEDULE - APRIL 1, 1984 - MARCH 31,1985

Period Covered : October 1 - October 31, 1984

Species	Job Title	Herd Unit	Areas	Personnel	Sample Size Obj.	Man Days	Report Due	Evaluation
Antelope	Post - Season Classification	Centennial	37,44	North Laramie Game Warden	800	1	10/30/84	
			45	Laramie Biologist	400	1	10/30/84	
Mule Deer	Harvest Age/ Sex	Goshen Hole	55	Torrington Game Warden	100	2	11/15/84	
			56	Wheatland Game Warden	100	1	11/15/84	

Figure 1. Format for Annual Workschedule for wildlife management personnel.

Harvest and sex and age classifications are attempted on all big game populations with periodic censuses accomplished based on need. These data are used to construct population models (Gross et al. 1973). The models are used to estimate population size and trend, simulate alternative management actions, and evaluate the impact of projects resulting in changes in natality and/or mortality.

Management Decisions

Each spring, management personnel propose big game hunting seasons for the coming fall to the administration of the game management division. This annual ritual is the most visible management exercise the agency goes through. Management by objective plays a strong part in this process. Season recommendations are made for each population using an MBO Worksheet (Figure 2). The worksheet illustrates the past performance of the population relative to management objectives and how the proposed hunting seasons helps/hinders the attainment of these objectives. Seasons designed to meet objectives are readily adopted by administrators. Seasons not designed to meet objectives are rejected in the absence of exceptional justification.

This approach to season justification is used with the public and ultimately, the Commission. This approach has been useful, particularly in selling controversial management decisions.

Case Study

To illustrate the value of management by objective, I would like to briefly describe two management situations, one where MBO was applied, and another where it was not.

Pronghorn

Wyoming presently has about 70 percent of the world's pronghorn (*Antilocapra americana*). This species was relatively scarce in the early part of this century. However, conservative harvests, water developments, and a reduction of sheep grazing resulted in a dramatic increase in pronghorn, and by 1983, the statewide estimated wintering population was 468,700.

There are 55 pronghorn herds in the state and objectives for each herd were established in 1975. However, many of these objectives were unrealistically low because of underestimates of population size. Landowner complaints began to rise and by 1983, complaints had become deafening. At the Game and Fish Commission meeting held in July of 1983, a group of ranchers proposed more landowner control of pronghorn management. Articles in newspapers talked of the pronghorn population explosion.

The Department, in the meantime, increased data collection and evaluation of population objectives. Population models illustrated that most herds were being underharvested. The increased field data substantiated this management problem. Estimates of wintering pronghorn numbers rose from almost 220,000 in 1979 to over 460,000 by 1983. Harvests were increased dramatically after 1980, going from 47,994 in that year to an estimated 106,255 by 1984.

The rate of increase in pronghorn had slowed by 1983, and the heavy harvest of 1984 combined with higher than usual winter mortality in some herds in 1983 resulted in a reduction in wintering pronghorn to approximately 430,000 in 1984. By 1984, 23

Species : Mule Deer
Herd Unit : Beaver Rim
Year : 1983

	$\bar{X}$ 1979 - 1983	Proposed 1984	Objective
Harvest	330.2	750	700
Hunters	1061.0	1360	1550
Animals / Hunter	0.31	0.45	0.45
Days / Animal	6.6	5.0	5.2
Recreation Days	1955.0	3750	3710

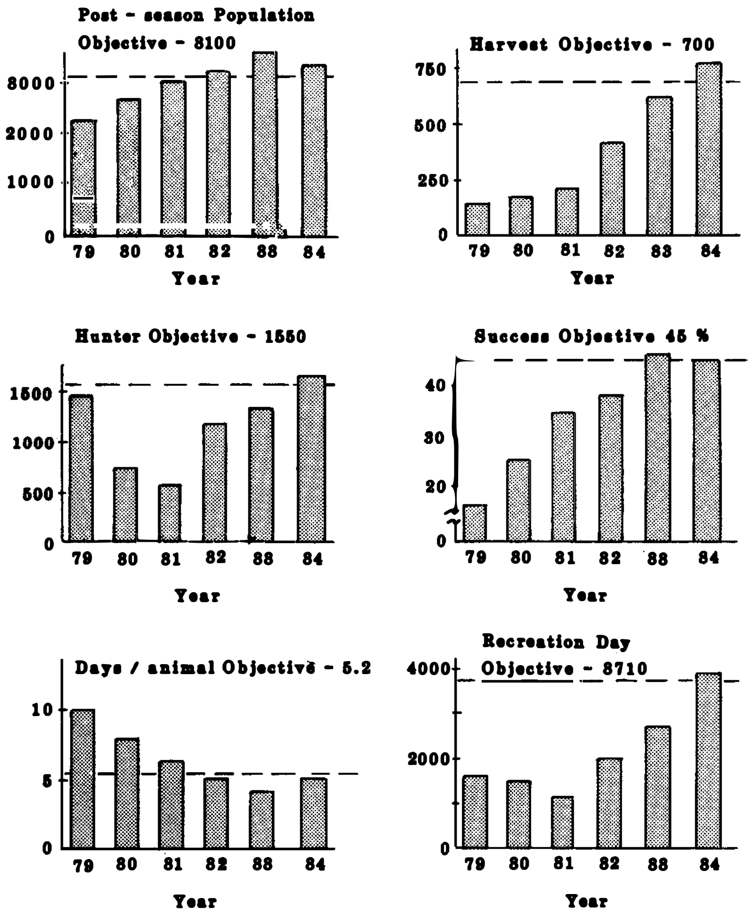


Figure 2. "Management By Objective" worksheet containing analysis of population history and proposed management direction.

of the 55 pronghorn herds were at or below objective with the remainder headed for objective. More importantly, the Department's planning efforts encouraged the public, including landowners, that we were sincere in our desire to reduce pronghorn numbers. The public began to demonstrate more respect for a species that, only a few years before, many had considered a pest.

On the downside of the pronghorn situation, many sportsmen have yet to realize the effect of MBO on pronghorn hunting. During the years we were trying to reduce pronghorn numbers, hunters became accustomed to high numbers of permits and high success. When pronghorn are reduced to the objective of 277,000, the number of permits will go down and the hunters' chances to find larger males will have been reduced. We have tried to explain this in our discussions about pronghorn management and some sportsmen are getting the message. These individuals assure us that they will be heard from when population objectives are again revised. What more could we ask?

Yellowstone Grizzly Bear

The grizzly bear (*Ursus arctos*) was listed as a threatened species by the U.S. Fish and Wildlife Service in 1975, pursuant to the Engangered Species Act of 1973. At the time of its listing, there was a divergence of opinion on the status of the bear (inventory), how many bear were enough, and where they should be (objective). As a result of the change in status, it was uncertain who was managing the bear. Was it the U.S. Fish and Wildlife Service, charged with implementation of the Endangered Species Act? Was it the U.S. Forest Service, the agency managing 90 percent of grizzly habitat in the lower 48 states? Or, was it the National Park Service, the agency responsible for managing a significant portion of the Yellowstone grizzly bear population's habitat? As a result of this confusion, bear recovery efforts had little direction.

The Interagency Grizzly Bear Study Team was formed in 1974. A review of the study team's activities in 1981 concluded that the team's major problems were insufficient financial support and direction. An attempt to designate critical habitat for the grizzly shortly after it was classified as threatened failed as a result of negative public sentiment. Finally, in 1982, the U.S. Fish and Wildlife Service published the *Grizzly Bear Recovery Plan* (U.S. Fish and Wildlife Service 1982). While this document set out goals and objectives, they are merely meant as guidance for recovery. The recovery plan is not a management plan.

The various Federal agencies and states involved in managing the bear and its habitat participate in an Interagency Grizzly Bear Committee which meets periodically to discuss grizzly bear management and research needs. All participants have found the exercise at the same time beneficial and frustrating. All would probably agree that management by committee is difficult.

Amidst all this confusion, the public has developed its own perception of the grizzly and its needs. And, in all matters of human thought, perception is reality. Probably the most commonly held perception is that "the managers" of the grizzly want as many grizzlies as possible wherever they occur. This pleases a few people, but scares the hell out of many more. As a result of these perceptions, management of the grizzly lacks credibility. The confusion is intensified by various groups wanting to protect the bear. It almost appears that management actions designed to help the bear are random, unrelated events. Many solutions have been proposed, including areas closed to human use, supplemental feeding, closure of black bear seasons, no sheep grazing, no timber harvesting, etc. Some or all of these solutions may have merit, but they often lack acceptance by the people most affected.

In my opinion, this situation is begging for management by objective. First, the agencies involved in management of the bear and its habitat must sort out who is in charge. I have no particular favorite in spite of my personal bias as to who is best qualified. Next, there must be an agreement on two basic objectives for the grizzly. How many do we want and where do we want them? Once those two issues are resolved amongst the agencies and sold to the public, then we can get on with the recovery effort.

Conclusion

Management by objective makes sense as a way of doing business for a wildlife agency. However, MBO is not easy because it depends on equal doses of commitment from agency administrators, data and systems support from staff, and acceptance by management personnel. Managers must accept:

1. Planning concept;
2. Objectives in the plan;
3. Inventory and evaluation tools;
4. Criticism when not working toward objectives; and
5. Change.

Agency effectiveness is essential if wildlife populations are going to remain a significant part of our lives into the twenty-first century. MBO can improve that effectiveness.

Literature Cited

Crowe, D. M. 1983. Comprehensive planning for wildlife resources. Wyoming Game and Fish Dep., Cheyenne. 143pp.

Donnelly, J. H., J. L. Gibson, and J. M. Ivancevich, 1981. Fundamentals of management. Business Publications, Inc., Plano, TX. 536pp.

Gross, J. E., J. E. Roelle, and G. L. Williams. 1973. Program ONEPOP an information processor: a systems modeling and communications project. Colorado Coop. Wildl. Res. Unit, Colorado State Univ., Ft. Collins, Co. 327pp.

U.S. Fish and Wildlife Service. 1973. Tactical planning in fish and wildlife management and research. Resource Publ. 123. U.S. Fish and Wildl. Serv., Washington, D.C. 19pp.

________. 1982 Grizzly bear recovery plan. U.S. Fish and Wildl. Serv., Denver, Co. 195pp.

Environmental Scanning: The Difference Between Strategic Success and Failure

Dennis A. Schenborn
Wisconsin Department of Natural Resources, Madison

Introduction

The future of resource management is integrally bound to changes in an "external" environment that includes the social, political, economic, technological, and ecological trends that will shape the society whose resources we manage. Change is inevitible and as Toffler observed in the *The Third Wave* "The extreme speed of change catches governments and politicians off guard and contributes to their sense of helplessness and confusion" (Toffler 1980). The lessons of history are clear; those organizations and institutions that anticipate and adapt to changes in the external environment will succeed (Steiner 1979).

Strategic planning is a formidable tool because it recognizes this fact and encourages agencies to think about the future and the agency's role in shaping the future. It reexamines the agency's mission (overall direction and policy) and analyzes that mission's relevancy in a future that is shapeable and—at least to an extent—predictable. Strategic planning has two goals:

1. Reduce the time between the society's demands and agency action by anticipating changes.
2. Move the agency in a direction which minimizes future threats and capitalizes on opportunities as they develop.

Successful businesses like General Electric, Citicorp, IBM, Xerox, Gulf Oil, Sears Roebuck, and others in the private sector periodically analyze the external environment and incorporate findings into their strategic plans and corporate policies (Thomas 1980, Gross 1984, Key 1984). This process encourages management to scan the present for trends that impact the business and signal future changes in corporate direction or policy (Pearce and Robinson 1983). By scanning significant trends and analyzing their likely future impacts, businesses practice a "pro-active" management style that anticipates likely changes and then plans for action. In contrast, many agencies practice a "reactive" or "crisis"management style that waits until demands by users, nonusers, or legislators force action.

With every change, there comes first an opportunity. Foregone opportunities become threats. Agencies caught in the crisis management trap consistently miss the opportunities and are forced to react to the threats created by a changing external environment. Environmental scanning provides an alternative to crisis management by anticipating change and identifying the opportunities before they become threats. Strategic planning uses that information to define missions, formulate policy, and develop strategies.

Developing sound strategy is both an art and a science, particularly in the field of resource management. It requires a degree of "intuition" and thorough analysis of the relevant factors and trends in the external environment. Until recently, few agencies have undertaken a systematic analysis of these trends and determined their impact on the business of resource management. The Wisconsin Department of

Natural Resources is an exception. This agency's *ad hoc* strategic Trend Analysis Group scans the external environment and provides senior management with a series of bulletins which discuss significant trends and forecast likely impacts on agency missions, policies, and programs over the next 10-15 years (Graf and Schenborn 1984, Wade 1984, Smoller and Schenborn 1984, Brick 1984, Visser 1985). These bulletins serve as a foundation for strategic plans being developed throughout the agency.

Strategic Trends

Megatrends (Naisbitt 1982). *The Third Wave* (Toffler 1980), *New Rules* (Yankelovich 1981), the U.S. Census Bureau, and other authorities have identified many demographic, social, economic, and political trends that will have an impact on resource management and environmental protection agencies. Those trends having the greatest impact include:

1. Dramatic shifts in the demographic composition of our constituencies.
2. Changes in social values and the relationship of society to the resources we manage for the society.
3. Movement toward a demassified society of narrowly defined and highly specialized resource users and nonusers, each demanding a "fairshare" of our limited natural resources.
4. A continued public demand for deregulation and down-sizing of government agencies and more direct public participation in decision making and program implementation.
5. Changes in the basic industrial and agricultural composition of the U. S. economy that will cause increased land and water use conflicts.
6. Widespread public demand for "quality" recreational experiences and a high quality contaminant-free natural environment (air, surface and groundwater, fish, and wildlife).

Demographic Changes

Throughout history, many of the greatest challenges institutions have faced have resulted from changes in the demographic composition of the societies they serve. Yet, natural resource agencies have paid little attention to the demographics of society's population. Nevertheless, the composition and distribution of people within a state does not have a profound impact on the mission, mandates, programs and policies of agencies. For example:

- The recreational habits and activities of people change as they age.
- Family composition and size affect recreational habits and revenues.
- A shift in population from urban to surburban and rural areas can result in a different appreciation for outdoor recreation (particularly hunting) and a different set of environmental values.
- Population migrations from the northeast and north central states imply decreased revenues for some states and increased revenues in sun-belt states.
- An increasing population of senior citizens who qualify for free or reduced-price licenses will decrease direct revenues.

Most agency mandates, policies, and programs were developed in response to yesterday's demographics, but tomorrow's demographic structure will be radically different. The baby boom of 1945-1965 gave us the family of four, urban sprawl, overcrowded schools in the 1960s, school closings in the 1980s, family camping, and the basic mandates and programs that characterize our agencies today. Many of these programs were built for a population structure like that of Wisconsin in 1970. This population was fast growing, with a median age of less than 27. By 1980, birth rates declined as a consequence of birth control and changes in lifestyle, and the median age rose to 29. These trends are continuing and the median age in Wisconsin will increase to 36.3 by the year 2000 and to 39 by 2010. Similar trends prevail in other north central and northeastern states. Overall population projections for the U. S. indicate that sun-belt states will face rapid population growth between now and the year 2000. (Table 1).

Startling as growth data may be for some regions, data for individual states (and counties) is more revealing. For example, although population growth in the north central states as a whole will be less than 1 percent, Wisconsin's population is projected to increase by about 18 percent over the next 15 years. The growth of older age cohorts is even more striking. By 2010, Wisconsin will experience a 34 percent increase in those over age 65, a 65 percent increase in those age 45-64, and a net decline in the population that is younger than age 44. Put in other terms, by the year 2010, over 55 percent of Wisconsin's voters will be age 45 or older and over 14 percent of our total population will be age 65+. These unprecedented shifts in age structure have profound implications for the types of recreational and resource management programs we will need to offer. Demographic information for other states is available from the U. S. Census Bureau and await analysis.

Table 1 implies that there is a substantial migration of population into sun-belt states. However, people are also migrating from urban areas to rural areas and small towns. Table 2 compares overall population growth with growth in small town and rural areas for each region. With the exception of southern states, migration out of urban areas is a national phenomenon and will result in increased development and recreational pressure on our resources. It also suggests decreased access for hunters and anglers as more rural property is divided into 5, 10, and 20-acre (2,4, and 8ha) parcels for homesites.

Social Changes and Social Values

Values dictate society's relationship to natural resources and toward the agencies to which it entrusts management of those resources. Values also determine the relationships between individuals or corporations which compete for their "fair

Table 1. Median age and population growth (1980-2010).

	Median Age			%Population Growth
Region	1980	2000	2010	(1980-2000)
National	30.0	36.3	39.9	+18%
North Central	29.0	35.9	39.5	+ 1%
Northeast	31.8	38.4	42.1	−16%
West	29.3	35.9	39.9	+45%
South	29.6	35.5	38.7	+31%

Adopted from Bureau of the Census 1983.

Table 2. Rural and small town growth (1970-1980) (U. S. Census Bureau Data).

Region	Overall growth	Rural/small town growth
North Central	+4.0%	+7.8%
Northeast	+0.2%	+12.4%
West	+23.9%	+31.8%
South	+20.0%	+17.1%

Adopted from Bureau of the Census 1983.

share''of the natural resources pie. Most natural resources agencies reflect the society and values of the 1960s and 1970s. That society and its values have changed and agency missions, policies, and programs must change to keep pace with the different set of values that society is now expressing.

There is a general societywide trend toward diversification of interests and personal commitment to causes that promote those interests (Hawken et al. 1982). Some social observers have termed this the "demassification" of society (Toffler 1980, Yankelovich 1981, Gallup and Proctor 1984, Smoller and Schenborn 1984).

Contemporary society offers much evidence for demassification. Since 1960 we have seen a dramatic increase in the number and diversity of groups interested in natural resources. Today, we no longer look for a single representative statewide sports organization. Instead we interact with a host of specialized organizations (Bass Masters, Muskies, Inc., Sturgeon for Tomorrow, the Ruffed Grouse Society, Pheasants Unlimited, Ducks Unlimited, Trout Unlimited, snowmobile groups, and cross-country ski clubs). Many of these groups are demanding specialized recreational opportunities that are tailored to their own interests (catch-and-release fishing, trophy angling, black powder only hunting seasons, "managed" hunts, etc.).

We also interact with innumerable environmental groups with perspectives as broad as global deforestation or as narrow as the local landfill. Similarly, the list of institutions and agencies with an interest in natural resources has also grown as we have come to realize the significance of transportation, industrial development, or agricultural policy on fish, wildlife, water, and the other natural resources that we manage.

Manufacturers have exploited the opportunity that diversification presents. They now offer outdoor recreators specialized products like custom bass boats, tackle boxes for plastic worm anglers, boats and motors designed specifically for striped bass fishing or trolling the Great Lakes for salmon, tree stands for bow hunters, and how-to video tapes for everything from cleaning deer to tying streamers. People who have specialized interests and make large investments in customized gear will demand that agencies provide more opportunities tailored to their interests.

There has also been a radical change in the political process. Traditional political classifications like right or left, liberal or conservative, Democrat or Republican, union or nonunion, resource user or nonuser have lost meaning in a society where more than 4,000 political action committees (PAC's) actively pursue separate causes on Capitol Hill. We have become a nation of people deeply committed to narrowly focused causes (Yankelovich 1981, Hawken et al. 1982). We can expect conflict wherever any strong interest group seeks special consideration for its share of our limited natural resources (Reidel 1980). Conflicts will not only erupt between interest groups competing for the same resources, but also between interest groups and the agencies responsible for managing those resources for the "common good" (Lancaster 1980). Mediating those conflicts presents new challenges for agencies.

The "baby boom" generation (those born between 1945 and 1965) has become the dominant social, political, and economic force in American society. Members of this generation now comprise more than 45 percent of the eligible voters in many states and their political preferences and demands for goverment services reflect their social values, recreational demands, and environmental concerns. They are the hippies and yippies that demonstrated for social justice in the 1960s and against the Vietnam War in the late 1960s and early 1970s. Commitment to causes and the will to challenge institutions and agency policies are a part of their history. Today they are older and called YUMPIES (young upwardly mobile professionals). They will continue to challenge government institutions and policies but will do so on the floors of our legislatures and in the courts (Smoller and Schenborn 1984).

Management authority Peter Drucker recently remarked that nobody believes government "delivers," at least at a reasonable cost. Gallup and Proctor (1984) and Hawken et al. (1982) suggest that Drucker's remark may be shared by a substantial segment of the public. The perceived failure of government to solve societal or environmental problems and the contant media barrage reminding us of "government waste, bureaucracy, and unresponsiveness" has eroded agency images and led the public to question agency expertise and competence. Consequently, agencies can expect more demands for "accountability" and must clearly prove the effectiveness of their programs to a skeptical public. Furthermore, the lessons of California's Proposition 13, the 58 referenda that were on state ballots in 1982, and the 100 + referenda on the ballots in 1984 are clear: the demand for genuine public participation in policy development, decision making, and program implementation has dramatically increased.

Land and Water Use Conflicts

Strategic fish and wildlife plans from at least six states recognize that current trends in land and water use pose major obstacles to the long-term "health" of fish and wildlife populations. American industry and agri-business are battling for survival within an economic structure that offers high interest rates and stresses short-term profits instead of environmental concern. For many businesses and farms, next quarter's profit or this season's crop is the difference between survival and bankruptcy. Yesterday's trade-off was between profits and environmental quality; tomorrow's choice, in many cases, is between unemployment and accepting longer pollution control compliance schedules.

Long-term investment in pollution controls or soil conservation measures has become a luxury that few farmers can afford. The U.S. Department of Agriculture estimated that in 1981, 61 percent of all farms accounted for less than 6.5 percent of all farm income, and the average income for that group was a negative figure. In some states, farm foreclosures have nearly ceased to be "newsworthy" because they have become commonplace. Under these conditions, some farmers have exchanged long-term conservation of their soil for more intensive cultivation and increassed soil erosion.

In 1977, the USDA estimated erosion from crop lands at 6.5 billion tons annually (U.S. General Accounting Office 1983) and the erosion problem is increasing. Since

1977, erosion in Wisconsin has increased at least 25 percent (Wisconsin Land Conservation Board 1984). Fence rows and shelter belts that once provided habitat for wildlife and buffered run-off into streams have been replaced by row crops and 160-acre (65-ha) center pivot irrigation systems. Conservation tillage can reduce erosion but requires nearly double the amount of herbicides and other pesticides. The trade-off in terms of fish and wildlife is one we need to carefully evaluate.

Recent legislation offering property tax incentives to riparians in Oregon and similar proposals in Idaho, Montana, and Colorado may provide agencies with new tools for improving habitat by influencing land use (American Fisheries Society 1984). National and state agriculture policy have a direct impact on fish and wildlife populations, and fish and wildlife agencies must recognize their critical "stake" and role in shaping that policy in the future.

Northeastern and north central states have been dubbed the "rust belt." Their basic industries gave the world mass-produced cars, tractors, and other goods. Today these industries are lapsing into obsolescence and are losing the battle against cheaper foreign imports and the "high tech" growth industries of the Sun-belt. Natural resources policy makers in these states face trade-offs between sacrificing some environmental values and adding to the unemployment lines.

The present controversy over the fate of the west branch of the Penobscot River in Maine is one example. The west branch offers the best white water canoeing east of the Rocky Mountains and has one of the largest populations of landlocked Atlantic salmon in the world. Unfortunately, it's located in an economically depressed area where 4,200 jobs and most of the economy depend on finding a source of cheap hydropower for the local paper industry.

Given a choice between jobs and preserving a stretch of wild stream, the society of the late 1980s and 1990s is likely to choose jobs. In cases like this, the challenge for natural resources agencies doesn't lie in opposing construction; rather, it is in finding viable alternatives that preserve both jobs and the natural environment.

Environmental Contamination

Pollution control is still an important issue. Public opinion polls conducted by CBS News and the New York Times in 1981 showed that 45 percent of those sampled agreed that "environmental protection is so important that requirements and standards cannot be too high [and that] continuing environmental improvements must be made, regardless of cost." The same survey was repeated in April of 1983, and 58 percent of those sampled agreed with the statement (*New York Times,* April 29, 1983). However, the overriding public concerns seem to have shifted from the ecological interests of the 1970s (preserving habitat and saving endangered species) to environmental health risks.

Articles about the potential health risks from pesticides, herbicides, nematocides, food additives and preservatives, chemical fertilizers, and industrial wastes receive almost daily media attention at both the national and local levels. At the international level, a recent United Nations' commission wrote "Few threats to the peace and survival of the human community are greater than those posed by the prospectus of cumulative and irreversible degradation of the biosphere on which human life depends" (Brandt 1980). Incidents as spectacular as the toxic waste problems at Love Canal and Times Beach, Missouri, or as elusive as acid rain lead the public to question the ability of our agencies to manage the natural environment and protect public health.

Consumption advisories for salmon on the Great Lakes, contamination of some municipal wells, and the recent catastrophe in Bohpal, India, are producing a widespread "chemo-phobia" in our society. The public will demand more than task force reports and research studies; they will demand rapid solutions to the problems. Unfortunately, acid rain, contaminated groundwater, and chemical residues in fish or game are complex problems where progress is slow and sometimes measured in parts per trillion.

Strategic Challenges

These Strategic Trends present natural resources agencies with four major challenges:

1. *Program Diversification.* Organized special interests reflect the broader society. Anglers, hunters, bird watchers, hikers, campers and other resources users who aren't members of organized groups are also seeking greater diversity and selection in outdoor recreation. Our programs must provide for the trophy angler, the dry-fly enthusiast, and the person who just wants fish for dinner. Agencies that limit their clientele to traditional users (e.g., anglers and hunters) and fail to offer anything for the nonconsumptive user will lose the opportunity to cultivate a new and powerful constituency. Worse still, those agencies will face threats as their programs, funding, and motives are challenged by nonhunting and nonangling publics. The concept of "quality" is becoming a hallmark in our society. "The quality goes in before the name goes on," "quality is job 1" and "best built, best backed" are just a few of the advertising and corporate slogans that reflect a national trend. Yet, quality outdoor recreation and quality hunting or angling are best defined by the individual. The challenge for agencies is to provide a broad spectrum of opportunities from which the individual or "specialized" group can select a personalized quality experience, and to prove that we have created that opportunity.
2. *Tailored Information and Education.* Demassification directly challenges our ability to educate and inform the public about agency motives, management efforts, and regulatory programs. General news releases, "generic" literature, and the traditional information conduits that we used in the past are not suited to a diversified society that expects information tailored to specific interests and delivered through customized information channels (club newsletters, low circulation publications, community opinions leaders, local and/or cable T.V., radio, video tapes, etc.). In an era where court and legislative challenges to agency action could become commonplace, effective information and education programs which use diverse information channels and develop customized approaches to packaging information will be essential to agency survival.
3. *Resolving Conflict and Effective Public Participation.* The society of the late 1980s and 1990s will be deeply committed to causes and equally committed to full participation in agency policy development and program implementation. Some interests will be mutually exclusive (e.g., animal rights activists and trappers). Other interests may conflict with agency mandates and missions (e.g., expansion of coal fired power plants versus tougher air quality standards, or wetlands

development versus wetland preservation). Successful agencies will be those that can mediate conflicts between interest groups.

Many of the resources problems we face are complex and require substantial and effective interaction with interested parties before agency action. For example, successfully allocating a limited fishery resource between sport, commercial, and Native American interests requires their direct participation in the allocation decision. In addition, public skepticism about agency expertise, motives, and "fairness" dictates increased public participation in all phases of agency action.

4. *Chemical Contamination of the Environment*. PCB's, dieldren, chlordane, and a plethora of other industrial wastes and agricultural biocides which accumulate in fish and game threaten to turn today's trophy into tomorrow's health problem. Toxic wastes in groundwater threaten domestic and municipal water supplies. Sulfur dioxide and nitrous oxide emissions from automobiles and fossil fuel power plants become acid precipitation that impact lakes, streams, and forests worldwide. Each of these problems is complex and requires long-term solutions for which an impatient and frightened public is not willing to wait. The challenge for agencies is two-fold. First, we must educate and inform the public about the trade-offs and long-term solutions that these problems require. Second, we must document our progress toward reducing contaminant levels and publicize the results for a public that is skeptical about our ability to solve complex problems at any cost.

Strategic Opportunities

The strategic trends discussed above can be viewed as threats. However, for those agencies that choose to "pro-actively manage," they are a catalog of potential opportunities waiting to be translated into plans and actions that are focused on keeping pace with a changing society. For example:

- An aging public is generally more law abiding, requires less direct regulation, and is more receptive toward voluntary compliance with harvest, gear, or season restrictions.
- A demassified public committed to narrow interests is willing to work for those interests. They tend to be highly informed abut their causes and are willing to support agency actions that benefit their interests. Support can include funding, volunteer labor, political support, direct lobbying, and access to organization newsletters and meetings.
- A demassified media provides agencies the opportunity to channel information directly to key groups. By tailoring our approaches to specific audiences, we can increase our effectiveness in educating and influencing the public.
- The representative democracy that has characterized our nation since 1776 is rapidly becoming a participatory democracy where government remains "of the people" and "by the people" but now works "with the people." Agencies should recognize this and develop effective public participation programs to evolve policy or resolve conflict between groups.
- The economic realities of the late 1980s and the 1990s could force environmental protection into a secondary role as the choice between strict compliance and jobs is resolved in favor of jobs. However, agencies willing to offer alternatives instead of inflexible policies and regulations will find their public respect and influence increasing at a time when most of government is suspect and forced to down-size and

deregulate. Viable alternatives already used by some states include tax incentives to influence land use by riparians, "buy-out" of commercial fishing rights, and encouraging development in some areas in order to preserve other, more environmentally sensitive, areas.

Over the last 50 years, we have come to realize that the collective impact of the public on America's natural resources far exceeds our ability to directly manage the resource. As a consequence, successful management during the next 50 years will depend on our ability to "indirectly" manage the resource by leading and influencing the public to act with us as stewards of the resource.

Resource management has evolved to where we have begun to realize that long-range thinking is vital to our continued success. Strategic planning can be a powerful management tool for insuring success provided that it is linked to an environmental scanning exercise that identifies the impact of social, political, and economic trends on the "business" of managing natural resources. By anticipating these broad changes and modifying our programs to meet their challenge, we can avoid the threats they pose and capitalize on the opportunities they present.

Literature Cited

American Fisheries Society. 1984. A weekly report of the executive committee from the office of the director. AFS Diary 10:#39. Oct. 5, 1984. p. 1.

Brandt, W. 1980. North-south; a program for survival. MIT Press, Cambridge, MA.

Brick, E. 1984. Information age trends. Wis. Dep. Natur. Resour., Madison.

Bureau of the Census. 1983. Provisional projections of population by states by age and sex, 1980 to 2000. P-25, No. 937 (GPO #003-001-91434-4). U.S.G.P.O. Washington, DC.

Gallup, G., and W. Proctor. 1984. Forecast 2000. Monrow & Co. New York.

Graf, R., and D. A. Schenborn. 1984. Demographic trends. Wis. Dep. Natur. Resour., Madison.

Gross, A. D. 1984. How Gulf Oil deals with uncertainty. Planning Review: March 1984, pp. 8-11.

Hawken, P., J. Ogilvy, and P. Schwartz. 1982. Seven tomorrows: toward a voluntary history. Bantam Books, New York.

Key, J. 1984. How retailers view customers of 2004. Chicago Tribune, 18 Nov. 1984.

Lancaster, R.A. 1980. Recreation trends—a future look "so what?: implications for the recreation profession". National Outdoor Symposium. Durham, NH., April 1980. pp. 203-205.

Naisbitt, J. 1982. Megatrends. Warner Books, Inc. New York.

Pearce, J. A., and R. B. Robinson, Jr. 1983. Environmental forecasting: key to strategic mangement. Business: July-Sept. 1983, pp. 3-12.

Reidel, C. H. 1980. Converging social trends—emerging outdoor recreation issues. National Outdoor Symposium. Durham, NH, April 1980. Pp. 9-14.

Smoller, J., and D. A. Schenborn. 1984. Trends in social and human values. Wis. Dep. Natur. Resour, Madison.

Steiner, G. A. 1979. Strategic planning: what every manager must know. The Free Press, New York.

Thomas, P. S. 1980. Environmental scanning: the state of the art. Long Range Planning 13: Feb. 1980, pp. 20-28.

Toffler, A. 1980. The third wave. W. Morrow, Inc., New York.

U.S. General Accounting Office. 1983. Agriculture's soil conservation programs miss full potential in the fight against soil erosion. U.S. General Accounting Office, Washington, DC.

Visser, K. 1985. Agricultural trends. Wis. Dep. Natur. Resour., Madison.

Wade, R. 1984. Economic trends. Wis. Dep. Natur. Resour., Madison.

Wisconsin Land Conservation Board. 1984. Soil erosion in Wisconsin. Wisc. Land Conserv. Board, Madison.

Yankelovich, D. 1981. New rules: searching for self fulfillment in a world turned upside down. Random House, Inc., New York.

Cumulative Effects Analysis: An Advance in Wildlife Planning and Management

Hal Salwasser
USDA Forest Service
Wildlife and Fisheries Staff
Fort Collins, Colorado 80524

Fred B. Samson
USDA Forest Service
Pacific Northwest Forest and Range Experiment Station
Olympia, Washington 98502

Introduction

A cumulative effects analysis is an assessment of how the combination of natural processes and events and man's activities cause resources and environmental conditions in an area to change over time (Figure 1). It is a major advance in wildlife planning and management. Among the reasons for doing a cumulative effects analysis are finding optimum decisions for resource management (including habitat improvements and mitigations) and communicating opportunities to interested publics and other professional resource managers.

Cumulative effects analysis is not comprehensive ecosystem modeling. Each analysis must have a specific focus. Complexity should be limited to major issues in a geographic area that encompasses those issues. And it is essential that analyses distinguish between natural effects and those induced by man's actions.

Recent technical advances in wildlife planning have made cumulative effects analysis feasible. In this paper we discuss some concerns for practicality in cumulative effects analysis, and show how advances in wildlife planning are useful. This is not a thorough treatment of the topic. Biologists are just beginning to discover the utility of cumulative effects analysis, and new technologies and concepts are rapidly evolving.

A Framework for Cumulative Effects Analysis

The concept of cumulative effects is simple. Effects are outcomes, consequences, or results; things that are produced more or less directly. They can be beneficial, adverse, or neutral in relation to specific goals. Cumulative means that the effects result from accumulation or the addition of successive parts or elements. We often talk about things in nature as being connected to everything else. It is, therefore, reasonable to assume that the production of species and diversity (the effects) will result from the accumulation of natural processes and events, our treatments to lands and waters, and the mix of human activities that occur on an area.

For example, the flow of elk, or wood, or water from a forested area can, at the simplest, be considered to be the cumulative effect of natural forest growth, the kinds and locations of treatments applied to vegetation, and the way people use the network of roads and trails in the area (Thomas 1979, Lyon 1983). Of course there are other factors that affect the elk, wood, or water, just as there are probably other resources that are important to people. The effects are always due to many different factors and

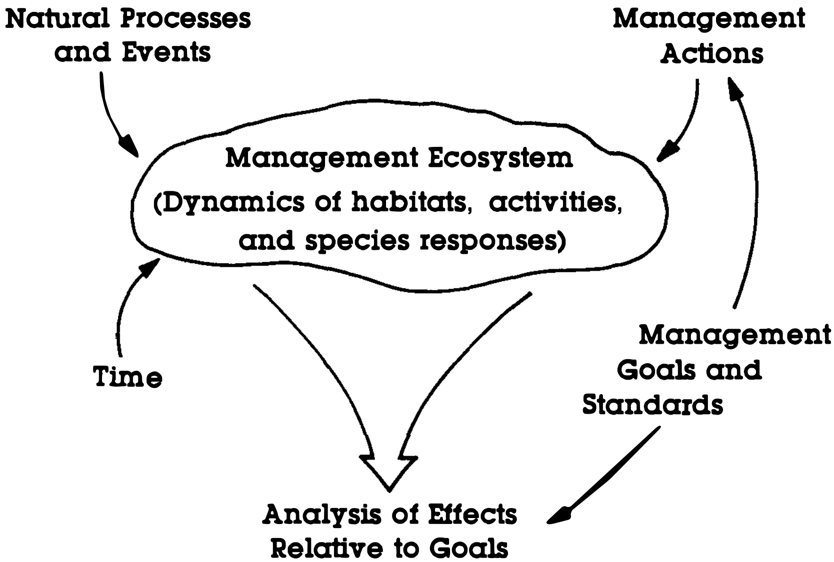


Figure 1. Important components of cumulative effect analysis.

those factors change over space and time. For pragmatic reasons, however, we can only look at major causes and effects.

Managers have been analyzing and predicting effects for years, though rarely have their efforts been called cumulative effects analysis. So what's new? For one, managers now try to evaluate more than one effect from the same land area, e.g., timber volume *plus* number of elk, water yield, recreational visitor days, and pounds of forage available. Second, they try to assess changes in the multiple-effects that are caused by a varied mix of factors, e.g., acres clearcut, miles of road built and kept open, number of backpacking parties per day, and likelihood of insect outbreaks. And third, managers are now concerned about how the mix of natural processes and management practices causes changes over time in the flow of effects. That can take a lot of pencil pushing.

The only way to consider the complexity inherent in cumulative effects analysis is to use computer models. Computers and models help organize data and assumptions and keep track of all the things we want to consider but don't have the finger power to do. But they can handle so much detail that an analysis can easily get out of hand. Consideration of the purpose and focus of an analysis helps keep it practical and feasible (Table 1).

Purposes for Cumulative Effects Analysis

A primary purpose of any planning analysis is to determine how best to maximize the attainment of goals while minimizing unwanted consequences of possible actions. When goals are simple, e.g., hunter success rate, and limited in time, e.g., next season, a cumulative effects analysis would be analytical overkill. As goals get more complex, e.g., deer harvest, instream flow, wood fiber, eagle recovery, etc., and the time horizon extends beyond the next few years, a cumulative effects analysis is essential.

Another purpose for analysis is to aid in adapting management to changing conditions. It is rarely possible to determine solely through analysis the most prudent course of management to meet goals. Actions must be taken, responses monitored, and plans adjusted. The entire course of management is adaptive (Holling 1978). Adaptive management requires periodic assessments of the status and trends of the managed system, along with revised projections of the potential results of changes in actions. A cumulative effects analysis can serve adaptive management as an ongoing assessment and prediction tool. It provides a place for new data and knowledge to become immediately useful to managers.

A third purpose for analysis is to aid in communication and understanding. Today, individuals usually do not make unilateral resource management decisions. Public involvement ensures that the different needs and concerns of diverse interest groups are considered. Cumulative effects analysis can help managers communicate with publics and allow all parties to better understand the array of things that are likely to happen under different courses of management. Alan Christensen, an innovator of cumulative effects analysis for grizzly bear habitat management, stresses three uses in communication (Christensen pers. comm.): testing the appropriateness of scheduling activities; identifying options, the "what if" use of models; and helping people take a look at possible futures.

Focusing a Cumulative Effects Analysis

We suggest three criteria to help focus a cumulative effects analysis: (1) limit complexity to major causes and effects, (2) address a sufficient geographic area so as to encompass the major factors that cause variation in the effects, and (3) distinguish causes and effects that result from natural processes and events from those that man induces through management actions.

Complexity can be limited by clearly stating the issues to be resolved by decisions. Wildlife resources are inherently complex; there are many different species. And wildlife goals can be ambiguous, e.g., maintain diversity. Therefore, wildlife issues must be stated in terms of specific species, e.g., management indicator species, and specific concerns about them, e.g., full species richness and production of selected species for recreational uses.

Table 1. Concerns for keeping cumulative effects analyses practical and useful.

Purposes	Criteria
Optimize decisions	Focus on goals and management actions
Support adaptive management	Periodically revise with new data and knowledge from monitoring and research
Aid communication and understanding	Limit complexity to major effects and their causes
	Address a geographic area that is meaningful to goals and ecosystem processes
	Distinguish inherent from induced effects

Another control on complexity is the reliability expected in an analysis. Higher reliability usually means higher costs in conducting an analysis. Common sense dictates that the cost of doing an analysis be commensurate with the expected benefits or the risk of failing to meet standards or goals.

The second criterion for focusing an analysis is geographic. An analysis should not go beyond the geographic area that is relevant to the decision. On the other hand, the area must be continuous and large enough to adequately assess effects. Define the area for analysis to correspond to the operational boundary of the management ecosystem. There are some obvious considerations for wildlife in doing this. Foremost is that the area encompass the home range, at least on a seasonal basis (e.g., winter range), of the widest ranging management indicator species, or the area of major human activities that will affect wildlife (Christensen and Madel 1982).

Watersheds of 1,000 to 10,000 acres (400 to 4,000 ha) encompass many species' home range needs. They are usually mapped. Often inventories are catalogued by them. And other specialists consider them to be significant to their resources as well. Watersheds or aggregations of watersheds are good geographic areas for cumulative effects analysis. For large species, or animals with low densities and large home ranges, e.g., grizzly bears, eagles, and cougars, the geographic area may need to be larger than just a few watersheds.

A third important criterion is to design the analysis to differentiate natural from man-caused effects. The difference between the effects of minimal, or custodial management and those that result when actions are taken are the man-induced effects. Usually "before and after" type simulations will be needed to distinguish induced effects.

Even a well-focused analysis will be sufficiently complex that computer models will be used. But bigger and better models alone won't solve all problems. We need to bring different kinds of models and methods together to serve different roles in cumulative effects analyses. In this light, let's examine some recent advances in wildlife planning.

Some Recent Advances in Wildlife Planning

There have been many recent technical and conceptual developments in wildlife planning. At least five are important to cumulative effects analysis: (1) specifying resource goals, (2) understanding the effects of habitat fragmentation on wildlife, (3) understanding the role of functional diversity in ecosystem productivity, (4) technologies for assessing temporal and spatial dynamics of ecosystems, and (5) empirical verification of assumptions about species-habitat relationships. While there are other important advances, this set illustrates the point that these advances should be seen as complementary in assessing cumulative effects; they serve in different but necessary ways (Table 2).

Specification of Wildlife Goals

Taking the ambiguity out of wildlife goals is essential to focus analyses. Specification of goals has advanced in three general areas: (1) strategic population planning in the states (Crowe 1983), (2) threatened or endangered species recovery planning through state-federal cooperation, and (3) planning habitats to meet population goals (Urich and Graham 1983, Nelson and Salwasser 1982). Improved inventories, use of

Table 2. Some steps in cumulative effects analysis and how advances in wildlife planning can improve them

Steps	Advances
Stating management goals and standards	Ability to translate population goals for recreational uses, viability, and recovery in terms of habitat kinds, amounts, and patterns
Representing major habitat factors	Models that represent species-area relationships and species-habitat relationships, e.g., species-area curves, HSI, and PATREC
Projecting changes in habitats	Role of functional diversity in stand dynamics; successional rates and pathways in relation to site differences and treatments, and temporal and spatial modeling technologies, e.g., simulation and GIS
Estimating wildlife effects	Empirical verification of species-area and species-habitat relationships models, population to recrational use coefficients, and effects of human activities on populations

population and habitat simulation models, and better measures of demand and user satisfaction have improved the reliability of goals for game species in many states.

The ability to specify habitat goals for maintaining viable populations of rare and sensitive species is an aspect of wildlife planning that has advanced greatly in the past 5 years. We now have practical and defensible methodologies (Salwasser et al. 1984) and a rapidly growing theoretical foundation for this kind of planning (Soulé 1980, Shaffer 1981, Schonewald-Cox et al. 1983, Samson 1984). Analytical models are evolving to address the specific roles of demographics, stochastic events in nature, systematic processes (such as succession), biogeography, and genetics as they affect population viability. This is a dynamic area of technology that will see significant advances in the next five years.

Effects of Habitat Fragmentation

Knowledge of the effects of habitat fragmentation on wildlife has two roles in cumulative effects analysis: (1) determining the wildlife consequences on each patch of habitat based on its size, shape, and location (alpha diversity and species-area concerns), and (2) determining the consequences across a landscape of progressive fragmentation (beta diversity concerns) (Samson and Knopf 1982). Principles and an empirical knowledge of biogeography as it affects wildlife goals are now generally understood and used in habitat planning (Thomas 1979, Samson 1980, Harris 1984). Major advances are occurring in the technologies of handling spatial relationships, e.g., geographic information systems. Improved knowledge of the effects of fragmentation at the landscape level is needed because few if any wildlife goals depend on the dynamics of a single patch of habitat.

The Role of Functional Diversity

Much has been accomplished recently in understanding the role of structural diversity in wildlife habitats (Thomas 1979, Short 1982). For example, the presence of large standing dead trees (snags) and large fallen trees makes a forested stand suitable habitat for 30 to 70 different vertebrates depending on what part of the country you are in (Thomas 1979, Davis et al. 1983, Raphael and White 1984). We are now gaining an understanding of the role of functional diversity as well. Maser and Trappe (1983) suggested that the slow decay rates and interaction between fungi and small rodents in large fallen trees are important determinants of future forest productivity and successional rates and pathways on a site. The ability to predict stand dynamics and therefore the cumulative effects of changes in the pattern of habitats in the fabric of a watershed will be enhanced by a better understanding of the roles of functional diversity.

Projecting Time and Space Dynamics

It is one thing to have theoretical and conceptual models of how ecosystems function and change. It is quite another to have practical models of those dynamics for resource managers to routinely use to gain insight into the effects of their actions. Much of the progress to date has been in developing "time-static" models of species-habitat relationships (Thomas et al. 1976, Nelson and Salwasser 1982, Schamberger and Krohn 1982). The future, in these models, is projected by guessing at what things would be like in x years if certain actions are taken (Sheppard et al. 1982).

We are beginning to see practical models for systematically projecting changes over space and time. Prototypes of time dynamics models, though not labeled as cumulative effects models, included linear programs (Mealey et al. 1982) and simulation models (Boyce 1980, Whelan et al. 1979). R. Holthausen of the U.S. Forest Service (pers. comm.) is now training biologists in many parts of the country to use and adapt an interactive, multi-stand habitat simulation model that has wildlife habitat capability functions imbedded into the program. The model is useful in watershed level cumulative effects analysis as part of implementing forest plans.

Another kind of modeling technology that supports cumulative effects analysis is automated mapping, often known as geographic information systems or GIS. Lancia et al. (1982) introduced an application of GIS to habitat model testing. Recently, a cumulative effects model for grizzly bears (Christensen and Madel 1982) has been developed into a GIS for rapid assessment of management proposals (D. Winn, pers. comm.). The eventual linkage of time dynamics habitat models with automated maps and data files will greatly increase the resolution and specificity of future cumulative effects analyses.

Empirical Verification of Models

A final area of recent advance is the empirical verification of various models and their assumptions. Progress has been made on verifying time static models of species-habitat relationships (Cole and Smith 1983). Some models appear to reflect reality well, others have shortcomings that will be difficult to overcome because nature is variable and unpredictable. We now know how to verify species-habitat relationships models and the limitations of empirical studies in doing so. Further advances will require commitments by managers to support verification research and by scientists to recognize the value of this applied branch of wildlife science.

Conclusions

We have reviewed in this paper the concept of cumulative effects analysis, the importance of focusing analyses on specific goals, and some recent advances in wildlife planning in light of their roles in cumulative effects analysis. Our purpose was to provide a foundation from which to make five points.

First, planning for wildlife habitat management should evolve toward cumulative effects evaluations. The evaluations should include major wildlife issues, the major factors affecting those issues, and the time and space dynamics of the ecosystem in question.

Second, managers should work with scientists to control the complexity of cumulative effects analysis, yet ensure that enough detail is included to yield understanding. Scoping the analysis and developing the models require give and take. Assumptions and sources of information must be documented in a way that is accessible to all interested parties. The technology must not leave people in a fog.

Third, what might appear to be unconnected advances in wildlife planning are likely to be key elements of a cumulative effects analysis. In fact, cumulative effects analysis can provide a framework for organizing these and other advances and, one would hope, result is a more rapid application of new findings and models.

Fourth, the role of research in resource management is more important than ever. Cumulative effects analysis is being done because we can no longer afford the waste of not getting optimum flows of benefits at minimum negative impacts. We need to know more about the production functions of ecosystems and their dynamics over time and space. But the number of models and assumptions that must be used to analyze management proposals is probably several orders of magnitude greater than our capacity to resolve them all through traditional approaches to research. We must prioritize needs and join forces in interdisciplinary, long-term applied research projects on the most important unknowns.

Fifth, increasing pressures on managers to manage and scientists to publish for other scientists have created a void and the need for specific linkages between research and application (Callaham 1984). The linkage is technology development. Cumulative effects analysis and and its models are not pure science nor pure management. They require different kinds of skills than either and different kinds of people, organizational structures, and reward systems.

Current resource issues are sufficiently complex and controversial that we are not likely to make great progress in efficiency until practical cumulative effects analyses become routine parts of adaptive resource management.

Acknowledgements

We thank R. Holthausen and A. Christensen for review of the manuscript.

Literature Cited

Boyce, S. G. 1980. Management of forests for optimal benefits (Dynast-OB). USDA For. Serv. Pap. SE-204. Southeastern For. Exp. Sta., Asheville, NC. 92 pp.

Callaham, R. Z. 1984. Managing for applications, not just for research and development. J. For. 82(4):224-227.

Christensen, A. G., and M. J. Madel. 1982. Cumulative effects analysis process for grizzly bear habitat, Cabinet Mountains, Montana.Tech. Pub. No. 14:124-132. Thorne Ecological Institute, Boulder, CO.

Cole, C. A., and R. L. Smith. 1983. Habitat suitability indices for monitoring wildlife populations—an evaluation. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:367-375.

Crowe, D. M. 1983. Comprehensive planning for wildlife resources. Wyo. Game and Fish Dep. Cheyenne. 43 pp.

Davis, J. W., G. A. Goodwin, and R. A. Ockenfels, tech. coords. 1983. Snag habitat management: proceedings of the symposium. USDA For. Serv. Gen. Tech. Rep. RM-99. Rocky Mtn. For. and Range Exp. Sta. Fort Collins, CO. 226 pp.

Harris, L. D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. Univ. Chicago Press, Chicago, IL. 211 pp.

Holling, C. S. ed. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York. 377 pp.

Lancia, R. A., S. D. Miller, D. A. Adams, and D. W. Haxel. 1982. Validating habitat quality assessment: an example. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:96-110.

Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. J. For. 81(9):592-598.

Maser, C., and J. M. Trappe. 1984. The fallen tree—a source of diversity. *In* New Forests for a Changing World. Proc. Soc. of Amer. For. Nat. Conf. Soc. Amer. Foresters, Bethesda, MD.

Mealey, S. P., J. Lipscomb, and K. N. Johnson. 1982. Solving the dispersion problem in forest planning. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:142-153.

Nelson, R. D., and H. Salwasser. 1982. The Forest Service wildlife and fish habitat relationships program. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:174-183.

Raphael, M. G., and M. White. 1984. Use of snags by cavity-nesting birds in the Sierra Nevada. Wildl. Monogr. No. 86. The Wildlife Society, Bethesda, MD. 66 pp.

Salwasser, H., S. P. Mealey, and K. Johnson. 1984. Wildlife population viability—question of risk. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:421-439.

Samson, F. B. 1980. Island biogeography and the conservation of nongame birds. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:245-251.

Samson, F. B., and F. L. Knopf. 1982. In search of a diversity ethic for wildlife management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:421-431.

Schamberger, M., and W. B. Krohn. 1982. Status of the habitat evaluation procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:154-164.

Schonewald-Cox, C. M., S. M. Chambers, B. MacBryde, and W. L. Thomas. 1983. Genetics and conservation—a reference for managing wild animal and plant populations. The Benjamin/Cummings Publ. Co., Inc., Menlo Park, CA. 722 pp.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. Bioscience 31:131-134.

Sheppard, J. L., D. L. Wills, and J. L. Simonson. 1982. Project applications of the Forest Service Rocky Mountain Region wildlife and fish habitat relationships system. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:128-141.

Short, H. L. 1982. Development and use of a habitat gradient model to evaluate wildlife habitat. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:57-72.

Soule, M. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-169 *in* M. E. Soule and B. A. Wilcox. eds. Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, MA.

Thomas, J. W., ed. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handbook No. 553. U.S. Dep. of Agric., Washington, D.C. 512 pp.

Thomas, J. W., R. J. Miller, J. E. Rodiek, and C. Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:452-476.

Urich, D. L., and J. P. Graham. 1983. Applying habitat evaluation procedures (HEP) to wildlife area planning in Missouri. Wildl. Soc. Bull. 11(3):215-222.

Whelan, J. B., A. R. Tipton, J. F. Williamson, P. R. Johansen, J. P. McClure, and N. D. Cost. 1979. A comparison of three systems for evaluating forest wildlife habitat. Trans. N. Amer. and Natur. Resour. Conf. 44:390-403.

The Role of State Fish and Wildlife Agencies in Federal Land Management Planning

William C. Unkel[1]
California Fish and Game Commission
1416 Ninth Street
Sacramento, California 95814

Opportunities for state fish and wildlife agencies to influence federal land management have greatly expanded in recent years. Federal law presently requires environmental review by states of water development, timber harvesting, mining, land reclamation, and many other activities which occur on federal land. More importantly, the states are now being asked to participate in basic policy-making by joining with federal agencies in the preparation of land and resource management plans.

The states' interests in these cooperative ventures are usually considerable. Substantial wildlife habitat presently exists on lands controlled by the federal government. Yet state participation is not always vigorously pursued nor is it as effective as it could be. State fish and wildlife departments are called upon to dedicate their time and expertise to these federal efforts, frequently at the expense of other, seemingly more pressing tasks. State agency participants are not always convinced that the benefits of cooperation exceed the costs.

The present effort to develop land and resource management plans for each of the country's national forests is a particularly topical example of potential federal and state cooperative planning. The National Forest Management Act of 1976 (hereafter NFMA) which requires such planning, and the Act's implementing regulations rely heavily on state agency officials to represent the public and its interests. From the states' perspective, whether the public interest in wildlife and fish are adequately conveyed will be greatly influenced by, first, the degree to which state agencies can be convinced that their efforts are necessary, and second, the extent to which the agencies can effectively utilize those opportunities to influence the various forest plans.

This paper addresses these two issues. Initially discussed are the reasons why land use planning, particularly national forest land management planning, is directly relevant to the missions of many state fish and wildlife agencies. The second subject considered is how state fish and wildlife agencies can maximize their effectiveness in national forest planning. Actual experiences of state and Forest Service participants in forest planning are examined and their opinions are analyzed to determine what has led either to success or failure in this cooperative effort.

Why Should State Fish and Wildlife Agencies Become Involved in Forest Planning?

The most fundamental argument in favor of state agency participation in forest planning is that it affords many states an opportunity to influence directly decisions

[1]Present address: Natural Heritage Section, California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814.

which can have an impact on their own wildlife management objectives. This opportunity has not existed in the past. It can be best understood by tracing the development of federal policy concerning state and Forest Service cooperation in wildlife management.

Extensive wildlife management on forest lands is a relatively recent phenomenon. Historically, game species were protected from overhunting and overfishing by state laws, with occasional efforts by the states to preserve habitat. Yet, little effort was made to combine Forest Service and state agency resources to improve national forest wildlife populations or habitat (Robinson 1975). This inaction was not due to any legal impediment since as early as the 1930s federal laws permitted the Forest Service to enter into cooperative wildlife management and planning agreements with the states. For example, while national forest administrators were authorized to jointly develop plans with state officials to restore wildlife habitat while managing and harvesting timber, very few national forests participated (Trefethen 1975). The Sustained Yield Forest Management Act of 1944 authorized the Forest Service to form cooperative sustained yield units among state, private and federal lands for the "preservation of wildlife," among other purposes (Alston 1972), but there is little evidence that this authority was used for the betterment of wildlife.

This lack of meaningful cooperation in wildlife and fish management persisted for many years, probably due to a number of factors. Forest Service emphasis on wildlife management was lacking. Wildlife production has historically been considered more of a by-product of timber production than an end in itself (Committee on Agricultural Land Use and Wildlife Resources 1970). The states, on the other hand, were often preoccupied with the protection of their "turf." This cautious attitude most likely stemmed from the enduring legal debate over state versus federal jurisdictional supremacy concerning resident wildlife. That debate resulted in an informal and volatile compromise in which states retained the authority to regulate hunting, fishing, trapping, and other actions directly affecting wildlife populations while the Forest Service and other federal land management agencies managed the habitat.

Historical accounts provide many examples of the fragility of that compromise and why the states continued to view federal agencies such as the Forest Service as a competitor rather than a partner in wildlife management. Many of the celebrated controversies involving wildlife, especially in the western United States where the federal presence is greatest, revolved around this issue. For example, in the 1920s when the Kaibab National Forest in Arizona became overpopulated with deer, the resolution of the problem became hopelessly mired on the question of whether the state or the Forest Service had the ultimate authority to regulate deer hunting (Trefethen 1975).

The federalism issue has simmered for many years. It came to a head most recently when a number of federal laws were enacted directly challenging the states' exclusive control of wildlife population regulation. The Endangered Species Acts of 1966, 1969, and 1973, the Wild Horses and Burros Act of 1971, and others are examples of what one observer termed " a dramatic and controversial departure from the traditional federal role in wildlife conservation" (Robinson 1975). In 1976, the United States Supreme Court settled the basic question regarding the constitutional authority of the Forest Service to protect the national forest resources. *Kleppe* v. *New Mexico* made it clear that Forest Service authority was paramount even to the extent that the means taken contravened state regulatory power over wildlife.

Despite this expansion of Forest Service authority over resident wildlife and fish, federal laws have continued to recognize the states' primary role in wildlife conservation. These laws provide formal mechanisms for state and federal agency coordination and cooperation. In many instances federal statutes enable the states to retain management jurisdiction by entering into cooperative agreements with federal agencies. As part of such agreements, the state would prepare plans and programs for the management of the particular species in question. Such is the case for endangered species, marine mammals, and wild horses and burros.

The Forest Service has generally avoided asserting its potential authority over fish and wildlife and has viewed management as a shared responsibility. Consequently, while the states' rights issue continues to flare up sporadically, the policies and actions of the Forest Service have been to provide advice to the state agencies in matters pertaining to wildlife and fish and to engage in habitat management planning (Robinson 1975).

The National Forest Management Act (NFMA) cooperative planning effort may be viewed as an extension of that policy. However, this planning is comprehensive and far-reaching rather than merely encompassing discrete habitat projects. Plans are intended to be decision documents (Cortner and Schweitzer 1981). They will guide future budgets and will dictate the levels and character of forest resources, including wildlife, over the prescribed 10-year planning cycle. Although the first generation of forest plans are scheduled for completion in the fall of 1985, the forest planning process is an ongoing, iterative activity in which plans are adopted and periodically revised. Thus, state agencies will need to know how to be effectively and continuously involved in the planning process.

Two major aspects of the planning process should concern state wildlife and fish agencies. First, Section 219.19 of the NFMA regulations requires the plans to establish means to maintain viable populations of all native vertebrate species in each national forest. State objectives for different species, especially species of particular commercial, ecological, or recreational value, need to be integrated into the calculations of viable population size. The second aspect of the planning process which state agencies should find compelling is the manner in which the Forest Service emphasizes the management of certain species. Planning alternatives can legally result in any size population of a species above that required for viability so long as other multiple-use objectives are satisfied and the plan results in an equitable share of wildlife and fish production to help meet national and regional needs (Hoekstra et al. 1981). For the state agencies to achieve their hunting, fishing, and even aesthetic objectives, it may be necessary to consider, and ensure selection of, alternatives that produce the desired surpluses.

These forest planning decisions are not value-neutral; they often involve tradeoffs in which the production of other resources are balanced against wildlife. Congress recognized in the NFMA that state agencies have an important stake in the outcome. Thus, the NFMA attempts to substitute active, and hopefully meaningful, cooperative planning for the time-honored Forest Service tradition of attempting to base management decisions exclusively on technical, professional judgement. Planning decisions are fundamentally political and will affect wildlife regardless of who does or does not participate. But in the final analysis the state agency will be held accountable by the public for successes or failures to produce and protect wildlife. It is the state agency that will remain primarily responsible for wildlife conservation.

Moreover, the future management of the forests will have an increasingly significant impact on the ability of many states to service specific demands for wildlife resources. In some regions of the country the contribution of the national forests in this regard is enormous. For example, studies conducted by the Forest Service have demonstrated that the nationwide demand for recreational uses of wildlife, especially freshwater fishing, will increase substantially during this decade (Schweitzer et al. 1980). These studies also reveal that in the West, where most national forest lands are located, two-thirds or more of the eight big game species taken by hunters during the mid-1970s were taken on federal lands, many of which were national forests. Most anadromous fishery resources in the West are produced from forested watersheds (Everest and Meehan 1981) and much of the important spawning and rearing habitat occurs in the national forests. Habitat for 38 of the 87 federally-listed threatened or endangered wildlife species found west of the Mississippi occurs on national forests or public domain lands. The majority of habitat for at least five threatened and endangered species is found in eastern national forests (Hoekstra et al. 1981).

The last argument in favor of state participation in forest planning is that it preserves the states' future option to pursue administrative and legal remedies. As a practical matter, the Forest Service is more apt to consider favorably the state's concerns if state objectives are made known during the development of the plan. And in the event that state objectives are not satisfied initially, formal appeals may be filed to higher administrative levels and ultimately to the courts. The likelihood that such appeals would prove successful is much greater if, and may be barred unless, a good faith effort was made to participate and that administrative remedies were exhausted.

Present Coordination Efforts

Recently many states have attempted to take advantage of the opportunities afforded by the NFMA planning process. In fact, most states with national forests have become involved to one degree or another. The results appear to be mixed. Some fish and wildlife agencies are remarkably pleased with the impact of their participation, at least up to this point, while other feel quite the opposite.

In preparation for this paper, I attempted to determine if patterns could be detected in the relationship between the ways that state agencies interact with the Forest Service and their satisfaction with the results of that interaction. To do so, the opinions of individuals actively engaged in forest planning were sampled. Thirty two of these individuals were contacted by telephone and then mailed questionnaires. Questionnaires were sent to an approximately equal number of state fish and wildlife department and Forest Service participants. States and national forests were chosen which were reputed to have had differing experiences and represented different geographic regions of the country. No attempt was made to obtain statistically valid results since the sample was relatively small and I was interested only in the general impressions that these individuals could provide. Many of the questions were designed to be open ended so that the results would not be restricted to any preconception of the most relevant factors. I also tried to ensure candor by guaranteeing anonymity to all the respondents.

Based upon the 29 returned questionnaires, the results of the survey were organized into two groups: characteristics of the coordination process as a whole which respondents felt affected the success of the cooperative experience, and characteristics of the individual participants which affected success. A successful experience was assumed to be one where the respondent indicated that agency participation had been effective and that concerns had been fairly and adequately addressed. Judged by these criteria, 19 reported success and 10 failure.

The first group of results, relating to the coordination process, yielded four conclusions. First, successful cooperation appeared to be virtually impossible without a strong commitment from the policy-making level of both the state agencies and the Forest Service. For the state agency, that commitment usually entailed a willingness to dedicate a large amount of personnel time and energy. Over half of the respondents who believed the state effort was successful specifically reported that their agency representatives had invested a significant portion of their time to forest planning. Frequently, individuals were assigned to work at the Forest Service Region, Forest and sometimes even at the District levels. While most state agencies would assign a biologist to forest planning on a part-time basis, in a few instances an Intergovernmental Personnel Assignment (IGPA) was made to allow a designated state representative to work exclusively on forest planning. Often, state agency planning coordinators represented the state, but shared their time with a number of other planning assignments. Where the assignment of individuals to plan coordination appeared most haphazard, satisfaction frequently registered the lowest.

Equally or more important was Forest Service commitment and a willingness to represent its positions consistently, openly, and honestly. If there was a suspicion by the state agency or its representatives that the hidden agenda was, for example, to increase timber harvest or land dedicated to timber harvest regardless of state agency concerns, cooperation suffered greatly. It was reported by nearly half of the dissatisfied participants that regardless of what wildlife concerns were expressed during the process, commodity production would be favored. It appeared that one way to guarantee at least the threat of a lawsuit was to give the state the impression that its views would be taken seriously and then to ignore them.

The second factor which appeared to influence the success of coordination was the timing of the states' interactions. Over two-thirds of all respondents felt that state participation was most effective when states became involved very early in the process and continued on throughout each of the steps dictated by the planning process. Critical planning steps were reported to include discussion involving the basic assumptions and issues to be considered in the plan, the formulation of the plan alternatives, and selection of the preferred alternative.

The third factor that respondents believed was important in facilitating state agency effectiveness was the Forest Service administrative level with which state agencies chose to deal. Over four-fifths of the respondents rated the forest supervisors, the forest planning officers, and other forest staff as the most influential contacts since, as expected, state effort was usually focused at the national forest level. Nearly three-fifths of the respondents considered the district rangers and their staffs as the next most influential while regional foresters and their staffs were reported to be the least important by the same proportion.

The nature of the state fish and wildlife objectives was the fourth factor considered. Some of the strongest opinions were expressed on this subject. The vast majority of respondents felt it was important or critical that the state present specific rationally derived objectives. One Forest Service respondent indicated that the state's objectives were consistently rejected because they were illogical, not based on data, and focused on short-term issues and minute details inconsistent with the types of issues considered in the plan. This point was further amplified by the remark that "I'm not sure that the state ever had any clear expectations for their involvement in planning and I think that this has been a problem."

It was also reported that the objectives must represent the unified position of the agency. State participants were often not taken seriously when their local, regional, and headquarters officials disagreed on agency priorities and requirements.

Some of the respondents further suggested that it was useful to have the political support of other governmental agencies and private groups. However most often this was not considered to be particularly important.

The second group of factors which respondents commented upon pertained to the characteristics of the individuals who participated in the process. Despite my original expectation that effective state participation depended upon the familiarity of participants with the complex NFMA planning process and the technical aspects of planning methodology, few felt that this was critical. Persons who became familiar with the state's positions, and had the ability and authority to represent them, were thought to be essential. Most respondents believed that persons with technical knowledge of the wildlife resource and wildlife resource management were so qualified.

The personal attitude of participants was also ranked high on the list of concerns. Most respondents indicated that success or failure depended greatly on the personalities of the state agency representatives. Individuals who were flexible in their negotiations and appeared cooperative and nonconfrontational were reported to have fared most favorably.

Finally, respondents commented upon the actual interchanges between state agency representatives and Forest Service planners. More than two-thirds of the respondents indicated that frequent interactions were vital in facilitating state agency effectiveness. Some reported that as many as 200 scheduled meetings were held since they first became involved in the consideration of a plan, although between 20 and 50 were most commonly cited. Even more important, the timeliness of these interactions and communications played a critical role in ensuring state agency success.

Conclusions

Forest planning presents an opportunity for state agencies to make considerable gains for fish and wildlife at relatively little cost. While some may argue that state involvement in federal land management planning can be politically risky (c. f. Cowart et al. 1985) this is probably less true for individual special interest agencies such as a fish and wildlife department than for an entire state administration charged with serving a variety of competing concerns.

While cooperative planning may not be politically risky, it is decidedly political. Technical expertise in wildlife management, models, and biological principles may be needed to rationally support and assess the impacts of planning decisions. But a willingness by the state to accept the political nature of its role in the planning process and utilize political skills may prove to be needed the most. This point did not appear to be commonly understood or accepted by many of the participants who responded to the questionnaire. For example, there was no indication by the respondents that state agencies made an effort to communicate with private wildlife-oriented organizations. As one individual observed, state agencies frequently are unaware of what the public wants and neglect to enlist the aid of constituent groups when political confrontations arise.

Further, to maximize the opportunities afforded by forest planning, state agencies should enter into plan negotiations with a clear unified idea of their objectives and a realistic expectation of what they may be capable of attaining. A rational objective is one that is neither too mundane nor too radical. It should be noted that, despite the stated intention of lawmakers that forest planning be a comprehensive, long-term discussion of resource allocation and tradeoffs, institutional characteristics inherent in the Forest Service organization inhibits its policymakers from making planning decisions that diverge far from the status quo (Cortner and Schweitzer 1981). Consequently, while there are significant gains to be made and perhaps more importantly, significant losses to be suffered by state wildlife and fish resources as a result of forest plan implementation, state agencies must shape their demands to the realistic possibilities available to them. This will require the state agencies to select the issues they pursue carefully, establish priorities, judiciously choose their representatives, settle intra-agency conflicts over objectives and priorities, and marshal the support of their constituents. The agencies may also be well advised to approach philosophically the NFMA planning process as an opportunity rather than as a threat. Although the potential exists that national forest management may adversely affect wildlife and fish resources, the plans can be designed to benefit them as well.

Cooperation is a two-way street. The Forest Service must be willing to act in good faith and represent its own positions in an unambigious and consistent manner. Predetermined ends for an ostensibly objective planning process will almost certainly ensure future controversy. In such cases, state participation can easily become an empty, meaningless excercise, and the Forest Service will find itself constantly fighting lawsuits. It may be more useful for the Forest Service to consider how it can most effectively serve in the role of mediator.

Literature Cited

Alston, R. M. 1972. FOREST-goals and decisionmaking in the Forest Service. Res. Pap. INT-128. U.S. Dep. Agric., For. Serv., Ogden, Ut.

Committee on Agricultural Land Use and Wildlife Resources. 1970. Land use and wildlife resources. National Academy of Sciences, Washington, D. C.

Cortner, H. J., and D. L. Schweitzer. 1981. Institutional limits to national public planning for forest resources: the Resources Planning Act. Natur. Resour. J. 21:203-222.

Cowart, R. , S. K. Fairfax, and L. Wilson. 1985. Beyond the Sagebrush Rebellion: state and local participation in federal resource management decisions. Unpublished manuscript.

Everest, F. H., and W. R. Meehan. 1981. Forest management and anadromous fish habitat productivity. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:415-423.

Hoekstra, T. W., J. W. Thomas, M. R. Lennartz, and D. P. Worley. 1981. Managing of federal lands for production and use of wildlife and fish. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 46:336-344.

Robinson, G. O. 1975. The Forest Service. The Johns Hopkins University Press, Baltimore. 337 pp.

Schweitzer, D. L., C. T. Cushwa, and T. W. Hoekstra. 1980. Wildlife and fish. Pages 163-243 *in* An assessment of the forest and range land situation in the United States. FS-344. USDA For. Serv., Washington, D. C. 631 pp.

Trefethen, J. B. 1975. An American Crusade for Wildlife. Winchester Press, New York. 409 pp.

Fishing for Dollars: The Role of Economics in Fishery Management

Patrick J. Graham
Montana Department of Fish, Wildlife and Parks
1420 East Sixth Avenue, Helena, Montana 59620

A recent advertisement in a national sporting magazine featured the winner of bass fishing's "Super Bowl" who broke his old record by capturing 75 pounds of fish. Promoting use of a powerful outboard motor, he said the key to bass fishing success is finding the right spot and beating everyone to it with a machine that "really screams."

In contrast, another advertisement beckons fishermen to a secluded resort, surrounded by fresh mountain air, a crackling fire, and the lure of jumping trout.

They are talking about the same sport. Can you think of another which offers so much diversity? Can you think of another where professionals have so much control over its destiny?

Public agencies, at least in the West, have a profound effect on the quality and quantity of outdoor recreation. As a result professional managers have a large responsibility in balancing competing uses of natural resources and in meeting increasing demands for recreation. Fishing and hunting are usually in the forefront of these activities, at least in part because sportsmen have long paid to have fish and wildlife managed for their use.

Fisheries management continues to evolve to meet these new demands. However, biologists must first work to sustain the ecological integrity of the fishery and related environments. Within these bounds, they try to provide for the diversity and quality of experiences that the fishing public desires.

For the most part, professional fishery managers focus attention on the biological implications of their actions or the actions of others on fish and aquatic environments. We are trained in biology, statistics, limnology, and hydrology. As experts, we use the tools of our trade to protect and manage fish and fishing opportunities. This, in itself, is a complex and challenging task.

But in surveying the broad array of regulations, hatchery practices, and management policies in action across this country, one must wonder how much of what we do is in response to public demands for fishing opportunities and how much is in fact shaping, knowingly or unknowingly, what the public expects from those opportunities.

This paper will explore some of the roles economics and the behavioral sciences can play in fishery management. Economic values can be used both as an index to evaluate the allocation of natural resources (e.g., fish, timber, water) and to select alternatives for providing fishing opportunities. This paper also discusses the need to articulate what quality fishing is and how our management decisions affect fishermens' perceptions of quality.

Valuation of Sport Fishing

Evaluating the allocation of natural resources in economic terms requires determination of comparable values for each resource. I will review the types of economic values to be considered. But first, I will define economic value. In order for a good or service, such as sport fishing, to have economic value it must provide individuals with enjoyment or satisfaction and it must be scarce. Economic value does not require the exchange of money (financial value), although financial values can be a component of the total economic value of a good or service.

The Dollar Spent

Historically, a common measure used to value sport fisheries has been gross expenditures or dollars spent. From a local or even regional perspective, knowing where and on what items and services money is spent is important. This is true for Chambers of Commerce, travel promotion groups, and local governments concerned with profit, economic diversity, jobs, and taxes. A study conducted in 1982 on the Madison River in southwestern Montana, for example, found that nonresident fishermen spent an average of $778 per party in Montana.

Unfortunately, expenditures do not measure economic values in a manner consistent with the way economic value is measured for other resources. Dollars spent, after all, are a cost, not a benefit, to users or producers. For that reason, economists look for measures of net benefits to compare the value of resources.

Net Economic Values of Sport Fishing

A growing body of literature is developing on the techniques used to assess the net value of opportunities such as sport fishing. These values are defined as the net willingness to pay over and above actual expenditures. The difficulty in assessing these values arises from the fact that economists must estimate what people would be willing to pay for a fishing opportunity in the absence of a market. The methods and their limitations have been reviewed by Dwyer et al. (1977), Devouges et al. (1983), Peterson and Randall (1984), and others.

Net economic values are used commonly in benefit-cost analysis to provide comparisons between market commodities and nonmarket commodities such as sport fishing and water quality. These values are a significant improvement over unit day values (Dwyer et al. 1977). While net economic values will not insure the perpetuation of quality fishing opportunities, they serve as a useful tool in guiding decisions.

Values Held by Non-Users

There are other economic values to be considered in addition to recreational use. Economists term these *preservation values* which include "option," "existence," and "bequest" values. If you hold an *option value* you would be willing to pay to avoid irreversible loss of the opportunity for future use of a resource. If you hold an *existence value* you would be willing to pay for the knowledge that a resource is preserved or that an opportunity exists to participate in an experience even though no use is contemplated. If you hold a *bequest value* you would be willing to pay for the satisfaction derived from endowing future generations with the opportunity to use a particular resource.

These values have been estimated for water quality, air quality, wilderness areas, and unique game and nongame wildlife. In the Flathead, Glacier Park, and Bob Marshall Wilderness watershed in northwestern Montana, we found that preservation values for water quality exceed water-based recreation use values by 20 times (Sutherland 1982). A similar study in Colorado found that these non-use values for 11 potential wild and scenic rivers were four times larger than the recreational use values (Walsh et al. 1984). Similar values could be calculated for native or unique species of fish in an effort to illustrate their relative value as viewed by society. These values, however, may not reflect the benefits to society for preserving a species for genetic or ecological reasons.

The Valuation Gap

It would be unfair to leave this topic without discussing a philosophical gap often faced when using net economic values. Values for sport fishing and the associated non-use values described above often are misunderstood or ignored because they do not represent money that has actually been collected (Loomis et al. 1984). The Reagan administration, for example, tends to discount these values. The U.S. Forest Service in its draft 1985 Resource Planning Act program, reviewed by O'Toole (1984), reduced the values calculated for outdoor recreation by 37.5 percent while inflating values for timber and other resources.

Chief of the Forest Service Max Peterson, in addressing a Forest Transportation Symposium in Casper, Wyoming said, "In Washington, D. C., budget makers are not interested in imputed values of wilderness experiences. They are interested in recovering costs, and that includes recreation costs."

As a result, a single state or isolated states have little hope of affecting federal decisions regarding the value of their fish and wildlife resources. At the least, regions of the country must work collectively to develop improved values of fish and wildlife. So too should managers begin to understand the economic issues from other sides.

Quality and Human Values in Sport Fishing

As discussed above, net economic values can provide an index to evaluate alternative management options. But without an understanding of what fishermen want and how those wants change or are affected by our management, economic values are of little use.

To address this challenge we must first develop a broad but simple foundation by asking—Where are we, where are we going, and how will we get there? I will use the trout fishing program in Montana's streams to illustrate my point.

Over 25 years ago, the decision was made in Montana to manage for wild trout through protection of the natural stream habitat. Hatchery trout were also stocked in many streams at that time because it was thought to be necessary to sustain the fishery at acceptable levels.

The struggle to protect habitat was waged on three fronts—water quantity, water quality, and stream bank protection. Montana's first stream bank protection law was passed in 1963 and later expanded in 1974. Water quality standards were strengthened. In 1969, special legislation was passed to provide instream flows for fish in 12 of Montana's "blue ribbon" trout streams. In 1973, state water policy was changed to allow for the reservation of water instream for any purpose.

Management of trout in streams also took a major step forward in the mid-1970s as studies showed that trout populations actually increased in streams when stocking of hatchery fish was eliminated. As a result, stocking of trout has been eliminated in all but a few streams in the states.

The management philosophies of habitat protection and wild trout are mutually supporting. The message they send to the knowledgable public and decision makers is consistent. They justify our policies of protecting free-flowing streams and riparian habitat, as well as those discouraging fishing derbies and the further introduction of exotic species.

The conceptual base was always simple, even as it grew. Now we are nationally recognized for our wild trout management program. The foundation continues to evolve as the use and demands on the fishery grow.

Even within the confines of wild trout management in streams, the diversity of opportunity is large. Whether fishing for a trophy, to catch a limit, for a native trout, catch and release, from a boat or shore, or to find solitude, the rivers offer fishermen a choice.

But how is the quality of experiences compared, how and where should they be provided, how much is enough, and how much is too much?

Measuring Quality of Fishing Opportunities

In Montana, we are concerned that the economic values available for making decisions affecting fish management and habitat lag far behind our management practices because they often fail to recognize differences in quality. Commonly, only average values for freshwater or cold water fishing are available. Seldom are values for specific types of waters or target species available.

In a recent study we evaluated the value of trout fishing in the Swan River and Lake (ECO Northwest 1984). The majority of users targeted no specific trout (67 percent) compared to only 10 percent who targeted trophy-size bull trout. However, the price of targeting bull trout per party-visit ($450) was 15 times larger than for targeting unspecified trout per party visit ($30). An analysis that looks only at an average price for fishing opportunities would not have recognized the high value of the more limited bull trout fishery.

Another example of failing to recognize differences in quality of sport fishing opportunities occurred in a recent draft forest plan for the Kootenai National Forest in Montana. Timber harvest was projected to increase water yield by 200 percent and sediment yield by 300 percent in the Forest Service's preferred alternative. Despite this, the agency projected that, overall, the number of catchable fish (those over 6 inches [15 cm] in length) would increase. The Forest Service assumed that using stream habitat improvement measures in tributaries, the population of small resident trout (6 ot 8 inches [15 to 20 cm] in length) would be enhanced, although the number of migratory trout (12 to 18 inches [30 to 46 cm]in length) would decline.

Unfortunately, the Forest Service failed to account for the differential preference of fishermen for larger trout in the rivers where they reside and the increased distance to the tributary fisheries. A survey in Idaho, for example, showed that fishermen were willing to pay about $13 per trip more for a 50 percent increase in the size of fish (Sorg et al. 1985).

A reduction in the quality of a fishery can result both in lower use and a lower average value to the remaining fishermen. Loomis et al. (1985) quantified the economic effects of a hypothetical hydroelectric project on a recreational fishery in the Henry's Fork in Idaho. A 50 percent reduction in size of fish caught would have resulted in \$1.07 million loss to fishermen using the site, and would have also reduced the number of trips to the site, increasing the net loss to \$1.35 million.

Shaping Values

The method by which we provide these opportunities is also very important. A Madison Avenue advertising firm may have convinced you that your social well-being is threatened by underarm perspiration or "ring around the collar," and we all know what it takes to be a "Marlboro Man."

In much the same way, people's perceptions of fishing are shaped by outdoor magazines, Disney productions, and the management policies of fish management agencies. The early dominant influence of hatcheries and bag limits as management tools continues to shape many people's perception of both quality fishing and the role of fishery professionals.

Our perception of quality, after all, is shaped by past experiences and the values we hold as individuals and as a society. To a large degree, our experiences shape our expectations. To understand fishermen's perceptions of quality, we must put fishermen into the context—Who are they, how are they changing, and how are our actions affecting them and the sport of fishing?

Hobson Bryan (1979) related the role of recreational specialization as a continuum of behavior from the general to the particular, reflected by equipment and skills used in the sport and fishermen's attitudes and values about the sport. He studied fishermen in trout fishing's "golden triangle" of southwest Montana, southeast Idaho, and northwest Wyoming. His typology of fishermen included the occasional fishermen, generalist, technique specialist, and technique-setting specialist, the later having a preference both for method and specific types of waters. His conclusions were that these fisherman groups also could be characterized by their social setting, leisure orientation, resource orientation, and management philosophy.

The occasional fisherman could be characterized by wanting to catch fish, any fish, on any available tackle in any water, with ease of access as a primary concern in management. He values fishing with his family and seldom takes vacations to fish. In contrast, the technique-setting specialist seeks to catch fish under exacting conditions on limestone spring streams with specialized equipment, prefers habitat management and preservation of natural settings. He enjoys fishing with fellow specialists and may center his life around the sport.

In a hypothetical example, two types of fishermen—generalists and specialists—use a river trout fishery. The manager decides he can either accommodate the increased use by stocking hatchery trout or managing for wild trout with special regulations. The average net value per trip for generalists was \$2, compared with \$10 for specialists. Present use is 120 trips, 100 generalists and 20 specialists. Stocking would increase trips by generalists to 150 and decrease trips by specialists from 20 to 10. Wild trout management would decrease trips by generalists to 50 and increase trips by specialists to 40. Use at the site would be higher (160 trips) for stocking, compared with 90 for wild trout. The net values, however, would be only \$400 for the stocking option, compared with \$600 for the wild trout option.

A management program that results in lower use at a site, therefore, does not mean that the total value of the site has diminished. The remaining users may value the site more and those leaving may be replaced by individuals who place a higher value on the site. Simply reducing congestion has been shown to result in an overall increase in total value of many recreation sites (Walsh and Gilliam, 1982).

Ideally, management alternatives can be found that would minimize impact on any group of fishermen. One example might be to apply the less restrictive regulations closer to the area where the fishermen reside. The specialists, if indeed they had a higher willingness to pay, would be more likely to drive the extra distance if the special regulations provided higher quality fishing.

Of concern, also, would be creating opportunities to attract people to the sport. These opportunities should be designed to nourish their evolution as sportsmen and promote the diverse fishing opportunities available.

In devising a management philosophy, we need to develop a conceptual framework of the types of fishermen who use the resource—those who have quit using it, and those who may someday be attracted to it. We need to better understand how fishermen, as individuals, evolve in their sport and how the sport has evolved historically. If we take these steps, I believe our programs will be much more likely to succeed.

Designs for Tomorrow

The popular book, *Megatrends* (Naisbitt 1982), offers some compelling evidence for trends affecting our society and suggests that this is indeed a unique period in the history of this country. One thing seems sure—we are experiencing a time of increasing uncertainty. Viewed another way, ours is a time of increased opportunity.

We are now observing a trend toward decentralization of power balanced by demands for increased government accountability. Likewise, we see increased demand for diversity balanced by a demand for quality. The complexity of the information society will be balanced by increased leisure time.

Fishery agencies in general will have an advantage because they are decentralized, which puts them in closer touch with the fishing public. Fishing already offers diversity of opportunity, and the public appeal of fish and wildlife gives a distinct advantage in a society where information is becoming the strategic resource.

In Montana, we are fortunate that a commitment was made to pursue, down parallel paths, the preservation of aquatic resources and management for quality trout fishing. The challenge now is to balance the already complex ecological information we use with the use of economic, psychological, and sociological information. We must be better able to articulate the values of and means by which we provide quality fishing experiences. The tools we design should be simple but able to perform the tasks at hand.

Take time now to reflect on the many reasons you fish and how those reasons change. Think about quiet moments in mountain meadows, dangling a line over a stream bank, or the methodical casting into the willows as you float easily along, broken by the rush of excitement when a fish is hooked, or stalking in the shadows along a riffle at dusk, braced for a strike

As managers we have a great responsibility to meet these diverse and changing needs in such a way that we do not needlessly change the character of the sport. Yet, as biologists, we are aware of the irreversibility of some decisions—stocking an exotic species or losing a wild strain of fish. It is also likely that there is an element of irreversibility in the human side of the sport.

Daniel Kemmis (1983), former Speaker of the Montana House of Representatives, may have captured it best:

> Values may be thought of as a focusing of human being and knowing upon certain crucial crossings of the strands of life which must not be broken or the fabric will begin to unravel. Like life itself then, values are not static, but neither are they arbitrary nor readily interchangeable. They are real, they are rooted, and they matter.
>
> And that, I believe, is where the end of the frontier gains its greatest significance.... It can be remembered nostalgically, but as the memories lose connection to life, they will disappear as well.

Our responsibility in managing sport fishing reaches beyond protecting the fishery resource. We must have both a vision of and commitment to quality fishing. Economics and other disciplines can help us define often diverse and dynamic views of quality. But to the degree we let the quality of sport fishing slip from our grasp, we start down a path along which we may never return.

Literature Cited

Bryan, H. 1979. Conflict in the great outdoors. Sociological Studies No. 4. Bureau of Public Administration, The University of Alabama, Birmingham.

Devouges, W., K. Smith, and M. McGivney. 1983. A comparison of alternative approaches for estimating recreation and related benefits of water quality improvements. EPA Report No. 230-05-83-001, Environmental benefits analysis series. U.S. Environmental Protection Agency, Washington, D. C.

Dwyer, J., J. Kelly, and M. Bowes. 1977. Improved procedures for valuation of the contribution of recreation to national economic development. Research report No. 128. Water Resources Center, University of Illinois at Urbana, Champaign.

ECO Northwest. 1984. Economic valuation of potential losses of fish populations in the Swan River. For Montana Department of Fish, Wildlife and Parks. ECO Northwest Inc., Eugene, Oregon.

Kemmis, D. 1983. Democracy at the headwaters: land-based values as a source of political effectiveness. In cooperation with Northern Lights Institute, Helena, Montana.

Loomis, J., G. Peterson, and C. Sorg. 1984. A field guide for wildlife economic analysis. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:315-324.

Loomis, J., D. Donnelly, and C. Sorg 1985. Quantifying the economic effects of hydropower development on recreational fisheries: a case study in Idaho. *In* Proceedings of Symposium on Small Hydropower and Fisheries. (In press.)

Naisbitt, J. 1982. Megatrends. Warner Books, New York. 333 pp.

O'Toole, R. 1984. Review of the 1985 RPA update. C.H.E.C., Eugene, Oregon.

Peterson, G. L., and A. Randall, eds. 1984. Valuation of wildland resource benefits. Westview Press, Boulder, Colorado.

Sorg, C., J. Loomis, and D. Donnelly. 1985. The net economic value of cold and warm water fishing in Idaho. Resource Bulletin, Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Fort Collins, Colorado.

Sutherland, R. J. 1982. Recreation and preservation valuation estimates for Flathead River and Lake system. Montana Department of Fish, Wildlife and Parks, Kalispell.

Walsh, R. G., and L. O. Gilliam. 1982. Benefits of wilderness expansion with excess demand for indian peaks. Western Journal of Agricultural Economics.

Walsh, R., L. Sanders and J. Loomis. 1984. Wild and scenic river economics: recreation use and preservation values. Department of Agricultural and Natural Resource Economics, Colorado State University, Fort Collins.

Capabilities for Research and Management: Status and Needs

Chairman:
LEWIS NELSON, JR.
Acting Head
Department of Fish and Wildlife Resources
University of Idaho
Moscow, Idaho

Cochairman:
BETTINA S. F. SPARROWE
Land Acquisition Coordinator
U. S. Fish and Wildlife Service
Washington, D. C.

Coordinated Resource Management and Planning—The California Experience

Delmer L. Albright
California Department of Forestry
4501 State Hwy. 104, Ione, CA 95640

Kent A. Smith
California Department of Fish and Game
1416 Ninth St., Sacramento, CA 95814

It is 1985. We are halfway through a decade in which it has been predicted that America will "turn the corner" relative to its declining economic condition. It is a decade in which we are to find renewed prosperity; a prosperity to be gained through less government, less regulation; through the free enterprise system. It is a time for individual freedom and for corporate freedom; a time to return to our roots, to the philosophy and commitment upon which our nation was founded.

Such is the direction proclaimed and promoted throughout the land by politicians; government agencies; agricultural, mineral, and other corporate interests; private citizens; and yes, even the public opinion polls. It is also a direction that has far reaching implications for natural resource management. The demand on our dwindling natural resource base has never been greater.

Throughout North America, and the world, land and other natural resources continue to become scarce, as competition for these commodities continues to increase. The consequences of meeting this demand are staggering. In 1980, the *Global 2000 Report* (Barney 1980) predicted severe shortages in a wide range of natural resources should we continue consumption at the current rates. In a recent interview with botanist Dr. Peter Raven of the Missouri Botanical Garden, it was predicted that at present rates of land alteration, we could, by the year 2010, reach a condition of species extinction rivaled only by the mass extinction of the dinosaurs over 65 million years ago (Brock 1985). Some would argue that we have already reached that point and are just not aware of it because of our limited knowledge regarding the number of organisms on earth. Land alteration on a large scale, such as that currently taking place in the tropics, could conceivably even influence the earth's climate as we know it today.

Closer to home, oil and mineral development, forest management, urban sprawl, recreational pursuits, acid rain, and a host of other activities loom as ominous purveyors of an unknown future. Possibly then, the greatest challenge facing resource managers today is satisfying diverse public demands for natural resources while ensuring environmental quality and the long term productivity of wildland ecosystems (Salwasser, pers. comm., 1981). We must learn to optimize resource outputs within a structure of wise conservation and continued use.

This paper discusses one approach to optimizing human resources to produce multiple resource outputs while at the same time, enhancing the natural resource base. The approach is called Coordinated Resource Management and Planning (CRMP), and this is the story of California's experience with CRMP.

In an era of severely constrained budgets and a mood toward less government in general, public resource agencies are at long last becoming enlightened to the fact that efficient resource management requires cooperation. To respond effectively to resource concerns, resource managers and private landowners must work together to achieve the greatest overall benefits. The challenge of facilitating cooperation between public representatives and private landowners is significant. The perceived differences in philosophy and general mistrust that have been developed over the years may seem insurmountable. They are not! And, in fact, our experience with CRMP indicates that great rewards can be gained through honest communication and cooperation.

Based on this recognized need for cooperation, by 1980, 11 state and federal agencies had signed a Memorandum of Understanding for Coordinated Resource Management and Planning in California (Table 1). Authority for federal participation comes from a similar agreement signed at the national level by the U.S. Forest Service, Soil Conservation Service, Bureau of Land Management, and the National Association of Conservation Districts. State authorities are contained within the legislated mandates of each state agency. These memoranda set the stage for cooperative planning in California. CRMP was originally developed in the 1950s in Oregon, and in a variety of forms, is currently being applied nationwide (Anderson 1977).

Coordinated Resource Management and Planning-An Approach

Coordinated Resource Management and Planning is an approach to land and resource management wherein individual, agency, and political boundaries are not limiting, and resource problems are solved based on resource boundaries. CRMP embodies the concept that integrating and coordinating resource uses will result in improved land and resource management, with the least conflict among users, owners, and public agencies.

Coordinated Resource Management and Planning is designed to achieve: (1) compatability between land and resource uses, including natural resources conservation, energy and mineral development, livestock production, watershed protection,

Table 1. Signatory parties to the eleven agency agreement for Coordinated Resource Management and Planning in California.

California Association of Resource Conservation Districts
California Department of Conservation
California Department of Fish and Game
California Department of Food and Agriculture
California Department of Forestry
California State Lands Commission
USDA-Agricultural Stabilization and Conservation Service
USDA-Forest Service
USDA-Soil Conservation Service
USDI-Bureau of Land Management
University of California Cooperative Extension Service

wildlife habitat enhancement, fire hazard reduction, wood products, and recreation; and (2) improvement of the resources and their perpetuation in a high quality condition.

The underlying theme is "improved land management through cooperation." This approach uses the best efforts of the local people involved: private landowners, interested federal, local and state agencies, and other specialists. It may be as simple or complex as needed to accomplish the goals of the combined group of participants.

In general, a CRMP approach is appropriate when any or all of the following conditions apply:

1. Ownerships are intermingled (public and/or private).
2. Conflicts are likely to develop.
3. Resource needs extend beyond individual, political, and agency boundaries.
4. Common use areas exist.
5. Resource problems cannot be as effectively solved using other techniques.

Tangible goals that can be attained through CRMP include:

1. Improving the quality and quantity of forage and habitat for wildlife and domestic animals.
2. Maintaining and improving planned harvest of forest products compatible with other resource values.
3. Managing watersheds to prevent or reduce pollution, siltation, and erosion.
4. Maximizing public benefit from the land and its resources, including recreation where practical.
5. Improving the economic status of both private and public land units involved.

Structure and Organization

The Memorandum of Understanding for Coordinated Resource Management and Planning in California established two groups at state level: the Executive Council and the Technical Advisory Council. The Executive Council, comprised of agency directors, provides direction and policy guidance; facilitates coordination; and establishes guidelines for determining priorities for planning throughout the state.

The Technical Advisory Council consists of a technical representative of each signatory agency. This group promotes CRMP; provides training and technical guidance; monitors progress; and facilitates resolution of local field problems when necessary.

The key element that distinguishes CRMP from other planning efforts is that it is undertaken and led by local groups. Coordinated, cooperative local planning facilitates a common sense approach to managing the land resource base. Management of local resources is over a large geographical area rather than small independent ownerships. This is accomplished through eight general steps:

1. Identify major resource interests and problems.
2. Define planning area.
3 Form planning groups.
4. Conduct "town hall" meeting.
5. Draft Coordinated Resource Plan.
6. Conduct field evaluation.
7. Formalize the CRP.
8. Implement and monitor.

A discussion of each of these steps follows.

The CRMP Process

*Step 1. Identify major resource interests and problems.*CRMP can be applied to solve problems and manage land areas for any number of reasons: For example, urbanization of forest lands, fire hazard reduction, and human encroachment of wildlife habitat. In Nevada it has been used for off-road vehicles management (Molini, pers. comm., 1982). Wherever cooperation is needed, CRMP can apply. Initial identification of the interests and problems is the first step; further refinement occurs as the process develops.

Step 2. Define planning area. As a general rule, a CRMP planning area includes all private and public lands necessary to obtain solutions to local resource issues. For example, to conduct prescribed burning to reduce fire hazard in a large watershed, the planning area would include any properties likely to be affected by a fire. Often, ridgetops are good locations for fire/fuel breaks: they thus serve well as CRMP boundaries. Watersheds are often good planning boundaries for wildlife and other concerns as well. The boundary lines should be logical and recognizable. Ranches, for example should not normally be divided arbitrarily by a CRMP boundary.

Step 3. Form a planning group. Representatives from the properties within the planning area are invited to become cooperators in the planning group. Once the CRMP boundary lines are drawn, tools like county assessors maps provide names and addresses of the individuals and agency landowners. Not everyone need be involved; and participation is strictly voluntary. Thus some ownerships may be excluded.

An important point to make here is that *all* landowners should be given the opportunity to participate. California experience has shown that once projects occur on the ground, CRMP gains credibility, and nonparticipating landowners get interested in cooperating

In addition to obvious landowners and public agencies, invitations should also be extended to other interested groups, local planning commissions, county government, and other special interest publics. To facilitate decision-making, the participants must be knowledgeable of the area and authorized to speak for the agencies, ownerships, or organizations they represent.

Areas encompassed by a planning group may be large or small, and more than one project or plan may be developed under the guidance of a single group. In San Diego County of Southern California, local, state, and federal agencies in cooperation with private landowners, have inaugurated a County Coordinating Group that uses CRMP to manage 1.6 million acres (0.6 million ha) of public and private chaparral lands. This County Coordinating Group facilitates projects, reduces duplication of agency efforts, and thus saves staff time and dollars. Rather than review individual projects, this group serves as a region-wide steering committee. They establish regional coordination procedures; set responsibilities; help determine a regional network of experts to aid in Coordinated Resource Plans; and formulate goals and objectives for coordinated efforts in resource management and planning in general.

Step 4. Conduct town hall meeting. Once the planning area and participant groups have been identified, the next step is to solicit attendance at a "town hall" type meeting. Interested parties should meet at a neutral location like a community center. Any interested individual or agency may initiate the CRMP process through phone calls and written correspondence. The bottom line is to facilitate the first meeting: not until then can the process proceed.

Step 5. Draft Coordinated Resource Plan. A Coordinated Resource Plan (CRP) is the action document of the CRMP process. At the initial town hall meeting, list in prominent view of the participants, the major resource issues and planning objectives as described by each participant. Here the interests of the participants get "laid out on the table." This is not a final plan—only a process for listing ideas, so include controversial ideas and objectives that may seem contradictory. Since CRMP is a conflict resolution process, *all* concerns should be addressed as early in the planning effort as possible.

The list of *issues* and the list of *objectives* will tend to match. For example, if adjustments in livestock forage allocations are listed as an issue, improvements in livestock forage probably will be listed as an objective. Planning will be easier if the lists are made as specific as possible. "Improving the ecosystem" may be a goal with which everyone agrees, but is too vague. In contrast, the objective of increasing livestock forage to a given level is measurable.

Then, list the *actions* proposed to achieve each objective. Those actions listed should be assigned to people who are willing and able to carry them out—in effect, to make the plan work. These three lists—*issues*, *objectives*, and *actions*—become the draft CRP.

Step 6. Conduct field evaluation. The Planning Group will select experts from among the participants to evaluate the draft CRP in the field. These experts comprise the Interdisciplinary (ID) Team. They do not make independent decisions, but rather bring recommendations to the main body for final decision.

Coordinated Resource Management and Planning assumes that no one agency or individual has sufficient expertise to solely manage a project involving complex natural resource ecosystems. Thus, a small group of experts in the essential resource subjects cooperate as an ID Team to review proposed CRMP projects. As a group, they inventory the planning area; analyze the information available; identify and define the objectives and alternatives; evaluate alternatives; and arrive at management decisions which are acceptable and suitable to the landowners and the CRMP planning group.

Each project has a lead agency that is responsible for obtaining the necessary participation from the available network of experts. For example, if fish and wildlife are to be affected by a prescribed burn on private land, the California Department of Forestry—lead agency for prescribed burning—would contact the local representative from the California Department of Fish and Game. This person then inspects the project on-the-ground as a member of the ID Team and provides input into the planning process.

Step 7. Formalize the CRP. The draft Coordinated Resource Plan is the list of *issues, objectives,* and possible *actions* that was developed at the "Town Hall" meeting. Based on the field evalution and recommendations of the ID Team, this draft is revised and put into final form. This is done by a group of four or five of the most interested participants, often referred to as the Core Team.

Next, the entire planning group should review the plan. It is important to re-read the *major resource issues, planning objectives* and *actions* lists to confirm that each issue has been considered. Then ask: Are the *objectives* in harmony, realistic, and internally consistent; and, is there an *action* for each *objective*? If there are severe contradictions in the plan, they should be worked out at this time. Also, make sure that sufficient monitoring measures are built into the plan to facilitate information flow and evaluate progress.

The group now has a Coordinated Resource Plan. The next step is for everyone to sign the last page, recording their agreement. Indicate on the last page any plan continuity, revision, and updating procedures.

Step 8. Implement and monitor. Finally, the members of the local CRMP group must carry out the *actions* they have agreed to undertake. This is where the process pays off—implementation of resource management on the ground.

The Status of CRMP in California

We have defined the process, but the real test lies in how well it works. In 1983 the CRMP Technical Advisory Council conducted a survey of agencies to determine how many, what size, and where projects were being carried out under CRMP in California (Newell 1983). The results surprised even those of us who had been working with the process for some time. We identified 70 projects totaling over 3.8 million acres (1.5 million ha) statewide.

Since that survey we have added the 1.6 million acres (647,000 ha) in the San Diego County planning area, bringing the documented total to around 5.5 million acres (2.2 million ha) (Table 2). California is approximately 100 million acres (40.5 million hectares) in size, so CRMP is being implemented on 5.5 percent of the total land area of the state, and approximately 15 percent of the state's wildlands. If we were to include (and we easily could) efforts like the 2.5 million acre (1 million ha) Modoc/Washoe Experimental Stewardship Area in California and Nevada, the numbers are considerably more impressive. Most of these efforts have been initiated within the past seven years. Of great significance is the fact that these lands are among the most valuable and productive in California.

There are a host of examples that point to the interest in and success of CRMP in California, including statewide programs such as the multimillion dollar Chaparral Management Program administered by the State Department of Forestry. We would like to share one example, however, that especially stands out in our minds.

We have known for some time that CRMP works in *rural*/wildland situations. But, in 1983, the CRMP Technical Advisory Council had the opportunity to tour

Table 2. Summary of Coordinated Resource Management and Planning projects by county as of October, 1983.

County	Number of projects	Project size (acres)	(ha)
Alpine	1	3,000	(1,214)
Amador	1	30,000	(12,140)
Calaveras	1	35,000	(14,164)
Colusa	4	12,000 - 196,000	(4,856 - 79,319)
El Dorado	1	9,000	(3,642)
Fresno	4	4,000 - 75,000	(1,619 - 30,351)
Glenn	2	81,800 - 106,000	(33,103 - 42,897)
Imperial	2	1,920 - 5,760	(777 - 2,231)
Inyo	2	56,000 - 306,000	(22,662 - 123,835)
Kern	3	59,000 - 306,000	(23,877 - 123,835)
Lake	3	20,300 - 174,330	(8,215 - 70,549)
Los Angeles	1	not available	—
Mariposa	1	30,000	(12,140)
Mendocino	4	6,000 - 33,920	(2,428 - 13,727)
Modoc	4	17,000 - 70,000	(6,880 - 28,328)
Mono	5	16,000 - 143,000	(6,475 - 57,870)
Orange	1	not available	—
Riverside	2	not available	—
San Benito	2	20,000 - 75,000	(8,093 - 30,352)
San Bernardino	6	3,700 - 40,960	(1,497 - 16,576)
San Diego	3	128,000 - 1,600,000	(51,800 - 647,504)
San Luis Obispo	3	2,960 - 59,000	(1,198 - 23,877)
Shasta	1	200,000	(80,938)
Siskiyou	4	58,500 - 188,250	(23,674 - 76,183)
Sonoma	7	913 - 50,000	(369 - 20,234)
Stanislaus	1	90,000	(36,422)
Tehama	6	30,000 - 125,000	(12,140 - 50,586)
Tulare	3	16,640 - 306,000	(6,734 - 123,835)
Tuolumne	1	7,000	(2,833)
Yolo	2	174,330 - 196,700	(70,549 - 79,602)
Total	81[a]	5,480,000 + acres[b]	(2,217,700 + ha)

[a]Total reflects duplication where a project extends to more than one county. Actual total documented was 70 projects.

[b]Estimated total does not include 2.5 million acres (1 million ha) Experimental Stewardship Program in Modoc County, California, and Washoe County, Nevada.

and participate in an *urban/*wildland project in southern California. The 8000 acre (3240 hectares) Lake Arrowhead basin in southern California is made up of a complicated array of ownerships with many organizational and agency overlaps. It has a varied land use pattern from wildland recreation to residental/commercial. Being a forested island in the mountains of the California desert, this ecosystem is fragile and under heavy pressure from the Los Angeles basin, whose 8 million residents are seeking a recreational experience in a forest setting that is close to home.

The private landowners in this basin, totalling almost 8,000 themselves, were concerned over the escalating deterioration of their forest and wildlands. They hired a professional forester to help them with their dilemma. Through him they became involved in a CRMP effort to identify and resolve a multitude of resource issues within the basin. Objectives were developed and actions identified. These actions are currently being implemented.

Education in the concepts and techniques of urban forestry is seen as the key to the success at Lake Arrowhead. The effort emphasizes the need for improved management of the surrounding and interspersed wildland parcels to prevent further decline of the forest resource. Management demonstrations resulting in regeneration and utilization projects are being implemented. An opportunity exists to generate an increasing interest in and knowledge of the local forest by those who live and work in the area. The end result will be a community of professionals, government agencies, and volunteers working together to make some permanent changes in the management of their community forest that will ensure its long-term survival.

Those of us who participated in the Lake Arrowhead project, who talked with the landowners and saw first hand their commitment to working with public agencies and to preserving the natural values of their environment were forever impressed. Gordon Van Vleck, Secretary for Resources in California, and a rancher himself, summed up the feeling in a keynote address when he stated: "As Secretary of the Resources Agency, I feel a great responsibility for seeing that efforts such as your Coordinated Resource Management and Planning program here at Lake Arrowhead are fostered and supported. We all know that government agencies can do only so much toward the management and protection of our precious resource heritage. We know that many important things can be accomplished only through the efforts and concern of private citizens . . . in partnership with government" (CRMP Keynote Address, Lake Arrowhead 1983).

In this paper, we have presented the concept of CRMP based on our experience in California. It may be called different things in other places, but the basic philosophy is the same—cooperation. As a management approach it is growing, and we believe it will continue to grow and prosper until long-term cooperative land management is the rule rather than the exception. It will grow because it works. It works for agency people and for landowners. It works to meet the goals of all those concerned at the least cost. It works to minimize conflicts by involving all interested parties early in the planning process. And, it works because it gets people back in touch with people. It *is* a way of satisfying diverse public demands for natural resources while ensuring environmental quality and the long-term productivity of wildland ecosystems.

Literature Cited

Anderson, E. W. 1977. Planning the use and management of renewable resources. Rangeman's J. 4(4): 99-102, 144-147.

Barney, G. O. 1980. The global 2000 report to the President. Vols. 1 and 2. Council on Environmental Quality and the Department of State, Washington, D.C.

Brock, R. G. 1985. Coming soon: mass extinctions. International Wildlife Magazine 15(1): 16-17.

Newell, L. A. 1983. Annual report of the Chairman, Technical Advisory Council, coordinated resource management and planning in California. California Department of Forestry, Sacramento. 8 pp.

Van Vleck, G. 1983. The urbanizing forest—renewable resources under siege. Keynote address presented at the Second Annual CRMP meeting at Lake Arrowhead, California. The Resources Agency, Sacramento, California.

Predicting the Effects of Land-Use Changes on Wildlife

John E. Hench and Vagn Flyger
Department of Animal Sciences,
University of Maryland,
College Park, Maryland 20742

Robert Gibbs
Montgomery County Department of Parks,
1400 Glenallan Ave.,
Wheaton, Maryland 20902

Keith Van Ness
Maryland and Washington, D. C.
Breeding Birds Atlas Project,
14705 Sugarland Road,
Poolesville, Maryland 20837

Over 26,000 acres (10,500 ha) of wildlife habitat exist in Maryland's Montgomery County Park System. This habitat is altered by recreational development, stormwater management projects, and a variety of park maintenance activities. What are the impacts of habitat changes on wildlife? In the past no one could answer this question. This lack of accountability led to the development of a model for predicting the effects of changing habitat quality and/or quantity on wildlife. The model is a management tool that shows how land-use changes affect wildlife. By using the model, resource managers and environmental planners can see the trade-offs in habitat and wildlife that occur because of land-use changes.

Although this research is limited to Montgomery County, the concepts are applicable to the management of wildlife habitat anywhere. The objectives of the research are: (1) to develop a model for predicting the effects of land-use changes on wildlife, and (2) to demonstrate how the model can be successfully applied in the Montgomery County Park System.

County Description

Montgomery County borders Washington, D. C., and covers 318,712 acres (129,033 ha) of Maryland's Piedmont province. Long narrow stream valleys drain the gently rolling topography. Elevations range from 229 to 702 feet (70-214 m). Estimates of forest cover in the county range from 22 percent (Whitcomb et al. 1981) to 29 percent (Powell and Kingsley 1980). These estimates vary due to differing definitions of forest cover. County parks account for approximately 33 percent of the forest cover in the county.

Chestnut oak *(Quercus prinus)* is abundant on drier soils in the northern and northwestern portions of the county. Tulip poplar *(Liriodendron tulipifera)* is dominant on rich moist soils throughout the remainder of the county. Flowering dogwood *(Cornus florida)* is an ever present understory tree. Stands of Virginia pine *(Pinus virginiana)* and red cedar *(Juniperus virginiana)* occur on drier or eroded upland sites. Beech *(Fagus grandifolia)* is present on stream valley slopes and occurs in the understory of upland and floodplain forests. Mixed mesophytic forests occupy the larger stream valleys. Common stream valley species include sycamore *(Plantus occidentalis),* green ash *(Fraxinus pennsylvanica),* box elder *(Acer negundo),* silver maple *(Acer saccharinum),* and river birch *(Betula nigra).* Red willow *(Cornus amomum),* smooth alder *(Alnus arrulata),* and black willow *(Salix nigra)* are common in swamps.

Model Development

Montgomery County parks provide a variety of wildlife habitats, including meadows, brushy fields, conifer stands, hardwood stands, lakes, ponds, marshes, and swamps. If resource managers and environmental planners understand the effects of land-use changes on habitat, then they should be able to predict the effects of land-use changes on wildlife. However this hypothesis requires an understanding of the habitat needs of wildlife.

A list was assembled of 23 amphibians, 28 reptiles, 158 birds, and 39 mammals that use habitats in Montgomery County during the breeding season and winter months. Distributional surveys published during the last decade and museum collections were useful sources of information. A habitat profile was developed for each species, containing data on feeding habitats, breeding habitats, and home range or territory size. Publications by Bishop (1947), DeGraaf and Rudis (1981), DeGraaf et al. (1981a, b), Hamel et al. (1982), Smith (1946), and Wright and Wright (1949,1957) were helpful for this purpose.

The major challenge was to relate wildlife habitat in Montgomery County parks, and the effects of proposed land-use changes on this habitat, to natural characteristics of plant communities. This was accomplished by equating wildlife habitat with stages of plant succession on upland, floodplain, and wetland sites. Plant succession was chosen as the basis for the model because successional stages represent measurable and directional changes in plant communities. Because plant succession is orderly, changes in wildlife habitat can be predicted over time.

Figure 1 illustrates the successional stages and habitat layers in an upland plant community. Plant succession begins on abandoned fields, fallow croplands, and other bare sites. The first successional stage offers little food and cover for wildlife. Grasses and herbaceous plants dominate the second successional stage and provide subsurface and surface habitat layers.

Shrubs and saplings (less than 5 inches [12 cm] DBH) dominate the third successional stage. Cover is usually dense. Tree species are usually very intolerant of shading, such as cherry *(Prunus* sp.), aspen *(Populus* sp.), Virginia pine, and red cedar. Subsurface, surface, and shrub layers are present.

Intolerant pole size trees 5 to 9 inches (13-23 cm) DBH dominate the fourth successional stage. Competition has eliminated many of the weaker stems. Because of dense shading, there are few herbaceous or understory species. With the exception of the tree canopy, there is little cover, and few feeding and nesting sites for wildlife.

Mature intolerant trees greater than 9 inches (23 cm) DBH dominate the fifth successional stage. Competition has eliminated additional trees from the site. Disease and windfall contribute to the loss. Seedlings and saplings of more tolerant species such as tulip poplar and red maple *(Acer rubrum)* appear in the understory.

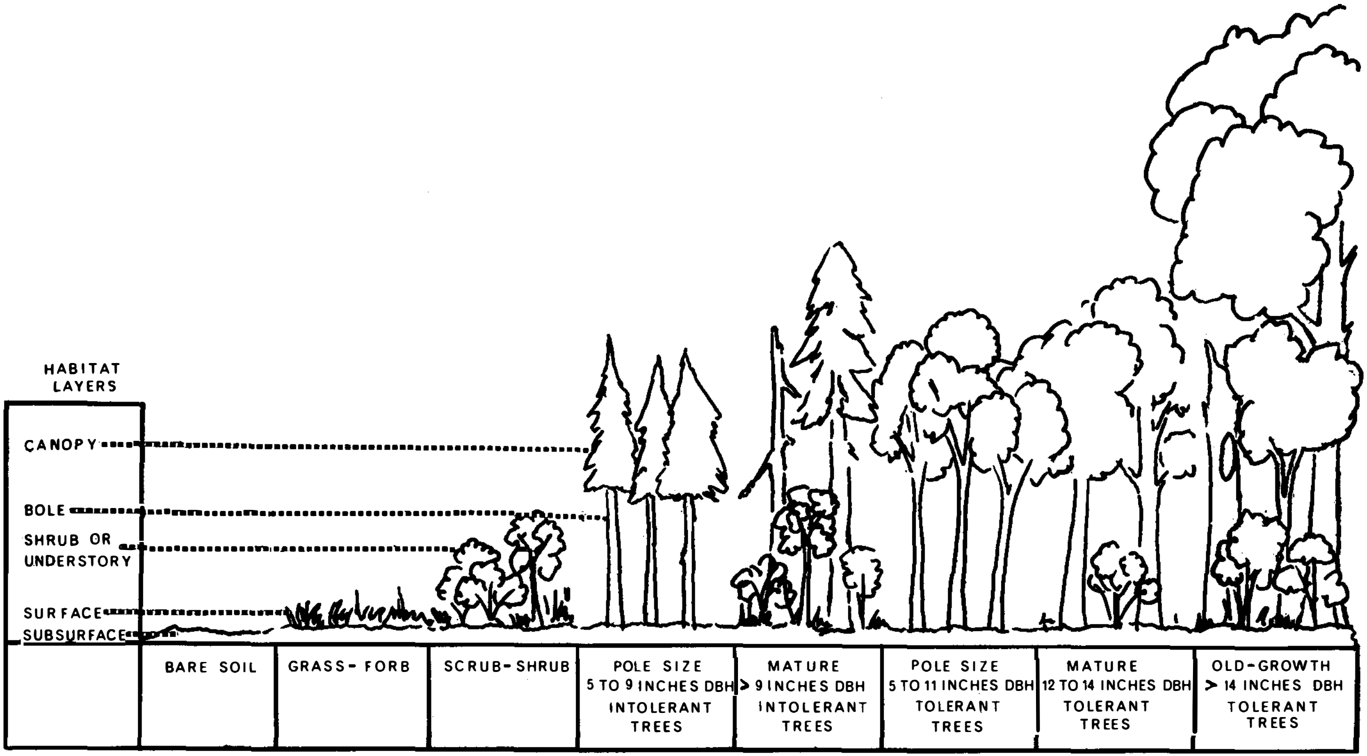


Figure 1. Diagramatic illustration of successional stages and habitat layers in an upland plant community.

Herbaceous and understory species may also be present. Snags and dead and down woody material add additional feeding and nesting sites. Subsurface, surface, understory, tree bole, and canopy layers are present.

Pole size tolerant trees 5 to 11 inches (13-28 cm) DBH dominate the sixth successional stage. Surface and understory layers are poorly developed or nonexistent.

Mature tolerant trees 12 to 14 inches (29-35 cm) DBH dominate the seventh successional stage. Competition, disease, and windfall begin to open the canopy, allowing herbaceous and understory species to become established. Snags and dead and down woody material add structural diversity to the habitat.

Old-growth tolerant trees greater than 15 inches (36 cm) DBH dominate the eighth successional stage. Large canopy openings allow abundant sunlight to reach patches of the forest floor. Herbaceous and understory species are common and well developed. Seedlings and saplings of more tolerant species such as oaks and hickories *(Carya* sp.) appear. Usually a subcanopy of dogwood, black gum *(Nyssa sylvatica),* and beech is present. Large snags and down logs are common. Old-growth forest offers the greatest structural diversity for wildlife.

Environmental factors, including soil moisture, soil type, slope, and aspect, define the distribution of upland, floodplain, and wetland plant communities. Physiographic processes (e.g., erosion, uplifting), and manipulation by people (e. g., draining swamps, damming stream valleys) can bring about a progressive change in the intensity of these factors, causing plant communities to alternate in space and time.

Successional stages and habitat layers are sometimes altered by recreational development and park maintenance activities. The construction of ball fields, golf courses, trails, and other recreational facilities create openings in upland and floodplain plant communities and increase edge habitat. Mowing, clearing brush, thinning forest stands, and dredging maintain plant communities in early successional stages. Seeding or planting herbaceous species or trees has the opposite affect.

Wildlife species are associated with plant communities, successional stages in these communities, and the habitat layers in each successional stage. These associations have been observed for insects (Murdoch et al. 1972), breeding birds (Johnston and Odum 1956, Balda 1975), and mammals (Rosenzweig and Winakur 1969, August 1983).

Studies comparing breeding bird populations of small isolated woodlots with extensive forests have shown that some groups (in this case neotropical migrants) are associated with larger tracts, or tracts with a high area to edge ratio (Whitcomb et al. 1981, Lynch and Whitcomb 1984). Historically, forest management for wildlife has emphasized the need for openings and edge. Although these management practices improve habitat quality and quantity for edge species they have the opposite effect on forest interior specialists.

The wildlife-habitat associations were the framework on which the land-use planning model was built. The habitat profiles provided the data needed to place wildlife species in the appropriate level in the model—*season, plant community, successional stage,* and *habitat layer combinations for feeding, reproduction, or both.* Data on the area requirements of birds in the study area (see Robbins 1979, Whitcomb et al.1981, Lynch and Whitcomb 1984) were used to separate this taxon into two groups. Birds that regularly occurred in tracts less than 125 acres (51 ha) were considered edge species. Birds that were normally found in larger tracts of over 125 acres (51 ha) were considered interior species. Similar data were not available for amphibians, reptiles, and mammals. The edge/interior classification for each species in these taxa was inferred from the habitat profiles.

It should be noted that field data was collected in the county parks to verify the accuracy of the wildlife-habitat associations. Wildlife species were surveyed in the same locations where quantitative and qualitative habitat measurements were taken (see Applications below). Species' vocalizations and visual observations provided data for amphibians, reptiles, and birds. Snap traps, rat traps, and pit traps provided small mammal data. The presence of larger mammals was noted from tracks, scats, scent-posts, and visual observations.

Applications

Quantitative and qualitative habitat data—including measures of plant diversity, vegetation height, canopy closure, density of ground cover and shrubs, basal area, average stand DBH, and soil moisture—were used to describe and map plant communities and their successional stages in county parks. The data was collected from ground surveys and aerial photographs. Figure 2 shows a habitat map for Little Bennett Regional Park. The Montgomery County Parks Department is currently preparing a master plan for recreational development on this 3600 acre (1458 ha) site. The model and habitat map will be used to evaluate the trade-offs in wildlife and habitat associated with each aspect of the plan.

Levels in the land-use planning model—*plant community*, successional stage, and *habitat layer*—are affected by land-use changes. Base-line data on habitat quality and quantity can be obtained during ground surveys and from aerial photographs. Levels in the model can be manipulated to reflect habitat changes that result from recreational development, storm water management projects, and a variety of park maintenance activities. Because the model is based on plant succession, changes in habitat and wildlife can be predicted through time.

The model allows resource managers and environmental planners to consider the trade-offs in habitat and wildlife that accompany land-use decisions. For example one aspect of the proposed master plan for Little Bennett Regional Park will recommend that a dam be constructed in Little Bennett stream valley. The dam will flood approximately 500 acres (200 ha). Wildlife that are associated with the affected wetland and floodplain plant communities (Figure 2), will be replaced by species associated with open water and other wetland successional stages. (Although fish were not included in the present model, this taxon will be included later.)

The concepts discussed in this paper should be applicable to the management of wildlife habitat anywhere. Succession occurs in all plant communities, and wildlife species are associated with plant communities and successional stages in these communities.

Acknowledgement

From a dissertation to be submitted to the Graduate School, University of Maryland, by John E. Hench in partial fulfillment of the requirements for the Ph.D. Degree in Animal Sciences.

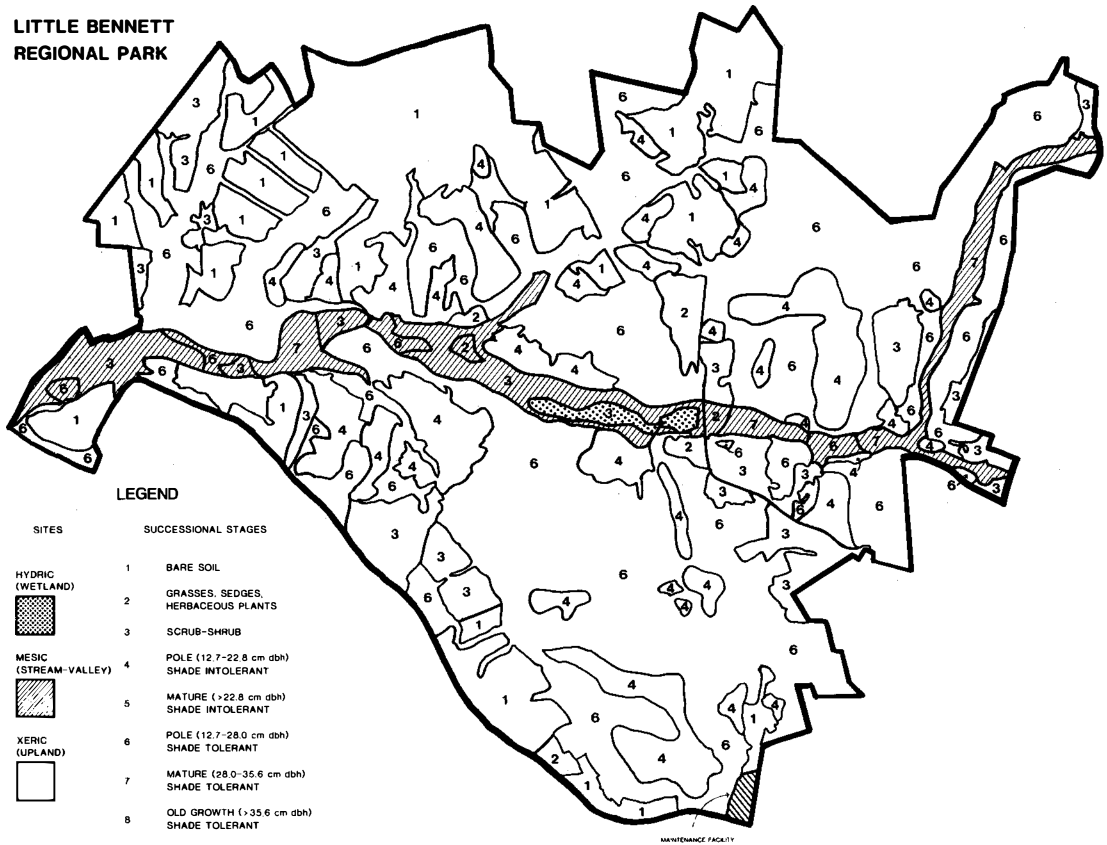


Figure 2. Habitat map for Little Bennett Regional Park, Montgomery County, Maryland. Quantitative and qualitative data from ground survey and aerial photographs were used to prepare the map.

Literature Cited

August, P. V. 1983. The role of habitat complexity and heterogeneity in structuring tropical mammal communities. Ecology 64:1495-1507.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. Pages 59-90 *in* Proceedings of the symposium on the management of forest and range habitats for nongame birds. Gen. Tech. Rep. 1. USDA For. Serv., Washington, D.C.

Bishop, S. C. 1947. Handbook of salamanders. The salamanders of the United States, of Canada, and lower California. Comstock Publ. Co., Inc., Ithaca, NY 555 pp.

DeGraaf, R. M., and D. D. Rudis 1981. Forest habitat for reptiles and amphibians of the northeast. USDA For. Serv., NE For. Exp. Station, Broomall, PA 239 pp.

DeGraaf, R. M., G. M. Whitman, J. W. Lanier, B. J. Hill, and J. M. Keniston 1981a. Forest habitat for birds of the northeast. NE For. Exp. Station, USDA For. Serv., NE For. Exp. Station, Broomall, PA. 598 pp.

DeGraaf, R. M., G. M. Whitman, and D. D. Rudis 1981b. Forest habitats for mammals of the northeast. USDA For. Ser., NE For. Exp. Station, Broomall, PA 182 pp.

Hamel, P. B., H. E. LeGrand Jr., M. R. Lennartz, and S. A. Gauthreaux, Jr. 1982. Bird-habitat relationships on southeastern forest lands. Gen. Tech. Rep. SE-22. USDA For. Serv., SE For. Exp. Station, Ashville, N. C. 417 pp.

Johnston, D. W., and E. P. Odum 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37: 50-62

Lynch, J. M., and D. F. Whitcomb. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biol. Conserv. 28: 287-324.

Murdoch, W. M., F. C. Evans, and C. H. Peterson 1972. Diversity and pattern in plants and insects. Ecology 53: 819-829.

Powell, D. S., and N. P. Kingsley 1980. The forest resources of Maryland. For. Serv. Res. Bull. NE-61. USDA For. Serv., NE For. Exp. Station, Broomall, PA. 103 pp.

Robbins, C. S. 1979. Effect of habitat fragmentation on bird populations. Pages 198-212 *in* Management of north central and northeastern forests for nongame birds. Gen. Tech. Rep. NC-51. USDA For. Serv., NC For. Exp. Station, St. Paul, Minn. 268 pp.

Rosenzweig, M. L., and J. Winakur. 1969. Population ecology of desert rodent communities: habitats and environmental complexity. Ecology 50: 558-572.

Smith, H. M. 1946. Handbook of Lizards. Comstock Publ. Assoc., Ithaca, N. Y. 557 pp.

Whitcomb, R. F., C. S. Robbins, J. F. Lynch, B. L. Whitcomb, M. K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pages 125-205 *in* R. L. Burgess and D. M. Sharpe, eds. Forest island dynamics in man-dominated landscapes. Ecol. Studies 41. Springer-Verlag, NY.

Wright, A. H., and A. A. Wright 1949. Handbook of frogs and toads. Comstock Publ. Co., Inc., Ithaca, NY. 625 pp.

Wright, A. H., and A. A. Wright 1957. Handbook of snakes. Comstock Publ. Co., Inc., Ithaca, NY. 1133 pp.

Species Selection for Habitat Assessments

Thomas H. Roberts and L. Jean O'Neil
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi 39180

Introduction

Habitat assessments are conducted to obtain baseline information that can be used for predicting the consequences of proposed projects on fish and wildlife resources. The Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980), the most widely used assessment method, is a structured evaluation framework that uses a standard terminology and provides a means of quantifying and documenting the assessment process. Unfortunately, HEP is sometimes used as a cookbook to "tell" what the environmental impacts of a project will be. It is not intended to be a rigid, mechanistic, or exact process that provides a totally objective "right answer" concerning the consequences of land use changes. HEP is a flexible tool for planning and management, a means of quantifying fish and wildlife considerations, and of displaying findings and professional judgments.

At the center of a HEP analysis is a determination of habitat quality for a set of species based on Habitat Suitability Index (HSI) models. Because the measures of quality used in the HEP accounting framework usually are based on a small number of species, selection of those species is a critical step in planning an analysis.

The species selection process will be the focus of this paper. We first present an overview of the process for determining objectives and designing the study. The emphasis will be on making decisions regarding "quality" in natural systems and how these initial steps relate to the species selection process and are critical to a sound and meaningful assessment. We then discuss various approaches to species selection and present some case histories that illustrate problems we have encountered. Throughout, we offer suggestions for improving the species selection process and discuss additional factors that should be considered by project planners.

Objectives and Study Design

The first step in any assessment is to define the objectives clearly. In a HEP study, this is usually done by a team composed of one individual from the U.S. Fish and Wildlife Service, the appropriate state agency, and the agency proposing the action. A team approach is not necessary but is recommended to balance agency perspectives and reduce bias. Examples of objectives include comparing two or more areas for siting a facility, determining the impact of project-induced land use change, or planning compensation measures for wildlife losses.

After determining these primary objectives, the team has to consider secondary objectives that relate specifically to fish and wildlife resources, their link to the project area or ecosystem, and the probable nature of the impacts on them. Because not ***all*** resources can or need to be considered, the team must decide which are the most important, significant, or valuable; i.e., which are the "quality" resources?

Quality of resources for habitat assessment may be defined by answering a series of questions. Is the goal to maintain high populations of a few species or to maximize species diversity? Are there cover types to be preserved for their inherent and multiple values? Which animal species or species groups are of special interest? What cover types do they require? What cover types will be impacted? How significant are those cover types as wildlife habitat locally and regionally? Will new cover types be created? If so, do they have inherent value of their own or serve as habitat for species of particular importance? And finally, which species will accurately reflect the project impacts and changes in land use?

Federal planning guidance recognizes the need to delineate the quality resources early in an assessment. For example, the Corps of Engineers and other action agencies include a step for determining significant resources (Water Resources Council 1983), and the Fish and Wildlife Service establishes Resource Categories (U.S. Fish and Wildlife Service 1981). Trade-off analysis is a tool to help make choices, usually with systematic comparisons among the factors being considered. Procedures for performing trade-off analyses are described in Ecological Services Manual 102 (ESM 102) (U.S. Fish and Wildlife Service 1980), and are normally used in decision making after habitat quality determinations have been made. We think that the use and documentation of such an analysis during species selection will help planners focus on quality resources and study objectives.

Using Guided Objectivity

Decisions on study objectives and the constituents of quality are local, project-specific, and critical to an effective HEP analysis. Each assessment must be "guided" to achieve results that accurately reflect potential impacts on important resources. This should not be interpreted as advocating that the outcome be predetermined or that studies not be objective, but an appropriate study design will increase the relevance and usefulness of a HEP analysis. The notion of guiding impact studies may be difficult for some to accept; however, human values and perceptions will always play a major role in decision making. We are suggesting that this be acknowledged and that the concept of objectivity guided by or tempered with human value judgments be accepted.

The following example illustrates how the team's decisions can help insure that a study clearly displays the impacts of a project. Mature bottomland hardwoods in the South are decreasing in extent and are generally considered to be a valuable resource. If a proposed project would result in the clearing of 2,000 acres (810 ha) of bottomland hardwoods, two objectives of the study might be to display the impacts of those losses and attempt to lessen or mitigate them. The team should select evaluation species that are highly dependent on bottomland hardwoods for their existence and would suffer population declines as a result of the project. The pileated woodpecker *(Dryocopus pileatus)* and gray squirrel *(Sciurus carolinensis)* are examples of species that would be appropriate. The woodpecker is a good choice because of its dependence on mature trees and large, decayed snags. The squirrel requires cavity trees and a diversity of mature mast-producers.

Clearing of bottomland hardwoods may result in a cover type not currently present in the area. If the future cover type and/or associated species are judged to be significant, then that cover type should be represented during species selection.

Because Federal planning guidance requires the description of both beneficial and adverse effects of an action under conditions both with and without the action, the team should select species to provide this information. However, a great deal of controversy exists on subsequent steps such as resource tradeoffs and determination of net effects, so the species selection process should be biologically meaningful and well documented.

Looking at the features of the project area and nature of the proposed impacts offers clues for species selection. For example, use of game species may be inappropriate in an urban setting in which aesthetics are more important than consumptive values, and other species may be better matched with management constraints. Cutting of old-growth timber with the accompanying loss of cavity trees should alert team members to consider cavity-using species. Projects in which habitats are only slightly altered,, such as periodically inundating a forested area which might affect only the understory, should signal the team to emphasize a subset of the forest wildlife community that relies on understory vegetation.

Mechanics of Species Selection

The species selection process is complex, combining decisions on resource quality with logistical concerns such as number of cover types, time available for the evaluation, and availability of models or information to build them. A species may be selected because of its own importance (economic value, management or public interest, ecological role) or because it represents (acts as an indicator for) a cover type or other species in the community that use the same resources. If a broad ecological perspective is desirable in the analysis, one or more species are usually selected to represent others. The following pages describe some problems we have seen with three approaches to a broad ecological perspective, suggest when they may be appropriate, and illustrate pitfalls to be avoided.

Surrogates

Species may be selected as surrogates (substitutes) for others. One of the main needs for surrogates arises when no model exists for the species of interest and insufficient time or information is available to build one. This is a legitimate reason, but careful planning is needed to avoid problems. The following example from a report we reviewed illustrates one significant disadvantage of using surrogate evaluation species.

The study was conducted on a public hunting area that was to be managed for a small number of species. These included ring-necked pheasant *(Phasianus colchicus),* northern bobwhite *(Colinus virginianus),* wild turkey *(Meleagris gallopavo),* and white-tailed deer *Odocoileus virginianus).* All four were initially proposed as evaluation species; however, the planners ultimately chose to include only the pheasant along with five other birds and two small mammals for evaluating terrestrial habitat quality. Apparently they intended to conduct a broad ecological assessment while obtaining information on habitat quality for the real target species by extrapolation from surrogates.

This example shows that failure to examine each model carefully to determine what habitat variables will be measured can result in inadequate or misleading results. None of the models they used includes a variable that will adequately estimate either the quantity or quality of deer browse. A model for one species, the fox squirrel *(Sciurus niger)* (Allen 1982), does include the variable "percent shrub crown cover" from which some estimate of browse quantity might be inferred. However, it is conceivable that an area could have a moderately dense understory (therefore assumed to be favorable for deer) while actually being of little value due to unpalatable or low quality browse species. The model for the turkey (Schroeder 1985a) emphasizes winter food and summer feeding and brood rearing areas. There is enough overlap in variables from the other models for a partial estimate of turkey habitat quality to be made, although some factors known to be important components of turkey habitat (evergreen and soft-mast producing trees) are not covered. Similarly, not all components of bobwhite habitat can be examined through the other models.

The amount of information that can be exrapolated from surrogates to the target species may vary greatly. An evaluation sufficient for management can only be assured by careful selection of enough species so that all the major variables from the target species' models are represented. This could result in having to select an excessive number of species. The alternative of choosing the species of direct interst is preferable.

Community Representatives

A practice with a great deal of appeal is the use of animal species to "represent" a plant community or cover type. HSI model score(s) are calculated and converted into a single overall quality rating for the community or cover type itself. The concept appears simple, and there are valid reasons for wanting procedures for assigning values to cover types (e.g., the use of Resource Categories). However, we have found that the results of such a procedure may be difficult to interpret or even contradictory.

The black-capped chickadee *(Parus atricapillus),* downy woodpecker *(Picoides pubescens),* and fox squirrel were selected to represent the upland forested areas on one project we examined. These species appear to be reasonable choices, as collectively they require mature forests with a number of hard mast producers and several snags per acre (0.4 ha)

However, an examination of each model's variables reveals that the habitat requirements of the species are sufficiently different to make a judgment about cover type quality difficult. For example, the chickadee and woodpecker are cavity nesters with a dependence on snags. Models for both species (Schroeder 1982a, 1982b) include a variable to account for snag availability, with five snags per acre (0.4 ha) required by the downy before the Suitability Index reaches its optimum value (Figure 1); the equivalent variable in the chickadee model attains an optimum value with only two snags per acre (0.4 ha). Because the reproductive life requisite of both species is determined solely by the number of snags, an area with two snags per acre (0.4 ha) would have an HSI of 1.0 for the chickadee but only 0.4 for the downy.

A similar situation is found in a comparison of the canopy closure preferences of the fox squirrel and the chickadee. In the squirrel model (Allen 1982), the curve for tree canopy closure peaks at 20 percent remains at optimum until 60 percent (Figure 2). The chickadee requires a more dense canopy, and the value for the same variable

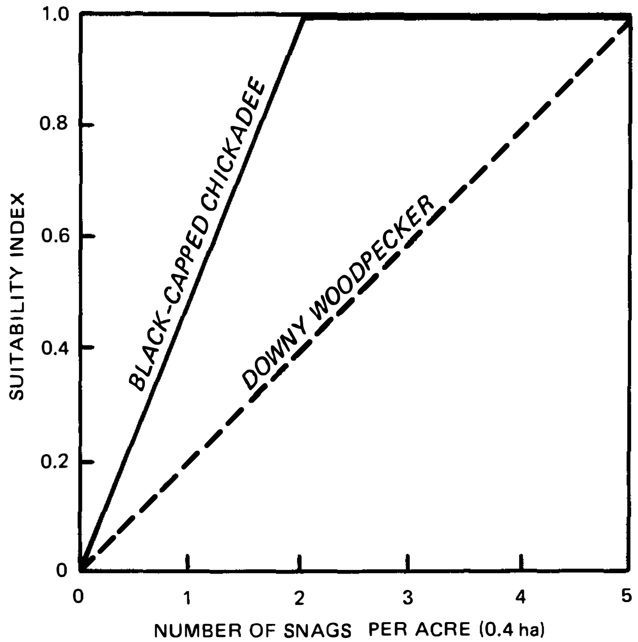


Figure 1. Suitability index curves for the number of snags per acre for black-capped chickadee and downy woodpecker (Schroeder 1982a, 1982b).

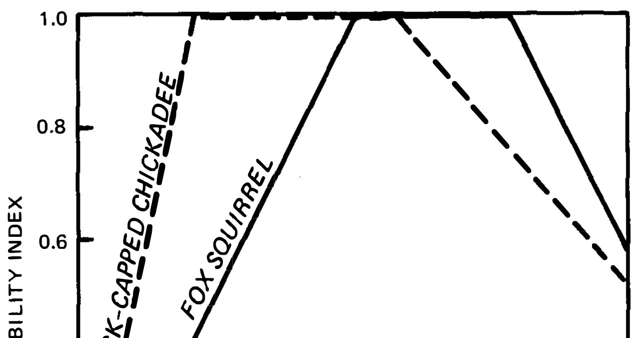


Figure 2. Suitability index curves for tree canopy cover for black-capped chickadee and fox squirrel (Allen 1982, Schroeder 1982a).

does not peak until 50 percent (Schroeder 19082a). If an area has a canopy closure of 20 percent and other variables are at their optimum values, the HSI would be 1.0 for the squirrel and 0.6 for the chickadee.

Faced with this situation, what score would a manager assign to the upland forests? Should the scores be averaged,, minimum ratings used, or a weighting scheme introduced? Possible scores in our example range from below average to optimum, although we have only considered a subset of variables in three species models. It is not difficult to envision the variation that could be encountered when more species are included. In some cases, the same variable for two species may have opposing curves (Figure 3).

What happened in our example was that the "pseudo guild" of upland forest users was too imprecise to allow meaningful inferences to be drawn regarding overall site quality. All that could be meaningfully done with the information gathered was to use the separate HSI's to make species specific value judgments. Inferences might also be made regarding habitat quality for closely related "true guild" members, but little else beyond that. To provide a better perspective of the community it would be necessary to redesign the study and select species that represent all the major guilds, or to develop a community HSI model.

Guild Indicators

A guild as defined by Root (1967) is ". . . a group of species that exploit the same class of environmental resources in a similar way." The guild concept has been recommended for allowing extrapolation of results from the evaluation species to

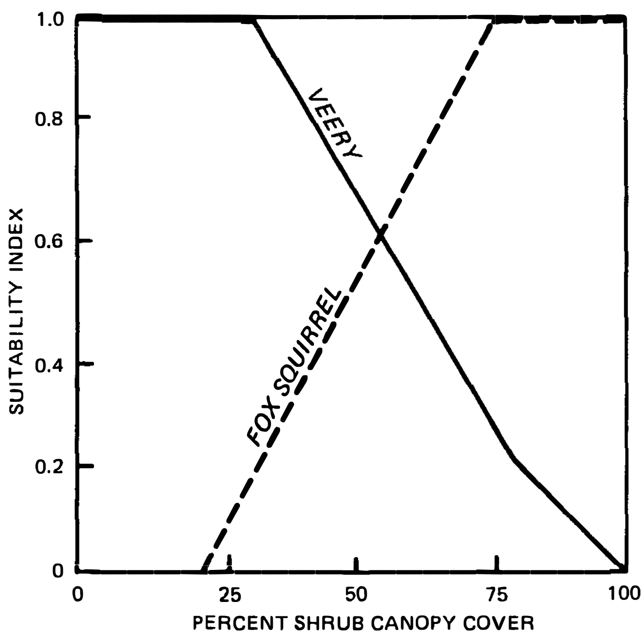


Figure 3. Suitability index curves for shrub canopy closure for fox squirrel and veery (Allen 1982, Sousa 1982).

larger groupings (U.S. Fish and Wildlife Service 1980, Severinghaus 1981). The concept has intuitive appeal and application to the habitat assessment process, because species exploiting resources similarly should logically be affected similarly by the alteration of those resources. This is a reasonable assumption if guild construction and species selection are done well, and if the degree of similarity among species is large enough. However, both the validity of, and techniques for, using guilds have come into question (Jaksić 1981, Landres 1983, Mannan et al. 1984. Verner 1984), and the amount of information that can be reliably obtained may often be insufficient.

Guild construction. Landres (1983) noted "... a guild is an artificial construct of the investigator for purposes of analysis in addressing certain questions." Therefore, it may be constructed according to any framework the user desires. If an assessment is being conducted to evaluate potential changes in habitat structure due to timber management, guilds might be built using vegetation layers or other structural components. If a broad ecological perspective is desired for a large-scale inventory, guilds might be constructed to emphasize cover type diversity (e.g., grassland, deciduous shrubland, etc). ESM 102 suggests a structure based on feeding and reproductive habits.

We believe that the guild block concept of Short and Burnham (1982) is desirable in that it concentrates on structural features of vegetation (layers) rather than taxonomy, feeding strategy, size, or other ambiguous relationships. Thus, there is a strong link to habitat. Combining feeding and reproductive loci eliminates the need for two separate types of guilds, which can be confusing. Table 1 is an example of a guild framework based on layers and other significant habitat features.

Species selection. Current guidance outlined in ESM102 emphasizes the "guild indicator" (terminology of Verner 1984) approach to species selection. The user should ask, what is the most representative species, the one(s) that best represents the guild cell and its other members? Depending on the nature of the impact and purpose of the assessment, a more specialized species (e.g., one found in only one cell) probably is preferable. When a species is assigned to more than one cell, it may or may not be severely affected by an impact on only one cell. How many species are adequate? The number of species is partially controlled by the resources available to collect data. Because it is unlikely that all guilds need to be represented, priority should be placed on those most affected by the impact.

Extrapolation. Because the basis for guild construction determines how species are allocated to a guild, and therefore what species are members of the same guild, it also places some bounds on extrapolation. Similarity of resource partitioning within guilds will allow extrapolation of results from evaluation species to associated guild members; however, biologists should be aware that the relationships may not always be as direct as they might like. Guild blocks are constructed around very gross habitat features; consequently, even species in the same guild may not use resources in exactly the same way. Mannan et al. (1984) found inconsistent responses within guilds (measured by bird abundance) to altered vegetation structure and felt that this precluded the use of only one member of each guild as an indicator. Although the process of extrapolation is not invalidated, this research does highlight the importance of critically examining each species' habitat requirements before deciding which other species would be similarly affected by a given habitat alteration.

Table 1. A deciduous forest guild based on layers of vegetation and other features used for feeding and breeding.

	Overstory canopy	Overstory bole and limbs	Mid- and understory canopy	Mid- and understory bole and limbs	Snags	Large shrubs	Small shrubs and woody vines	Ground cover	Litter and bare ground	Elsewhere
Overstory canopy										
Overstory bole and limbs										
Mid- and understory canopy										
Mid- and understory bole and limbs										
Snags										
Large shrubs										
Small shrubs and woody vines										
Ground cover										
Litter and bare ground										

The directness with which inferences can be drawn fron one model to another depends largely on the number of shared model variables and on the similarity of the variable curves. The following example will illustrate this point. The northern bobwhite and eastern meadowlark *(Sturnella magna)* are ground dwelling birds and occupy the same guild block. Both require grassy areas for nesting and consequently both HSI models include variables that quanity the structure of ground level vegetation. An examination of habitat requirements of the two species reveals that although there are some similarities, the two species require very different structure. The bobwhite prefers relatively open areas with a grass canopy cover of 40 to 60 percent and heights of 16 to 24 inches (40 to 60 cm) (Schroeder 1985b). A moderate proportion of the ground (30 to 60 percent) should be relatively bare or covered with light litter. On the other hand, the meadowlark prefers much denser and shorter vegetation where the total herbaceous canopy cover is at least 90 percent; of that, 80 percent should be grass. Preferred heights are between 6 and 14 inches (15 and 35 cm) (Schroeder and Sousa 1982).

While it would not be meaningful to use the index of quality for one species as a direct estimator of habitat quality for the other, this does not mean that inferences about quality cannot be drawn. Depending on the level of detail desired, project biologists could simply estimate the values for the nonevaluation species, or they could choose to re-analyze the field data using the variable curves in the other model. The latter procedure may not be the most direct means of gaining information about guild members, but it is an option that has become less difficult with the increased availability of HSI software.

With traditional guilds like those in Table 1 it may be necessary to expend additional effort to gain information; however, the effort should not be great in proportion to the return. In the majority of studies, the data gathering phase usually requires the most effort. Once the data have been collected and summarized, it is relatively simple to manipulate them for a variety of purposes. When viewed in this light, some of the criticisms of the "guild indicator" concept appear less severe.

We feel that the concept of direct information extrapolation among guild members is often misunderstood. It is likely that only at the highest levels of guild detail will direct comparisons of habitat quality be possible. In fact, it might be necessary to construct guilds according to measurable descriptors of the model variables themselves. Instead of having a single guild of "tree canopy users," construction of guilds of "open canopy users" and "closed canopy users" might be required to reduce variability within the guild and allow direct inferences about habitat quality for non-studied species. This process could be used in any guild block where a gradient of habitat conditions might be encountered. The major drawback would be the greatly increased complexity and effort resulting from the large number of guild blocks.

Whole Guilds

The procedures outlined by Short (1983) and Verner (1984) offer an alternative to selecting one or more species from a guild cell. The "whole guild" approach emphasizes species richness with the entire guild (all the species in a cell) as the evaluation unit; therefore, the problem of dissimilarity in resource use among guild members is eliminated. This concept has been applied in the field, although it has not yet been widely used.

Some limits to its usefulness exist. First there can be a great deal of uncertainty in interpreting the results of a whole guild analysis. This is supported by Mannan et al. (1984), who found inconsistent reactions among guilds to the land use differences being examined. By design, the technique includes little information about plant species composition, density of overstory or understory, soil type, etc. As a result, it may be possible to draw only general inferences about habitat changes that have resulted in an increase or decrease in the number of guild members. It may be difficult to assess the factors which contribute to habitat quality differences (as reflected by the guild members) even in simple situations when the habitat factors themselves are not measured directly. The difficulty is greatly magnified when a gradient of habitat conditions is considered, for example in determining the effects that various levels of thinning might have on a guild of tree canopy users.

Another consideration is that animal censuses may be difficult and time consuming to conduct. Bird counts, which form the basis of Verner's (1984) procedure, require specialists who may not always be available. Additionally, seasonal considerations often do not coincide with project timetables. In spite of these shortcomings, the concept is noteworthy (particularly for low resolution studies) and should be the subject of continued research.

Conclusion

The outcome of a HEP analysis is largely determined by the species selected for evaluation. Because land use changes affect species in different ways, the results of an impact analysis can vary greatly, depending on the species chosen. We have seen cases in which species were apparently chosen without an appreciation for this influence. Users may have been of the perception that HEP is to be applied mechanistically, with little flexibility possible in guiding the applicaiton, i.e., they failed to regard HEP as a planning tool.

The notion of guiding impact studies may be difficult for some to accept given the increasingly quantitative nature of the wildlife management profession; however, human values and perceptions will always play a major role in natural resource decision making. We are simply suggesting that this be acknowledged and that the concept of a totally objective study be discarded. Once this is accepted as legitimate in conducting impact studies, the quality and reliability of those studies will improve.

The comprehensive study requiring a broad ecological perspective has been particularly troublesome for many HEP planners; guild theory can be used in a multitude of ways and appropriate options should be explored. Root's (1967) original definition of guilds has been modified and some might say abused. We treat it as a case of the scientific arena providing a potentially useful tool for the planning and management arena. Guilds can be used to streamline extrapolate, and otherwise reduce complexity. A basic drawback then, is the knowledge that small pieces of information, some perhaps important, are lost. We hope that some of the thoughts in this paper and those we cited will encourage researchers to improve on guilds as a species selection tool, and will help users to be more alert to the subjectivity and professional judgment inherent in and necessary to a meaningful habitat evaluation.

Acknowledgements

This work was conducted under the Environmental Impact Research Program (work unit 31729) sponsored by the Office of the Chief of Engineers. We thank C. O. Martin, A. C. Miller, B. S. Payne, P. J. Pierce, M. L. Schamberger, W. D. Severinghaus, H. K. Smith, J. D. Verner, and J. S. Wakeley for their review comments and suggestions and D. M. Roberts for typing early drafts.

Literature Cited

Allen, A. W. 1982. Habitat suitability index models: fox squirrel. FWS/OBS-82/10.18. U.S. Fish and Wildlife Service, Washington, D.C. 11 pp.

Jaksic, F. M. 1981. Abuse and misuse of the term "guild" in ecological studies. Oikos 37:397-400.

Landres, P. B. 1983. Use of the guild concept in environmental impact assessment. Environ. Manage. 7:393-398.

Mannan, R. W., M. L. Morrison, and E. C. Meslow. 1984. The use of guilds in forest bird management. Wildl. Soc. Bull. 12:426-430.

Root, R. B. 1967. The niche exploitation pattern of the blue-gray gnat-catcher. Ecol. Monogr. 37:317-350.

Schroeder, R. L. 1982a. Habitat suitability index models: black-capped chickadee. FWS/OBS-82/10.37. USDI Fish and Wildlife Service, Washington, D.C. 12 pp.

_____. 1982b. Habitat suitability index models: downy woodpecker. FWS/OBS-82/10.38. USDI Fish and Wildlife Service, Washington, D.C. 10 pp.

_____. 1985a. Habitat suitability index models: eastern wild turkey. USDI Fish and Wildlife Service. (In preparation).

_____. 1985b. Habitat suitability index models: northern bobwhite. USDI Fish and Wildlife Service. (In preparation).

_____, and P. J. Sousa. 1982. Habitat suitability index models: eastern meadowlark. FWS/OBS-82/10.29. USDI Fish and Wildlife Service, Washington, D.C. 9 pp.

Severinghaus, W. D. 1981. Guild theory development as a mechanism for assessing environmental impact. Environ. Manage. 5:187-190.

Short, H. L. 1983. Wildlife guilds in Arizona desert habitats. Tech. Note 362. USDI Bur. of Land Manage. 258 pp.

_____, and K. P. Burnham. 1982. Technique for structuring wildlife guilds to evaluate impacts on wildlife communities. Special Sci. Rep—Wild. 244. USDI Fish and Wildlife Service. 33 pp.

Sousa, P. J. 1982. Habitat suitability index models: veery. FWS/OBS-82/10.22. USDI Fish and Wildlife Service, Washington, D.C. 12 pp.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP). Ecological Services Manual 102. USDI Fish and Wildlife Service, Washington, D.C.

_____. 1981. U.S. Fish and Wildlife Service Mitigation Policy. Federal Register 46(15):7644-7663.

Verner, J. 1984. The guild concept applied to management of bird populations. Environ. Manage. 8:1-14.

Water Resources Council. 1983. Economic and environmental principles and guidelines for water and related land resources implementation studies. Water Resources Council, Washington, D.C.

Application of Expert Systems in Wildlife Management

Gary C. White
Department of Fishery and Wildlife Biology,
Colorado State University,
Fort Collins, CO 80523

Len H. Carpenter
Colorado Division of Wildlife,
317 W. Prospect St.,
Fort Collins, CO 80526

David R. Anderson
Colorado Cooperative Fish and Wildlife Research Unit,
Colorado State University,
Fort Collins, CO 80523

Introduction

Artificial intelligence (AI) has been an area of basic research for over 20 years. Four areas of interest in AI are speech/natural language recognition, vision/image analysis, robotics, and expert systems (also termed consultation systems). A loose definition of AI might be "the science of creating machines that emulate the human mind" (Shannon 1984). Now AI is beginning to provide practical results, particularly in almost-off-the-shelf expert systems. AI tools are now becoming available to help technicians develop and maintain their own expert systems, provided they understand what an expert system is and what kinds of problems it can solve (Rauch-Hindin 1983). The purpose of this paper is to provide our ideas on applications of expert systems to wildlife management, with examples of where expert systems can contribute, and where expert systems may fail.

What is an expert system? AI systems cannot provide solutions for problems that humans do not know how to solve. Rather, expert systems encode the information of many experts into computers, and therein lies the power of expert systems—in that knowledge, not in clever programming. An expert system is a program that can perform at the level of a human expert by mimicking the activities that a human expert would undertake in the resolution of a problem.

Expert systems consist of two components (Rauch-Hindin 1983). The first is the knowledge base. This base, in some symbolic manner, represents facts, judgments, rules, intuition, and experience about a particular narrow problem area, with emphasis on the word "narrow". This limitation makes it feasible to provide a computer program with sufficient knowledge to make decisions in a restricted area.

The second component of an expert system is the inference mechanism or inference engine. It can interpret the knowledge base and perform logical deduction and certain knowledge base modifications to make decisions (Rauch-Hindin 1983). The inference mechanism does not change with time, while the knowledge base continues to grow as supporting experts contribute additional information. Complexity of the mechanisms to store knowledge, plus the inference mechanism, distinguish an expert system from a data base. Data bases generally lack mechanisms to store common sense knowledge, whereas expert systems make this feasible. In contrast, sophisticated computer models generally do not use a large data base to draw inferences, but rather a small amount of knowledge (relative to an expert system) combined with a rigid inference mechanism to provide outputs.

Some of the most successful expert systems have been developed in the medical fields. MYCIN (Duda and Shortliffe 1983, Shortliffe 1976) aids physicians in the selection of antibiotics for patients with severe infections. INTERNIST-1 is designed to undertake diagnosis for all problems in internal medicine (Miller et al. 1982). DENDRAL (Lindsay et al. 1980) is used in organic chemistry laboratories throughout the world to deduce the structure of organic molecules from mass spectra, nuclear-magnetic-resonance data, and other kinds of information. PROSPECTOR is a consultation system to aid in mineral exploration, designed for problems in regional resource evaluation, ore deposit identification, and drilling site selection (Duda et al. 1979).

One of the advances making expert systems readily available to non-experts is the increase in the power of micro-computers. Desk top machines are as powerful as main frames of the 1960s. In addition, software for the development of expert systems (expert system "toolkits") is now available for micro-computers (e.g., REVEAL and Expert-Ease operate on an IBM PC-XT). In addition, EMYCIN, ROSIE, and KAS-PROSPECTOR are programs to develop expert systems which run on mini-computers, such as the VAX series of DEC.[1] These programs provide the inference mechanism, but knowledge engineers must provide the knowledge base by questioning experts on the problem, although the programs provide logical methods to do so. Besides software that runs on existing machines, some manufacturers are providing desk top computers that are specially designed for AI applications (e.g., Symbolics Inc., Cambridge, MA). In these cases, hardware is designed to be especially efficient for symbol processing necessary to run an expert system.

As an example of an application of an expert system to wildlife management, consider the Endangered Species Program in the United States. A large and extremely diverse segment of our society is involved in this program: staff in various state and federal agencies; technical people in consulting and engineering firms; biologists in universities and institutes; scientists in research and development organizations; and businessmen in many forms of commerce. These people need objective, timely answers to a wide array of questions ranging from legal to technical to procedural to regulatory. Some information needs are simple, such as a current list of threatened and endangered species, extent of critical habitat for a particular species, or the office that can provide details on procedures, forms, and permits. Others are involved in broader, more complex issues, such as aspects of the CITES Convention, specific recovery plans, technical material from the Office of the Scientific Authority, or specific consultation requirements. An expert system would potentially serve these information needs, be able to "learn" and update itself easily, and aid directly in decision making. Diverse user groups could make inquiries concerning sophisticated issues, much as if a number of experts were available on the issue. The expert system would ask questions and process answers from the user, just as in a consulting session with a team of experts.

[1]The use of trade names or commercial products does not constitute an official endorsement of the product described.

A second example of an expert system applicable to wildlife management is the selection of an appropriate population estimation technique for a particular wildlife species in a specific habitat. Many methods of population estimation currently exist for wildlife populations, such as capture-recapture, line transects, quadrats or strip transects, and change-in-ratio sampling. The biologist facing such a decision either relies on past methods that have proven effective, or consults an expert, because the mass of literature on this topic precludes a short survey. Hence the need for an expert system. Some of the questions that an expert system would ask are: (1) can the animal be captured easily, (2) is the animal visible to observers (i.e., nocturnal or diurnal), (3) is the animal mobile, and (4) is the population geographically or demographically closed? Cost functions for field procedures would be needed, as well as information on precision required for the project. We believe that such a system is reasonable because of the similarity of the problem to other examples where an expert system has been successful. For example, MYCIN is basically a classification process, just as is this example. In theory, a very large binary key, such as a plant taxonomy key, could be developed. In practice the number of decisions probably preclude this brute force approach, and suggest the reasoning power of an expert system is needed.

Discussion

Benefits of an expert system are numerous. The knowledge base provides an information repository, and a very practical summary on the state of the art of the problem being addressed. This information repository would be an excellent educational tool. Students could access the expert system to provide hands-on training. Expert systems such as MYCIN provide their reasons for reaching a particular decision, further enhancing their capability as an educational/training tool. In addition, the expert system frees experts from routine, repetitive decisions so they may concentrate on more challenging problems.

Expert systems are developed from expertise of more than one expert, and thus provide greater experience than any one individual. A better grasp of the total situation is provided by this enhanced experience. In addition, the expert system is repeatable, since it will not have "sick" days and periods of low productivity. More importantly, the expert system is unemotional and totally objective, assuming that the knowledge base is developed objectively. Thus the expert system is beyond the influence of politicians in sensitive issues.

Additionally, the expert system has total recall. Information is not lost or forgotten. Numbers, such as variances from past experiments, in the case of population estimation, can be recalled with complete accuracy at the moment needed. Internal consistency checks can be made. Additional information can be added as it becomes available.

Once an expert system is developed, its application will be very economical. However, the large cost of development (manpower) of an expert system may preclude a cost/benefit ratio > 1 over its lifetime. Only reoccurring problems will be practical for the development of an expert system.

On the negative side, expert systems can reach incorrect decisions, necessitating a very comprehensive validation process. Development of an expert system, even with the sophisticated tools becoming available, is not to be taken lightly.

Finally, the most limiting factor in development of an expert system is knowledge. An expert system cannot solve a problem that human experts cannot solve if basic information is lacking. We believe this will be the most limiting in the application of expert systems to wildlife management. The commonly heard statement that the practice of wildlife management is an "art" implies that basic knowledge needed to scientifically manage a population is partially lacking. Hence development of an expert system to solve such a problem is likely to be only partially successful.

A session at the 1984 American Association for Artificial Intelligence meeting was titled "The coming Dark Ages of AI." The thesis for this discussion was that public expectations of what AI can do are much too high; the inevitable failure to meet these expectations may prompt a slashing of support for both basic and applied research, with the eventual near disappearance of AI. In response to various myths about AI, several facts were presented: (1) it takes someone with more backgound than a tutorial, a book, and a few interested friends to build a useful expert system; (2) even persons successful in the past at building an expert system will occasionally fail, so that we should not expect all attempts at building expert systems to be successful; and (3) expert systems will err, but do approach or even exceed the performance of human experts (where a tolerance of some mistakes is allowed).

Literature Cited

Duda, R., J. Gaschnig, and P. Hart. 1979. Pages 153-167 *in* D. Michie ed. Expert systems in the microelectronic age. Edinburgh Univ., Edinburgh, Scotland.

Duda, R. O., and E. H. Shortliffe. 1983. Expert systems research. Science 220:261-268.

Lindsay, R. K., B. G. Buchanan, E. A. Feigenbaum, and J. Lederberg. 1980. Applications of artificial intelligence for organic chemistry: the DENDRAL project. McGraw-Hill, New York. 194 pp.

Miller, R., H. Pople Jr., and J. Myers. 1982. Internist-I, an experimental computer-based diagnostic consultant for general internal medicine. New England J. Med. 307:468-476.

Rauch-Hindin, W. 1983. Artificial intelligence: a solution whose time has come. Systems & Software 1:150-177.

Shannon, T. C. 1984. The shape of machines to come. DEC Professional 3:125-134.

Shortliffe, E. H. 1976. Computer-based medical consultations: MYCIN. Elsevier/North-Holland, New York. 264 pp.

New Role for Science in National Parks

C. J. Martinka
National Park Service
Glacier National Park
West Glacier, Montana 59936

Introduction

National parks represent a unique form of public land management that originated in the nineteenth century. Emergence of the concept is traceable to a growing need for some form of cultural identity in the United States (Runte 1979). As the century ended, establishment of the first national parks was a dramatic departure from widespread utilitarian attitudes and policies toward public land use. However, the cultural roots of the concept were in place and public support for parks grew in the early twentieth century. The National Park System has continued to expand and currently provides a model that has been adopted by countries throughout the world.

The first national parks were established largely for their attractiveness as scenic monuments (Runte 1979). Management during the early years was pragmatic and sought a fair and supportable balance between preservation and use (Everhart 1983). Public use was considered politically essential, but once the matters of park protection and visitor needs were addressed, attention was directed toward the aesthetic value of parks (Albright 1933). The shift in management strategy required knowledge that was not available and fostered the beginning of a science program for the national parks.

This paper addresses the role of scientific research in the development of national park management as well as the emerging role of national parks as scientific resources. These roles have been distinguishable for nearly a century and it has only been recently that their synergistic characteristics and significance have been recognized. Background information was obtained from published literature, agency reports, park scientist interviews and personal experience as a park research biologist from 1967-85.

Science Program History

The history of biological research and management in the national parks has been thoughtfully discussed by Sumner (1983). He described a cyclic pattern in the evolution of park science beginning with its birth and extending through successive periods of growth, neglect, and recovery. Each period had characteristics that were both scientifically and organizationally distinct.

A gradual awakening to ecological principles and their application to park management occurred during the early decades of the century. The philosophical foundations for park science likely originated from the teachings of Joseph Grinnell. He recognized that inherent park values extended beyond scenic beauty and emphasized that natural conditions and evolution should be a purpose of parks. The naturalist program of the newly created National Park Service (1916) was first to take advantage of these new ideas and information. Their interest resulted in the formal establishment of a Branch of Research and Education in 1930.

The period of ecological awakening was accompanied by a growing awareness that environmental deterioration was occurring in many parks. In an effort to address this concern, George Wright began systematic wildlife surveys in the parks in 1929. His studies were personally financed and were clearly intended to collect information that would help preserve native values of wilderness. The undertaking was innovative by any measure and demonstrated the importance that many scientists attached to the national park concept.

The wildlife surveys marked the beginning of a new and exceptionally productive period for park science. In 1932, a Wildlife Division was created in the Branch of Research and Education with a sole purpose of organizing ecological research and managing biological resources. The published results of the first wildlife surveys directed program emphasis toward the prevention and correction of wildlife problems (Wright et al. 1933). By 1936, 27 staff biologists were in place and their contributions to park management and wildlife science were substantial. Of special note were the faunal monographs which quickly attained status as classic wildlife field studies. Few would disagree that significant progress was made toward restoration of natural park conditions during the 1930s.

The era of George Wright and the Wildlife Division was followed by nearly two decades that are best described in terms of neglect. National attention turned to war, science support severely reduced, and new study efforts deferred indefinitely. The eclipse in scientific activity extended well after the war, suggesting that other factors were also involved. The decades of neglect came to an end as scientists and managers again identified the presence and consequences of ecological deterioration in the parks. In 1958, a small research budget was created, and better days were ahead for science in the parks.

The science program revival accelerated with the completion of two important program reviews. In 1963, a report on wildlife management in the national parks provided strong encouragement for an expanded science program (Leopold et al. 1963). It was followed by a second evaluation that more fully addressed natural history research needs and opportunities in the national parks (Robbins et al. 1963). The combined influence of these documents moved the science program into a period of sustained recovery.

The recovery period was characterized by an expanding staff, improved financial support and a functional field organization. Under the leadership of a chief scientist, the program developed into a small but identifiable unit of the national park management organization. Field scientists were assigned topics that dealt with ecological problems or provided a basis for sound management of natural processes. Wildlife studies continued as a prominent part of the program with renewed emphasis on ungulates and predators. In addition, sensitive species, such as the crocodile *(Crocodylus acutus)*, and dangerous species, represented by grizzly bears *(Ursus arctos)*, received much needed attention. Perhaps most important was the beginning of a much broader base of ecological research designed to foster an understanding of such diverse issues as wildfire ecology, plant species requirements, and human sociology (U. S. Department of the Interior 1976).

By 1970, the environmental movement, congressional action, and administrative policy began to exert a substantial influence on the developing science program. As a new decade unfolded, laws required that air and water quality be addressed, endangered species be given greater consideration, and ecological data incorporated into all management decisions relating to natural resources. Public attitudes fueled the movement toward environmental awareness and placed the integrity of national parks in a priority position. The science program responded and progressed toward a diverse organization with potential for addressing a spectrum of needs from development planning to legislative compliance. Not unexpectedly, organization structure became dynamic as it sought a new identity in changing times. As the decade came to a close, the entire program matured, and a trend toward consolidation became apparent.

In retrospect, the two decades of program recovery were both dynamic and productive. National park science regained momentum, quality, and credibility reminiscent of earlier years. At the same time, the scientific community increasingly recognized the inherently unique attributes of parks as natural areas. As a result, many parks became theatres for independent research projects. Scientists from government agencies and university campuses not only proposed park research, but also provided much of the needed financial support. Their independence often led to the treatment of basic research questions, a dimension frequently lacking in the applied atmosphere of park science programs. Cooperative studies helped to reduce the scientific isolation of parks and promoted a trend toward regional ecosystem management.

Park science programs made numerous contributions of general scientific interest during the recovery period. Examples include the role of fire in natural ecosystems (Kilgore 1976), experimental design in wildlife management (Cole 1971, Houston 1982), value of long-term studies (Allen 1979), dynamics of natural systems (Dolan et al. 1984), and collection of baseline environmental information (Herrmann 1982). Each of these, as well as other contributions, carried the results of national park science well beyond park boundaries and into the realm of general management concepts. As such, the seeds for a new role for park science were planted during the program recovery era.

Current Science Program

Scientific research in the national parks is currently administered as an integral part of the natural resources management program. Policy reflects an organizational commitment by clearly stating that natural and social science information is necessary for management of the National Park System. Furthermore, policy directs that a program will be conducted to provide accurate scientific data upon which all aspects of planning, development, and management of the various park resources may be based. In the absence of adequate knowledge, natural resources programs are designed to maintain the status quo or prevent irreversible damage until adequate research data are available. The national park science program is somewhat unique in that it developed from a base of organizational support rather than as a response to a legislated mandate.

The science organization is best described as decentralized, with operational responsibilities resting in ten regional offices and a number of larger parks. Exceptions include air and water programs as well as special needs programs which function largely at the national level. Regional programs serve as the administrative backbone for scientific research in the parks by providing study funds, contracting support, and general continuity as needed. Regional scientists are assigned to parks or universities and conduct or direct research studies identified as important in park natural resources management plans. A university scientist may be stationed in a park or at a cooperative park studies unit on campus. The university program is of relatively recent origin and adds an academic dimension to park science. In particular, access to the full spectrum of university resources and expertise is an important feature of the cooperative units.

Science programs at the park level are administered as an integral part of the park organization. Scientists are typically permanent staff, with the park budget providing a continuing and relatively predictable source of financial support. Park programs are distinctive in that they provide an opportunity for continuity, monitoring, and follow-up on field research projects. In addition, staff scientists are available as technical consultants, a service that most managers utilize extensively.

Research contracts and cooperative agreements are an important part of the science program at the national, regional, and park levels. These tools complement staff capabilities by exploring for and utilizing the technical talents of other agencies and universities. Administratively, they are especially effective for short-term projects designed to fulfill specific study requirements. Their usefulness extends from small graduate student projects to major interdisciplinary investigations.

In keeping with the 1963 review group recommendations (Leopold et al. 1963, Robbins et al. 1963), science program content generally conforms to the specific mission and needs of the individual parks. Problems relating to the conservation of natural ecosystems are being addressed at the factor, species,community, and ecosystem levels. The value of many studies extends to groups of parks with similar ecological conditions. Other park projects reveal a trend toward regional studies and interagency team efforts. Baseline research and environmental monitoring have become more important as the legal obligations of park management are more clearly understood. Finally, human sociology and advanced technology are making their way into the park science picture.

During recent years, there have been about 100 staff scientists serving the national parks in various administrative and technical capacities. In 1984, they were supported by a budget of about $18 million, which was approximately 3 percent of the total base operating budget of the National Park Service. Allocations to the national, regional, and park levels were 37, 40, and 23 percent, respectively. Recent budget and personnel stability appear to reflect the maturation of the recovery period.

Science in Future Years

Conservation of natural ecosystems has attained general acceptance as a primary mission of national parks. The conceptual foundation for this mission initially found functional utility in the identification, understanding, and solution of wildlife management problems. As knowledge about wildlife populations increased, scientists and managers broadened their perspective to the ecosystem level. Ultimately, much research in parks was directed toward documenting pristine conditions and processes, determining the completeness of park ecosystems, and developing management procedures to maintain or restore the ecosystem (Houston 1971). This trend resulted in science program diversity that was capable of addressing many of the priority needs of park managers. It seems likely that program diversity will continue to expand with, perhaps, an even greater emphasis on the role of humans in park ecosystems.

The transition to an ecosystem perspective also pointed to the need for scientific studies that extended beyond park boundaries. Most boundaries were not selected on the basis of ecological criteria and there is now some consensus among managers that boundary location and/or park size are significant problems. In fact, human encroachment and environmental changes in surrounding buffer zones are considered to represent major sources of real and potential degradation to parklands (Everhart 1983). Regional research projects, motivated by common interests and shared values, have been an important form of response to external threats issues. A typical project might involve technicians from federal, state, and local agencies as well as representatives from universities and industry.

Regional research projects possess unique attributes that complement their potential for technical performance. Most important is the cooperative atmosphere that is required by the multiplicity of involved interests. Teamwork has led to a better understanding of problems while enhancing the probability that acceptable solutions will be discovered. In addition, cooperative efforts help to assure an adequate and effective financial support base through pooling of available resources. Regional team studies have demonstrated their usefulness and will undoubtedly continue as an important part of park science programs.

Regional ecosystem analysis has been accompanied by a discernable move toward experimental management as another means of understanding and solving park problems. A conceptual model for this technique proposes that science advances most rapidly by manipulative experiments and that managers are in a position to implement the process (Macnab 1983). In practice, many park programs conform to the basic requirement that a change be instituted, but only a few have been designed in a way that carries the process through to completion. The potential effectiveness of experimental management rests on planning and implementation based on scientific principles. Technical proficiency is a requisite that is being addressed through entrance requirements and/or subsequent training of resource personnel. Experimental management will likely accelerate with improving managerial expertise and a blending of science and management roles is already underway in many parks.

Comprehensive park science programs that emphasize ecosystems analysis and experimental design have helped to reinforce the concept that national parks possess inherent scientific values. Indeed, these values were apparent to many who proposed the creation of parks and reflected in the testimony and legislation that formally established parks. The academic community has been responsive and often utilized parks as outdoor laboratories. However, managers faced with the very real challenge of protection tended to tolerate rather than encourage use of the parks as scientific resources. It remained for a growing scarcity of natural areas and a public concern for environmental quality to elevate the scientific values of national parks to a level of management significance. I propose that this change will have a profound influence on the way in which national parks are viewed and used in future years.

The potential scientific contribution of national parks was brought into focus in 1972 when the United Nations created an innovative program entitled Man and the

Biosphere. An important program goal was the establishment of a network of biosphere reserves that represented major biotic associations throughout the world. The purpose of the reserves was to (1) conserve the integrity of biotic communities and their genetic diversity, (2) provide for ecological and environmental research, and (3) provide facilities for education and training (Miller 1982). Selection of reserves emphasized the need for large conservation areas with legal protection that could be used as benchmark comparisons for nearby manipulated areas. As such, biosphere reserves would ultimately help to provide an ecological rationale for sustained use of the world's natural resources. National parks were logical selections for reserves and the National Park Service has assumed a leadership role in implementing the program.

Scientific research is a distinguishing feature of biosphere reserves. Designated parks have therefore been thrust into a new role that reaffirms their value as scientific resources. The added responsibility extends the mission of parks and offers many distinct benefits. For example, science programs will acquire the capability to implement the concept of experimental management without the need for manipulating park resources. At the same time, collection of benchmark data within parks will enhance the potential for mitigation of external threats through cooperative negotiation or legal action (Keiter and Hubert 1984). And finally, the traditional role of parks as protected sanctuaries is strengthened by regional land use allocations based on scientific principles.

The emerging role of science in the national parks presents a number of challenges that relate to both content and organization of the program. Scientific research has only gradually achieved standing in the National Park Service, partly because the tradition of the natural areas has been to protect natural resources rather than study them (Everhart 1983). However, the program is in place and actively addressing topics of perceived importance. These topics tend to focus on existing problems, symptoms rather than causes, heroic species, conspicuous phenomena, and political concerns (Franklin 1985). The topical areas were considered appropriate if not wholly adequate to meet future science needs. I concur with Franklin's evaluation that park science emphasis should shift toward long-term projects and place an even greater emphasis on the study of whole ecosystems. In addition, improved functional support seems essential if a successful transition into a new era is to be realized.

Conclusion

A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism (Leopold 1949). This enlightened observation predicted a new role for national parks and other wilderness settings with remarkable accuracy. In fact, national parks, their management, and their science programs have evolved in much the same fashion as a successful generalist species. The cultural niche of parks has expanded to include a functional role in the ecological welfare of the biosphere and the sustenance of its human population. Science has been a contributor to the expansion and established a very real presence as part of the national park management organization. Its value is moving toward a position commensurate with resources conservation and visitor enjoyment in the national park mission.

Literature Cited

Albright, H. M. 1933. Research in the national parks. The Scientific Monthly June: 483-501.

Allen, D. L. 1979. Wolves of Minong: their vital role in a wild community. Houghton Mifflin Co., Boston, MA. 499 pp.

Cole, G. F. 1971. An ecological rationale for the natural or artificial regulation of native ungulates in parks. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 36:417-425.

Dolan, R., B. P. Hayden, and G. Soucie. 1978. Environmental dynamics and resource management in the U.S. National Parks. Environmental Manage. 2(3):249-258.

Everhart, W. C. 1983. The National Park Service. Westview Press, Boulder, CO. 198 pp.

Franklin, J. F. 1985. Observations from outside. Park Science 5(2):19.

Herrmann, R. 1982. Obtaining baseline knowledge for U. S. Biosphere Reserves. Pages 103-114 *in* R. C. Scace and C. J. Martinka, eds. Towards the biosphere reserve: exploring relationships between parks and adjacent lands. U. S. Department of the Interior, National Park Service, Washington, D. C. 239 pp.

Houston, D. B. 1971. Ecosystems of national parks. Science 172:648-651.

_____. 1982. The northern Yellowstone elk: ecology and management. MacMillan Publishing Co., Inc., New York. 474 pp.

Keiter, R. B., and W. A. Hubert. 1984. An assessment of research needs to develop legal bases for challenging external threats to Glacier National Park. University of Wyoming-National Park Service Research Center Report. 67 pp.

Kilgore, B. M. 1976. From fire control to fire management: an ecological basis for policies. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 41:477-493.

Leopold, A. 1949. A sand county almanac and sketches here and there. Oxford University Press, Inc., New York. 226 pp.

Leopold. A. S., S. A. Cain, C. M. Cottam, I. N. Gabrielson, and T. L. Kimball. 1963. Wildlife management in the national parks. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 28:28-45.

Macnab, J. 1983. Wildlife management as scientific experimentation. Wildl. Soc. Bull. 11(4):397-401.

Miller, K. R. 1982. Biosphere reserves in concept and practice. Pages 7-21 *in* R. C. Space and C. J. Martinka, eds. Towards the biosphere reserve: exploring relationships between parks and adjacent lands. U. S. Department of the Interior, National Park Service, Washington, D. C. 239 pp.

Robbins, W. J., E. A. Ackerman, M. Bates, S. A. Cain, F. F. Darling, J. M. Fogg, Jr., T Gill, J. M. Gillson, E. R. Hall, and C. L. Hubbs. 1963. A report by the advisory committee to the National Park Service on research. National Academy of Sciences, National Research Council, Washington, D. C. 156pp.

Runte, A. 1979. National parks: the American experience. University of Nebraska Press, Lincoln, NE. 240 pp.

Sumner, L. 1983. Biological research and management in the National Park Service: a history. The George Wright Forum 3(4):3-27.

U.S. Department of the Interior. 1976. Research in the parks. National Park Service Symposium. Series No. 1. Washington, D. C. 232 pp.

Wright, G. M., J. S. Dixon, and B. H. Thompson. 1933. A preliminary survey of faunal relations in national parks. Fauna Series No. 1. U. S. Government Printing Office, Washington, D. C. 157 pp.

Potential Federal Funding of State Nongame Management Programs: Results of a U.S. Fish and Wildlife Service Study

John B. Loomis and Rodney W. Olson
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526

"In wildlife conservation, as in most endeavors, the bottom line is marked with a dollar sign" (National Audubon Society 1984).

The *1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* documents the substantial interest Americans have in all forms of wildlife. About 55 percent of Americans over the age of 16 (93 million persons), participate in either active or passive nonconsumptive use of wildlife (Shaw and Mangun 1984). About 17 percent of Americans over the age of 16 (28 million persons) took trips of at least 1 mile (1.6 km) from home specifically to observe, photograph, or feed wildlife. By comparison, 10 percent and 25 percent of the American public over the age of 16, hunted or fished, respectively (U.S. Department of Interior 1982).

Although participation in nonconsumptive wildlife recreation is substantially greater than participation in hunting, funding for management of nongame wildlife and nonconsumptive uses of game animals is a small fraction of total wildlife funding (Wildlife Management Institute 1975:14). Research aimed at providing federal and state agencies with information on the economic value of wildlife recreation for benefit cost analysis and national forest planning has concentrated on hunting and fishing. As of 1982, there was by one count, at least 25 angling studies and 20 hunting studies that had estimated that net economic value of these two types of activities (Sorg and Loomis 1984). This does not include the dozens of expenditure studies on hunting and fishing conducted over the last two decades.

Only about four studies exist which make a reasonable attempt to estimate net economic values for nonconsumptive uses of wildlife (Environmental Research Group 1975, Meyer 1980, Richards 1980, Stoll and Johnson 1984). At the same time, information on net economic values of nonconsumptive uses of wildlife is required for national forest planning and the Resources Planning Act (U.S. Forest Service 1984). Unfortunately, the nonconsumptive recreation use values for both 1980 and 1985 Resources Planning Act Programs have been derived largely from professional judgment since there were too few studies to develop region specific values.

One reason for the differences in funding for nongame management and research relates to the history of cooperative federal-state relationships in wildlife resources. The Pittman-Robertson Federal Aid in Wildlife Restoration Act and Dingell-Johnson Federal Aid for Sport Fish Restoration Act provide funds from excise taxes levied on firearms, archery equipment, ammunition, and fishing equipment to states to manage for game animals and sport fisheries. No such counterpart exists for nongame wildlife or to support nonconsumptive uses of game animals.

To improve research and funding of nongame species, Wildlife Management Institute recommended in 1975 that at least $40 million (about $75 million in 1984 dollars) be raised through excise taxes and other means to provide grants to states enabling them to move from nongame programs limited to "the fact finding" to "management" (Wildlife Management Institute 1975:36). In 1980, Congress passed the Fish and Wildlife Conservation Act which emphasized management of all fish and wildlife species including nongame species. No funding mechanism was authorized, but instead Section 12 of the Act required the Director of the U.S. Fish and Wildlife Service to conduct ". . . a comprehensive study to determine the most equitable and effective mechanism for funding State conservation plans and actions . . . including but not limited to: funding by means of an excise tax on appropriate items" (U.S. Congress 1980). In addition to the findings from this study, the Director was required to provide recommendations to Congress. This paper summarizes the results of this study in terms of revenue sources evaluated, amounts of potential revenue from each and the equity of each item studied. The reader desiring a more detailed presentation should see U.S. Fish and Wildlife Service (1985).

Sources of Revenue

Based on testimony during Congressional Hearings on the Fish and Wildlife Conservation Act and other information, the U.S. Fish and Wildlife Service's oversight committee provided analysts with a list of possible revenue sources for evaluation. These included potential items for excise taxation, voluntary sources, and entrance fees. Space constraints prohibit discussion of all of the items suggested and this report will concentrate on a subset of those. The reader desiring a complete list and evaluation should see U.S. Fish and Wildlife Service (1985).

Evaluation Criteria

Section 12 stipulated the equity and effectiveness of each source be evaluated. To make these criteria operational, these concepts were refined to be consistent with well-established principles of taxation. In particular, equity is defined in terms of the "ability to pay" of the potential taxpayer (or contributor) and benefits received by taxpayer (or contributor) in relationship to amount paid (or contributed). Effectiveness is defined as potential level of revenue received each year and the net loss or gain in economic well-being of consumers and producers due to the tax. These four factors are hereafter referred to as Ability to Pay, Benefits Received, Funding Potential, and Economic Efficiency (respectively). Each of these factors is discussed briefly below.

Effectiveness

In terms of revenue potential from excise taxes, the two factors which must be considered are sales volume and the price sensitivity of demand for the product. Clearly, the higher the sales volume, the greater the potential for revenue derived from excise taxes. However, the greater the sensitivity of quantity purchased to price of the product, the lower the tax revenue will be. For example, if a 15 percent tax causes some consumers to reduce the amount of purchases and other consumers to stop buying the good altogether, then this could result in a large drop in sales volume. Since the tax is collected only on units actually sold, tax collections would be lower than if the good were not price sensitive.

When the tax induces consumers to switch from the newly taxed good to some other good, a loss of consumer and producer well-being occurs. The tax, by raising the product price, distorts consumer choice away from the originally preferred product and hence generates an economic efficiency loss called excess burden. It is "excess" burden because it is the loss in well-being in excess of the direct burden, the latter being the tax payment received by the government. The loss in excess burden is not received as revenue by anyone but instead resides as a loss in individual well-being. This economic efficiency loss can be measured in dollars as "consumer and producer surplus." Alternatively, if current consumption of some good is in excess of the socially optimum amount, the tax-induced reduction in the quantity consumed generates an excess benefit.

The economic efficiency loss along with the revenue potential was used to evaluate the effectiveness of potential tax sources.

Equity

When beneficiaries of a government program can be identified, a tax to finance that program can be evaluated in terms of the benefits-received linkage. Do those who receive more benefits pay more taxes than those who benefit less? Benefits from nongame wildlife programs take several forms, ranging from satisfaction gained knowing wildlife exists (existence value, see Randall and Stoll 1983) to recreational observation, photography and feeding of wildlife around the home or on travel taken specifically to visit a site for nonconsumptive wildlife recreation. In some of these cases it is relatively straightforward to measure the level of benefits since those actively photographing or feeding wildlife or making trips to observe wildlife engage in market transactions. If the level of their activity (and hence benefits) is related to their level of expenditure on photographic equipment, bird seed, or entrance fees to a recreation site, then a tax on these products or an addition to an entrance fee will often accord well with the benefits-received notion of taxation.

If on the other hand, few people who buy the product use it for wildlife recreational purposes, then a tax on that product would not be consistent with the benefits-received notion of taxation. In this paper, benefits received is evaluated in terms of what proportion of total tax paid would be made by persons using the good for nonconsumptive wildlife recreation.

When the beneficiaries of a program cannot be easily identified or society chooses not to tax along the lines of benefits received, then the ability-to-pay criterion emerges as an indicator of equity of a tax. For example, the benefits persons receive from just knowing wildlife exists is a "public good" available to all citizens regardless of whether they feed birds or visit wildlife refuges. For these public goods, economic theory stipulates mandatory payments be made by all, often as some form of income tax.

Ability to pay comparisons between taxes are made in terms of whether the tax is regressive, proportional, or progressive. A tax is progressive if the percentage of income paid as taxes rises as income increases. If the percentage of income paid as taxes decreases as income rises, the tax is regressive because lower income persons pay relatively more of their income as taxes. The tax is considered proportional if taxes paid are a constant percentage of income, regardless of the level of income.

Given these definitions of the four evaluation criteria, potential funding sources can be grouped in terms of contribution to each criterion. A discussion of the strengths and weaknesses of each of these "product groups" with respect to all of the criteria is presented.

Methodology for Implementing Criteria

Calculation of the revenue potential and economic efficiency losses associated with different tax rates normally requires an estimate of the price sensitivity or price elasticity of demand. From this information, the reduction in quantity demanded associated with different tax rates can be calculated. Revenue is estimated by applying the tax rate only on the remaining quantity of the good sold. By calculating the consumer (and when required, producer) surplus lost on those units no longer consumed, the economic efficiency loss can be compared to tax revenue received to calculate the loss in well-being per dollar of tax revenue.

For each revenue source, these estimates of price elasticity were obtained from existing demand studies by statistically estimating a demand curve from data showing quantity demanded at alternative prices or, when no data was available, by inference from economic characteristics of the product.

To evaluate the benefits-received linkages and ability-to-pay relationships, data from the nonconsumptive section of the *1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* was used (see Shaw and Mangun 1984). The Consumer Expenditure Survey performed by the U.S. Department of Labor (1978) was also utilized as a source of data on ability-to-pay relationships. Using expenditure patterns from both of these surveys, ability-to-pay indices, measuring the degree of progressivity or regressivity, were calculated.

Evaluation of Funding Sources

Voluntary Methods

Adding a "nongame checkoff" to the federal income tax return and sale of "prestige" or semipostal stamps, which include a surcharge contributed to wildlife, were both evaluated. Based on the work of Harpman (1984), a federal checkoff would have yielded an estimated $40 million in 1980. Large amounts of contributions are possible since the size of the average federal tax refund is larger than the average state tax refund.

If one semipostal stamp depicting wildlife were sold per person, with a 5 cent surcharge contributed to nongame wildlife, at least $11.3 million could have been raised in 1980. If this rate of participation (based on the West German experience) is increased to the rate in Switzerland (nine stamps per person) and the surcharge increased to 10 cents, about $200 million would have been raised in 1980.

Although these methods are voluntary, the other three criteria still apply. In particular, analysis of Idaho tax returns indicates that while contributions rise with income, the contributions as a percentage of income fall, making contributions regressive (Harpman 1984). Although contributors must feel they are able to pay, or their voluntary contributions would stop, the benefits received and economic efficiency factors are still not completely satisfied. The reason is that others who do not contribute via checkoffs or stamps can still receive the public good type benefits from nongame programs funded by others. There is nothing to prevent nonpayers from viewing wildlife around the home or getting satisfaction from knowing wildlife exists. Since individuals can benefit without contributing, economists have predicted that many people would not contribute, and the resulting overall level of funding would be below optimum if voluntary methods are relied on exclusively (Samuelson 1955).

Recreation User Fees

Table 1 shows revenue potential from each major type of federal land, assuming that half of a $1 per visit entrance fee increase is devoted to the nongame program for these five federal agencies. In 1980, the total from all five federal agencies was estimated to be $103 million. This figure is somewhat variable depending on exactly which recreation units of each agency lend themselves to actual fee collection. The ability-to-pay relationship appears regressive since most empirical studies show that recreation visitation does not increase in proportion to increases in income.

If entrance fees were paid only for entering federally owned lands for the purpose of nonconsumptive wildlife recreation, then such fees could have a strong benefits-

Table 1.

Potential sources	Revenue in 1980 (millions)
5% and 10% excise tax on wild-bird seed	$3.8 and $7.3
5% and 10% excise tax on wild-bird products	$2.4 and $4.6
5% and 10% excise tax on backpacking and camping equipment	$14.3 and $28.1
2% and 5% excise tax on off-road vehicles:	
snowmobiles	$3.5 and $8.0
off-road motorcycles	$5.9 and $14.6
four-wheel drives	$66.6 and $123.2
5% and 10% excise tax on binoculars, monoculars, and spotting scopes	$2.3 and $4.6
5% and 10% excise tax on wildlife identification manuals	$0.5 and $1.0
1% and 5% excise tax on photographic equipment and film	$25.2 and $124.0
Fees for use of Federal lands and waters:	
U.S. Fish and Wildlife Service	$12.2
National Park Service	$15.0
U.S. Forest Service	$50.1
Army Corps of Engineers	$7.5
Bureau of Reclamation	$18.3

received linkage. Two limitations to this linkage arise, however. First, if the fee is paid by all recreationists entering federal land, regardless of type of recreation they engage in, then the benefits-received linkage is reduced. Secondly, for the benefits-received linkage to be high, state expenditures of their nongame wildlife funds must generate at least some increases in wildlife at federal recreation sites where the fees would be paid.

The first limitation could be overcome by varying the level of the added entrance fee to the percentage of recreation occurring on agency lands related to nonconsumptive use of wildlife. It appears that nonconsumptive wildlife recreation represents well over half of the visits to wildlife refuges and the benefits-received linkage there would be higher than on most other types of federal land. National parks also receive a large fraction of their use related to nonconsumptive use of wildlife. Perhaps high fees at wildlife refuges and national parks and lower fees on other lands, unless a particular site's main attraction is nongame wildlife, would significantly increase the benefits received linkage.

An entrance fee can improve economic efficiency (that is generate an excess benefit) for recreation sites that are congested at the current fee (Loomis 1982). With an appropriate fee at these sites the current excess burden of crowding or nonprice rationing of capacity could be eliminated. However, for federal recreation sites which are not crowded or have no rationing of use, an entrance fee may cause an excess burden. This excess burden would occur because some current recreationists would switch to other recreation sites due to the increased fee at those federal sites, even though the cost of admitting one more user at these federal sites may be close to zero (Rosenthal et al. 1984).

Excise Taxes

Fifteen products were evaluated for potential excise taxes. These included wild-bird products, camping equipment, off-road vehicles, binoculars, wildlife identification manuals, recreational diving equipment, amateur photographic equipment, film, travel trailers, and motorhomes. Space limitations preclude extensive discussion of all items and the interested reader is referered to U.S. Fish and Wildlife Service (1985).

These products can be grouped according to ratings on certain criteria. For example, bird products, camping equipment, wildlife identification manuals, and binoculars all rate reasonably well on benefits-received grounds. The linkage is far from perfect since some persons who enjoy wildlife buy few of these products and many people who buy some of these products do not use them for wildlife-related uses. But there is more to the benefits-received linkage than the percentage of buyers using the product, primarily or secondarily, for wildlife recreation. For example, although 40 percent of the people who bought or had owned binoculars in 1980 said nonconsumptive use of wildlife was their primary purpose (Shaw and Mangun 1984), approximately 75 percent of binoculars costing more than $250 were bought by birders (Payne and DeGraff 1975). Thus, while 40 percent of binocular buyers are nonconsumptive wildlife users, the fact that the tax would be a percentage of purchase price implies that wildlife users would be paying an above average amount of the tax, on a per person basis, since they tend to buy more expensive binoculars.

This same relationship of a larger amount of tax paid than the simple percentage of buyers would indicate holds for cameras, lenses, and camping equipment.

Although 13 percent and 18 percent of persons buying camping and backpacking equipment, respectively, indicated that nonconsumptive use of wildlife was the primary reason (Shaw and Mangun 1984), this group would probably pay more tax on a per person basis than the typical purchaser of the equipment. Typically, many nonconsumptive users of wildlife purchase more expensive equipment since it is often used in backcountry and wilderness settings as compared to typical purchasers.

The analysis of amateur photographic equipment expenditures indicates that about 60 percent of sales are to buyers for whom wildlife photography was either a primary or secondary use.

Wild-bird seed and other products such as feeders, waterers, and baths also have reasonably good benefits-received linkages. Again, this relationship is less than perfect, since current state nongame expenditure patterns indicate that few birds likely to be attracted to feeders are currently being emphasized in management (Boggis and Hamilton 1984). Thus, the degree of the benefits-received linkage partly rests on the assumed relationship between interest in feeding wild birds and interest in nongame wildlife in general.

The rationale for excise taxation of other products such as off-road vehicles rests on the notion of improved economic efficiency rather than benefits received. For example, numerous studies have shown that off-road motorcycles have adverse effects on soils (Wilshire et al. 1978), on vegetation and nests of ground-nesting birds (Luckenback 1978) and on abundance and diversity of small mammals (Bury et al. 1977). These external costs to society are not currently accounted for in the purchase price or operating costs of off-road motorcycles. Therefore, the amount of these external costs can be reduced by levying an excise tax that requires the buyer to internalize these social costs when purchasing the product. The resulting reduction in habitat damage from fewer off-road vehicles would reflect an excess benefit to society from the tax (Boadway 1979, Musgrave and Musgrave 1980).

As Table 1 indicates, the amount of potential tax revenue varies significantly between potential funding sources. Bird products and wildlife identification manuals, while having high benefits-received linkages, may not, by themselves, be effective in terms of providing sufficient revenue for nongame wildlife management (cited earlier as at least $75 million). Of the other products with relatively high benefits received linkage, camping/backpacking equipment and photographic equipment/film provide significant potential revenues.

In terms of ability to pay criterion, excise taxes on products with relatively high benefits-received linkage would generally be regressive. Wild-bird seed, wild-bird products and binoculars being the most regressive and photographic equipment being nearly proportional.

As Table 1 indicates, revenue potential is moderate for snowmobiles and off-road motorcycles and quite large for four-wheel drive vehicles. An excise tax would appear to be mildly regressive, bordering on proportional, for these products, but inadequate data prevents actual measurement of the degree of regressivity.

The percentage of economic efficiency losses (at the specified tax rates) would be quite small for binoculars and photographic equipment (ranging from less than 1 cent lost per dollar tax revenue at the lowest tax rates to about 2 cents lost per dollar at the highest rates). Economic efficiency losses would be slightly higher for bird products and camping equipment, and at the 10 percent tax rate are estimated to be about 12 to 15 cents per dollar of tax revenue. The overall excess burden associated with raising a given amount of revenue would be minimized if lower tax rates were selected for price sensitive products such as camping equipment and bird products and higher tax rates were selected for more price insensitive products such as binoculars and photographic equipment (Boadway 1979).

Conclusion

This paper presents the results of a comprehensive evaluation of alternative funding sources to provide revenue for nongame wildlife management. Based on four criteria, several sources of revenue appear promising although no one source ranks best on all four criteria. Many of the potential revenue sources contribute to one or more criteria but fall short of other criteria. None of the excise taxes is capable of capturing the benefits received from the public good aspects of wildlife which are not associated with direct viewing or photographing of wildlife. Voluntary methods capture some of these benefits, but their voluntary nature makes sub-optimal funding likely due to capability to enjoy benefits of wildlife management without contributing. Annual appropriations (funded from personal and corporate income taxes) is a potential revenue source that was studied which could overcome the limitations associated with regressivity of excise taxes and the sub-optimal levels of funding associated with voluntary methods. Since sole reliance on annual appropriations does not rate well on all four evaluation criteria either, a mix of revenue sources may be a policy alternative worth considering.

As the introductory quote indicates, active management of all wildlife species will require dollars. These dollars would make possible research enabling better understanding of species-habitat relationships of nongame fish and wildlife. Currently such research is lacking until the species population diminishes through neglect to the point it becomes a candidate for threatened classification under the Endangered Species Act. More research on the economic benefits provided by nonconsumptive wildlife recreation will help to demonstrate the economic value associated with protecting nongame species habitat.

An apparent goal of many of the parties involved in development and passage of the Fish and Wildlife Conservation Act of 1980 may be stated quite simply: An ounce of prevention is worth a pound of cure. Adequately funded nongame wildlife management programs may turn out to be society's cheapest way to reduce the number of nongame species becoming listed as threatened or endangered in the future.

Acknowledgments

This paper summarizes an effort in which many people have aided. We are indebted to (in alphabetical order) Phillip Agee, Spencer Amend, Richard Coon, David Harpman, Gerald Horak, Laurence Jahn, Richard Johnson, William Mangun, Charles Revier, Charles Segelquist, and William Shaw. Each of these persons has helped to educate the authors in the many disciplines required for this study. Of course, any errors or opinions are the sole responsibility of the authors. The authors' views do not necessarily reflect those of the U.S. Department of the Interior.

Literature Cited

Boadway, R. 1979. Public sector economics. Little, Brown and Co., Boston, Ma. 467pp.

Boggis, C., and M. Hamilton. 1984. Budgeting wildlife checkoff funds: twenty states priorities. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:222-232.

Bury, R., R. Luckenback and S. Baush. 1977. Effects of off-road vehicles on vertebrates in the California Desert. Research Wildlife Report #8. U.S. Fish and Wildlife Service, Washington, DC. 22pp.

Environmental Research Group. 1975. Position paper on wildlife economic values. Georgia State University, Atlanta. 51pp.

Harpman, D. 1984. An economic analysis of the nongame checkoff. M.S. Thesis. Colorado State University, Ft. Collins. 70pp.

Loomis, J. 1982. Effect of non-price rationing on benefit estimates from publicly provided recreation. J. Environ. Manage. 14:283-289.

Luckenback, R. 1978. An analysis of off-road vehicle use on desert avifaunas. Trans. N. Amer. Wildl. and Resour. Conf. 43:157-162.

Meyer, P. 1980. Recreational/aesthethic values associated with selected grouping of fish and wildlife in California's Central Valley. Center for Natural Areas, Davis, Ca. 55pp.

Musgrave, R., and P. Musgrave. 1980. Public finance in theory and practice. McGraw-Hill, Inc., New York. 855pp.

National Audubon Society. October 1984. Audubon Action. Vol 2(2).

Payne, B., and R. DeGraaf. 1975. Economic values of recreational trends associated with human enjoyment of nongame birds. Paper presented at Symposium for Management of Forest and Range Habitats for Non Game Birds, Tucson, Az. 7pp.

Randall, A., and J. Stoll. 1982. Existence value in a total valuation framework. *In* R. Rowe and L. Chestnut, eds. Managing air quality and scenic resources at National Parks and Wilderness Areas. Westview Press, Boulder, Co.

Richards, M. 1980. An economic measure of nonconsumptive wildlife values: implications for policy analysis. Ph.D. Dissertation. University of Arizona, Tucson.

Rosenthal, D., J. Loomis, and G. Peterson. 1984. Pricing for efficiency and revenue in public recreation areas. J. Leis. Res 16(3):195-208.

Samuelson, P. 1955. Diagramatic exposition of a theory of public expenditure. Review of Economics and Statistics 37.

Shaw, W., and W. Mangun. 1984. Nonconsumptive use of wildlife in the United States. Resource Publication 154. U.S. Fish and Wildlife Service, Washington, DC. 20pp.

Sorg, C., and J. Loomis. 1984. Empirical estimates of amenity forest values: A comparative review. General Technical Report RM-107. Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Fort Collins, Co.

Stoll, J., and L. A. Johnson. 1984. Concepts of value, nonmarket valuation and the case of the whooping crane. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:382-393.

U.S. Congress. 1980. Fish and Wildlife Conservation Act of 1980. 96th Congress of the United States.

U.S. Department of Interior. 1982. 1980 National survey of fishing, hunting and wildlife associated recreation, National Summary. U.S. Goverment Printing Office, Washington, DC. 156pp.

U.S. Department of Labor, Bureau of Labor Statistics. 1978. Consumer expenditures survey: Interview survey 1972-1973. U.S. Government Printing Office, Washington, DC. 681pp.

U.S. Fish and Wildlife Service. 1985. Potential funding sources to implement the Fish and Wildlife Conservation Act of 1980. U.S. Fish and Wildlife Service, Washington, DC. 203pp.

U.S. Forest Service. 1984. Draft Environmental Statement for 1985 Resources Planning Act. U.S. Department of Agriculture, Washington, DC.

Wildlife Management Institute. 1975. Current investments, projected needs and potential new sources of income for nongame fish and wildlife programs in the United States. Wildlife Management Institute, Washington, DC

Wilshire, H., S. Shipley and J. Nakata. 1978. Impacts of off-road vehicles on vegetation. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:131-139.

Oregon's Nongame Wildlife Management Plan

David B. Marshall
Consulting Wildlife Biologist
4265 SW Chesapeake Ave.
Portland, Oregon 97201

Introduction

This paper describes an ongoing planning process for Oregon's nongame wildlife program. The Oregon Plan represents a more extensive and different approach than the Idaho plan presented last year at this gathering by Morache (1984), and differs from usual procedures by combining a strategic and operational plan into one document. It is also being prepared in the absence of a state comprehensive wildlife plan. The plan was released for public and interagency comments as a review draft on September 24, 1984 by the Oregon Fish and Wildlife Commission. We are currently making revisions to it as a result of the comments. The United States Fish and Wildlife Service has indicated the plan could become an example for a modular nongame plan with an addition that will be covered later in this paper. The Oregon Fish and Wildlife Commission will be asked to approve the plan following the revisions. In the absence of an approved version of the plan, I will first describe the draft. That will be followed by a discussion of comments received and contemplated changes. This should provide other states with an insight on problems involved in preparing and gaining acceptance of a plan of this magnitude.

Need for Nongame Plan

As in many other states, an income tax check-off provided significant funding for a nongame wildlife program in Oregon. This fund first became available in 1979. A citizen nongame advisory committee was appointed by the Director of the Oregon Department of Fish and Wildlife (hereafter referred to as the "Department") to provide advice on how the newly dedicated funds should be allocated. The committee and Department subsequently realized that, unlike the game program, there were few precedents to help guide a nongame program; program needs exceeded available funds, competition for funds could result in funding of low priority projects, and some little-known species with critical needs could be overlooked while monies went to the popular ones. In the absence of nongame wildlife program objectives, some potential contractors for studies and research submitted proposals that constituted hobby type projects rather than ones which would answer priority management needs. There was a strong need for improved program coordination between nongame activities conducted by the Department, other agencies, and private scientific and conservation organizations. Also needed was development of better understandings between private landowners and the Department of each other's goals and needs. Past planning experience showed the need for both a strategic and operational plan, as without the latter, plans often have little practical application. Required was a document that presented needed activities on a logical basis from which department budgets could be prepared and which could be used for guidance by outside parties, including contractors, volunteers, and other agencies.

It was further determined that preparation of such a plan would be beyond the capability of the existing staff, not for lack of expertise, but because of the everyday demands already placed upon them. Accordingly, the Department sought qualified contractors to work with them in preparation of a plan. The writer was selected for this task, which began in early 1983.

Plan Requirements

The passage of the Fish and Wildlife Coordination Act of 1980, more often referred to as the Forsythe-Chafee Act (P.L. 96-366), prompted us to prepare a plan which would meet U.S. Fish and Wildlife Service Federal Aid planning standards, as it became increasingly evident that existing state funding sources would not meet program requirements. We designed the plan to address the key items outlined in Section 14.4 of the Federal Aid Manual including coverage of the following: (1) a time frame of at least five years; (2) Department legal responsibilities and mission; (3) species to be addressed; (4) species population numbers, trends, and distributions as known; (5) habitat conditions and trends; (6) species objectives; (7) problems and strategies; (8) priorities; (9) program evaluation and monitoring procedures; (10) public and interagency involvement procedures; and (11) provisions for plan revision at three-year intervals. The planning standards do not contain a suggested plan format. Plans prepared by other states provided some ideas, but it soon became apparent Oregon was starting a new approach.

Three topics not in the standards were added. A major one covers those authorities and activities of cooperating agencies that pertain to plan implementation, as well as the role of key private cooperators such as The Nature Conservancy. The reason for this is rather obvious considering the fact that the Department's authority to influence habitat is limited compared to agencies which have authorities directed to land uses such as the United States Forest Service, Bureau of Land Management, Oregon Department of Forestry, and State Department of Land Conservation and Development. The latter agency oversees county and city land-use planning and zoning procedures, and about half the state is administered by the above two Federal agencies. Without the authorities possessed by these agencies, an effective nongame program could not exist in states like Oregon nor could it be effective without volunteer help from a wide range of other people including landowners, academic people, and the active field ornithologists from the private sector who monitor various birds. The plan strives to involve these groups and considers their activities and authorities to be as important as those of the Department.

We also added a short historical perspective on the program and a program justification statement.

Description of Draft Plan

Taking the draft plan by sections as shown in Table 1, Section I, outlines the purpose of having a plan, and points out that a successful nongame program must be oriented toward both species and habitats. For most species, an ecosystem or habitat preservation and management approach is emphasized, but for endangered and other species needing special attention a species approach is used. The statutory authorities and responsibilities of the Department for nongame are described. In

Table 1. Abreviated table of contents of Oregon Nongame Draft Plan.

Oregon all vertebrates except cetaceans and those designated in statutes as game species or furbearers are classed as nongame wildlife. Authority over invertebrates is vague and limited to aquatic forms. With some exceptions the plan's operational schedule primarily addresses the needs of native vertebrates which are not taken as game or for commercial purposes. The authorities of other agencies that interface with the program are subsequently described. Examples include the Endangered Species Act, Federal Land Policy and Management Act, Sikes Act, Migratory Bird Treaty Act, and National Forest Management Practices Act. Appropriate sections from Forest Service and Bureau of Land Management manuals that provide direction on administration of these statutes are cited.

Another part of Section I constitutes a justification statement for a nongame program. It cites data on nonconsumptive use taken from the *1980 National Survey of Fishing, Hunting and Wildlife Associated Recreation*(U.S. Fish and Wildlife Service and Bureau of Census 1982) and its Oregon supplement (undated) and briefly describes ecological benefits from maintaining the resource.

Section I terminates with a description of the process used for interagency and public review. Three-hundred copies of the draft were printed. Distribution was made to state and federal agencies, county planning departments, state universities, representatives of conservation, environmental, scientific, and industrial groups, potential contractors, and within the Department. Copies were also made available for public review at Department offices. A series of graphics reproduced on 35 mm transparencies was used to describe the draft plan to over 25 groups, including this conference.

Section II of the draft plan describes the state in terms of its geography, climate, land uses, ownerships, and vegetation. This is done with a wildlife habitat emphasis including a description of physical factors and practices which influence wildlife habitats. While we may have exceeded federal standards in this section, it does help explain the problems confronting wildlife managers. In describing the state, we used the nine physiographic provinces used by the Oregon Natural Heritage Data Bank operated by the Nature Conservancy as adapted from Dyrness et. al. (1975) and later used in the *Oregon Natural Heritage Plan* (Natural Heritage Advisory Council 1981). These provinces are based mainly on vegetation which reflect the wide range of climates that extend across Oregon. Appendices provide statistical data by provinces that includes information on division of land ownerships among the private sector and government agencies, including wildlife refuges.

Section III of the draft plan describes the wildlife of the state first in general terms for the entire state and then in more detail by provinces. This description is largely derived from listings of all state vertebrates that appears in the Appendix. The listings consist of a series of matrices modified after Thomas (1979). Symbols provide data on the status of each species by province, whether game, nongame, or furbearer, native or introduced, and show regular use, or nonuse, for feeding and reproduction in 30 major community types and habitat components. Examples of the components are ocean, offshore rocks, estuaries, coniferous forests, sagebrush steppe, alpine sites, riparian, streams, marshes, croplands and pastures, urban, cliffs-talus-rimrock, snags, downed wood, and artificial structures. All vertebrates except non-anadromous saltwater fish are described or listed in this section and referenced appendices in order to place nongame in perspective with other groups and to recognize ecological relationships. It also emphasizes the fact nonconsumptive users observe game and furbearers with nongame.

Preparation of these matrices, which involved consultation with numerous parties and a literature review, enabled us to compile some interesting statistics on the state's vertebrates, as illustrated by Tables 2 and 3. Special attention is given to describing in each province those species which represent special status categories such as endangered or threatened, candidates for such status, endemics, disjunct populations, sensitive, little known, or otherwise requiring special attention. Data from various population inventories is also provided. It ranges in quality from almost complete censuses of sandhill crane (*Grus canadensis*) breeding pairs to counts of nests in the largest heronries, gross estimates of the more conspicuous nesting seabirds, and trend data from roadside raptor counts to Fish and Wildlife Service breeding bird censuses and counts of coyotes (*Canis latrans*) and jackrabbits (*Lepus californicus*) made incidental to game censuses. Population data is lacking for numerous important prey species including small mammals, reptiles, amphibians, and fish. Often, information is restricted to only general knowledge of the presence of these species in a given area.

Section IV of the draft plan briefly describes 48 problems that relate to meeting program objectives. This is presented in four columns; the first one describes a problem activity, the second lists animals involved and effects of the activity, the third lists remedial measures; and the fourth refers to a strategy number found in the next section of the plan that can be used to resolve the particular problem. The 48 listed problems include eight forest management practices, seven agricultural practices, four socio-political type problems, six biological problems including man-induced ones like introduced species, four out-of-state problems relating to migratory birds, five relating to industrial and urban development, three relating to

Table 2. Approximate number of species of vertebrates known to occur in Oregon and its offshore waters exclusive of saltwater fish.

	Freshwater Fish	Herptiles	Birds	Mammals	Total
Native breeding	69	56	246	116	487
Migration and/or wintering-inshore	—	—	77	2	79
Migration and/or wintering-offshore	—	4[a]	15[b]	22[c]	41
Subtotal	69	60	338	140	607
Irregular occurrences/ accidentals	1	—	85	2	8
Cumulative total	70	60	423	142	659
Introduced & breeding	36	1	10	12	59
Cumulative total	106	61	433	154	754
Current status not clear	—	—	—	1[d]	1
Extirpated or extinct	2	0	2	4	8
Subtotal	2	0	2	5	9
Grand total	108	61	435	159	763
Percent	14	8	57	21	100

[a]Marine turtles.
[b]Species that migrate offshore but seldom reach land in state.
[c]Includes 21 cetaceans and Northern fur seal.
[d]Gray wolf.

Table 3. Numbers and percentages of native herptiles, birds and mammals that regularly use selected habitat components out of the total numbers using the three community types listed.

	Total	Use snags		Use downed wood		Use burrows	
	no.	No.	%	No.	%	No.	%
Herptiles							
Coniferous forest users	28	*	*	24	86	19	68
Deciduous woods users	16	*	*	13	81	14	87
Riparian area users	16	*	*	7	44	6	37
Birds							
Coniferous forest users	89	33	37	13	15	0	0
Deciduous woods users	79	30	38	15	19	0	0
Riparian area users	132	31	23	12	9	3	2
Mammals							
Coniferous forest users	63	24	38	44	70	38	60
Deciduous woods users	42	16	38	35	83	26	62
Riparian area users	70	18	39	40	57	42	60

*Snag use for herptiles not determined.

lack of information on species and habitat trends and eleven miscellaneous ones dealing with such items as accidents, illegal taking, overcollecting, etc. Many of the problems relate back to discussions in the texts of the previous two sections.

Section V of the plan covers the program goal, objectives, strategies and substrategies with explanatory notes. Table 4 lists the goal, objectives, and strategies.

Section VI covers program priorities. Anyone who has worked with priority systems knows the many inherent problems involved in devising a useable system. We are not satisfied with our system. It basically gives first priority to restoring endemic endangered species, candidates, or otherwise vulnerable populations. Second priority goes to nonendemic populations of the same category and third priority is for maintenance of widespread populations considered to be secure. Fourth priority goes to actions which would enhance local populations for public viewing and the fifth and final one involves actions relating to interpretive services and minimizing damage to property caused by nongame. These priorities represent a guideline only; subjective judgements must bring into play the numerous economic, social and logistical factors. For example, without taking on some activities in Priority 5, there would be little public support or understanding of tasks to be accomplished under Priority 1.

Section VII is the operational section of the plan which is to be updated annually. It lists, in a matrix adapted from Fish and Wildlife Service endangered species

Table 4. Program goal, objectives and strategies.

PROGRAM GOAL

To maintain naturally sustaining populations of native Oregon nongame wildlife at approximately present levels or at greater levels so as to provide for optimum ecological, economic, aesthetic, educational, scientific, and cultural benefits.

OBJECTIVES

1. Maintain populations of all native nongame species in secure habitats at approximately 1983 levels or greater where opportunities exist or as needed to assure species survival in state. This includes restoring threatened and endangered species to nonthreatened/endangered status and taking measures to assure no additional species reach such status.
2. Develop and maintain self-perpetuating populations of nongame species extirpated from state or regions within state consistent with habitat availability and public acceptance.
3. Provide public enjoyment and recreational, educational, aesthetic, scientific, economic, and/or cultural benefits derived from the state's wildlife resource for citizens and visitors.

*STRATEGIES ABSTRACT

1. Assess status of nongame populations on a continuous basis as needed for appraising the need for management actions, the results of such actions and for evaluating habitat and other environmental changes.
2. Identify and implement management measures required for restoring or securing vulnerable and sensitive populations and maintaining or enhancing other populations.
3. Reintroduce species or populations where they have been extirpated as may be feasible.
4. Utilize outside opportunities, resources and authorities through cooperation with other agencies, private conservation organizations, scientific and educational institutions, industry and general public in meeting program objectives.
5. In coordination with Watchable Wildlife program conduct and cooperate with others in activities and projects which provide quality aesthetic, educational, scientific, cultural and recreational experiences and economic benefits derived from the state's wildlife, but not in ways that are detrimental to the resource.
6. Assist with nongame property damage and nuisance problems without compromising objectives, utilizing education and self-help in place of landowner assistance whenever possible.

*The strategies break down into substrategies that are not shown.

recovery plans, those actions or jobs to be conducted. The jobs are arranged under appropriate substrategies and simply represent the actions or tasks to be accomplished to fulfill the strategies. Opposite the listed jobs are 11 columns which denote the following: (1) priority, (2) lead agency or Department region charged with primary responsibility for the job denoted, (3) cooperating parties, (4) method of execution—staff,contract, volunteers, or another agency, (5) project years, and (6) Department costs over and above salaries and other fixed expenses listed under columns denoting five fiscal years or later. Projected expenses for each fiscal year match anticipated revenues. Annual budgets are prepared from this schedule. The entire operation therefore represents a step-down from a single program goal. Of 296 tasks or jobs outlined in the schedule, over half, or 160, involve surveys and inventories, 94 involve management actions and research, and 42 cover miscellaneous projects including such items as public information and such activities as preparing reviews and comments on federal projects.

At the request of the Oregon Fish and Wildlife Commission, a supplement was prepared which provides information concerning the reservations of some members in accepting the program goal, objectives, and priorities. Also at their request, the supplement contains a statement on economic aspects of the program including difficulties involved in placing dollar values on the worth of wildlife resources versus costs of maintaining habitat to society.

Public Reaction to Draft Plan and Possible Changes

Initial public review of the plan's major parts came through the nongame advisory committee. Once the draft was released, we found demand for it far exceeded the 300 copies and were criticized for not printing more copies. Fifty-six written comments were received on the plan. Government agencies accounted for 23 of these. Their comments were mainly technical in nature. Eleven letters were received from individuals. They were generally supportive or covered technical matters. Eleven letters from environmental and conservation organizations varied from simple endorsements of the draft to mixed reviews that contained both technical comments and ones of a policy nature. Some used the opportunity to vent their feelings against the Department's predator control policies or called for the Department to conduct activities it does not have authorities or funds for. Only one letter of comment came from the academic community. However, the academic community was extremely cooperative in providing technical data for the draft. Ten letters from industry, all but one of which were forest product groups, were critical, particularly of the proposed goal, objectives and strategies as well as remarks made in the problems section about forest management practices. Some industry groups and one Commissioner called for a complete economic analysis of the costs to the state's economy that would incur from plan adoption, despite the fact the plan does not call for any new legislation and seeks only voluntary cooperation from landowners. The program justification statement may in part have been responsible for comments from industry which called for the plan to describe negative program aspects, i.e., loss in timber receipts caused by animal damage and preservation of old growth timber stands. The Fish and Wildlife Service pointed out we did not provide an adequate link for monitoring the success in meeting Objective 1 which calls for maintaining populations of most species approximately at or above 1983 levels.

The comments provide the opportunity to make numerous noncontroversial changes, mostly of a technical nature. Recommendations for changes of a more substantive and controversial nature will be made through the staff and advisory committee to the Commission.

In general, even the most critical comments from the forest industry assisted in revealing where the draft plan is weak. Nearly all parties commented on the value of the document as a reference on the wildlife of Oregon for teaching, environmental impact statement preparation, and similar purposes. It will serve as a common bond of understanding between environmental groups, industry, and government on species occurrence and status.

We feel portions of the plan that the forest products industry objected to as being unduly critical can be rewritten in a more cooperative vein. The biggest hurdle involves writing an acceptable program goal and Objective 1. Both environmental groups and industry pointed to a policy statement in Oregon statutes that call for maintaining "all species of wildlife at optimum levels," but industry was quick to remind us of another statement which reads in part "to regulate wildlife populations . . . in a manner that is compatible with primary uses of the lands and waters of the state." These two statements are not always congruent. I feel both industry and environmental groups would be happy with an objective that reads "to maintain populations at optimum levels," with each having a different concept of "optimum." However, "motherhood" objectives that all parties can accept are not measurable and will not meet Federal Aid standards. I anticipate we will rewrite the objective to allow for some reduction from present day population levels for the more common species, but retain the proposed objective for threatened and endangered species and those which could become threatened or endangered.

One of our greatest mistakes with Objective 1 was to use 1983 as a base year without adequately explaining our intentions to allow for natural population fluctuations and routine animal damage control programs. While maintaining populations of most species at present day levels can be considered an admirable goal, many of us feel it is not realistic in light of ongoing and planned land management practices and developments.

To correct the deficiency in the plan that was pointed out by the Fish and Wildlife Service, we propose to prepare some tables which list present day population estimates or indices of key species followed by population objectives for each.

No decision has been made as to how to address the request for an economic analysis.

Acknowledgements

Although I had primary responsibility for preparation of the draft plan and will carry it through to an approved version, I can't overemphasize the necessity for a contractor to work closely with an agency staff on all phases of a plan. The comprehensive nature of the plan represents a group effort entailing several lengthy sessions with the field staff to reach a consensus on many issues and develop the operational section. Particular thanks goes to Mr. William I. Haight, Staff Nongame Biologist, who coordinated this entire effort with other Department activities and people. Numerous discussions were also held with personnel of the Federal Aid Division of the Fish and Wildlife Service. We also thank the latter group for the graphics used to brief organizations on the plan. Much encouragement came from the Department Directorate and members of the Nongame Advisory Committee as well as Dr. Laurence

Jahn of the Wildlife Management Institute through the Nongame Committee of the International Association of Fish and Wildlife Agencies. Also essential was the information so freely supplied by specialists throughout the state on the status and habitats of all the approximately 763 vertebrates that have been known to occur in the state in recent years. Mr. William A. Neitro of the Bureau of Land Management, Mr. Donald V. Friberg of the Fish and Wildlife Service and again Mr. Haight are to be thanked for their critical review of this paper.

Literature Cited

Dyrness, C. T., et. al. 1975. Research natural area needs in the Pacific Northwest. Pacific Northwest Forest and Range Experiment Station, U.S. Dept. of Agric., Portland, Oregon. 231 pp.

Morache, M. 1984. Idaho's modular nongame conservation plan. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:210-214.

Natural Heritage Advisory Council. 1981. Oregon natural heritage plan. State Land Board, Salem, Oregon. 141 pp.

Thomas, J. W. tech. ed. 1979. Wildlife habitats in managed forests of the Blue Mountains of Oregon and Washington. Agric. Handbook No. 553. U.S. Forest Service, Washington, D.C. 512 pp.

U.S.D.I. Fish and Wildlife Service and U.S.D.C., Bureau of the Census. 1982. 1980 national survey of fishing, hunting, and wildlife associated recreation. U.S. Fish and Wildlife Service, Washington, D.C. 156 pp.

U.S.D.I., Fish and Wildlife Service and U.S.D.C., Bureau of the Census. Undated. 1980 national survey of fishing, hunting, and wildlife associated recreation. Oregon. U.S. Fish and Wildlife Service, Washington, D.C. 76 pp.

Research Accomplishments and Prospects in Wildlife Economics

Robert K. Davis
Office of Policy Analysis
U.S. Department of Interior
Washington, D.C. 20240

Introduction

This paper undertakes the large task of reviewing the accomplishments of the past 50 years in the application of economic analysis to problems of wildlife management and conservation and draws conclusions about the future from current trends in the field. In order to make the task more manageable the review is restricted to the subjects of terrestrial wildlife and their habitats on the North American continent.[1]

Although there have been significant conflicts between wildlife conservation and economic activity throughout history, economists in growing numbers are applying their skills to the analysis of wildlife policy issues and management problems. In view of the apparent antithesis between economic growth and the conservation of wild nature, it is understandable that wildlife managers adopt a value system and philosophical outlook that is the opposite of the outlook of the business community. However, the mores of the economy do not dictate the intellectual endeavors of professional economists. Indeed, the work of economists has provided a powerful argument that our society errs in not having a more active policy toward the preservation of natural assets (Krutilla 1968).

The study of the economics of wildlife management and conservation is particularly challenging because the production and consumption or use of wildlife take place outside of organized markets. In part because we have chosen to make it so, wildlife is an "extramarket" good (Hines 1951). Estimating a market value for extramarket wildlife has challenged numerous economists and has become a small industry.

Were we to choose to make wildlife a market resource, then it would be necessary to deal with the fact that wildlife is a fugitive resource. It is difficult to reconcile a market system based on private property rights with the characteristics of a resource which must be reduced to possession before it can be legally owned (Ciriacy-Wantrup 1952). The wasteful depletion that has resulted from the migratory nature of waterfowl, for example, is common knowledge. It is a particular challenge to economic thought to devise systems based on conventional economic incentives to remedy the depletion of fugitive wildlife resources. This is the case regardless of whether wildlife remains inside or outside the market.

[1]This narrow definition forces us to ignore much good work in fisheries and in the wildlife of other continents as well as related work in sociology and social psychology.

Output and Employment of Wildlife Economists

Upward trends exist both in the employment of economists in public and private organizations concerned with wildlife conservation and of publication of economic studies of wildlife management and conservation in the professional literature. There are currently seven economists employed by the U.S. Fish and Wildlife Service, a handful in state game agencies and three or four known to be employed by private, non-profit wildlife conservation organizations in the U.S. A few economists in the universities and consulting firms are noted for their concentration on the particular problems of wildlife resources. A rough count of articles on wildlife written mainly by economists and published in the professional literature of economists and of wildlife managers reveals a publication rate in excess of three papers per year for the past ten years. This is more than double the rate of the previous ten year period.

The Historic Role of Biologists in Wildlife Economics

Biologists rather than economists were the first to show an interest in the economic aspects of wildlife. Early in this century bulletins of the U.S. Biological Survey and state agricultural experiment stations were devoted to the thesis that birds provided services of economic value to farmers (Beal 1904, Gossard and Harry 1912). A preoccupation with the economic status of species such as the eagles or the red fox carries into the literature of recent times (Imler and Kalmbach 1955, Arnold 1954, Scott 1955). Economic status here seems to mean how the species adds to and detracts from man's economic activities. Particular studies in this vein have compared the costs of agricultural damage by certain species with the economic value of the muskrat pelts (Errington 1940) or the income from deer hunters (Thomas and Pasto 1955).

Economic arguments were also used by biologists to counter myths about the effectiveness of bounties for controlling predators. A simple comparison of the costs of bounties with the biological arguments concerning the futility of population controls by this device were used by game departments in North Dakota, South Dakota, West Virginia, Michigan, and Pennsylvania. One research study is reported during this period (Latham 1953).

Biologists employed economic methods to compare the returns to wetlands in their natural state with wetlands that had been drained (Anderson 1947, Bellrose 1945).

Biologists were the first to use economic methods to evaluate wildlife as a public resource. A burst of studies of the economic value of wildlife within states appeared after World War II (Dambach and Leedy 1948, Stains and Barkalow 1951, Wallace 1952, 1956, Univ. of Utah 1957, Campbell 1958). Typically based on sample surveys of hunters and fishermen, these efforts estimated the total private expenditures that could be attributed to wildlife within a state and added in the gross sales values of raw furs or other wildlife commodities.[2]

[2]Dambach and Leedy were so thorough as to include a value of $6.4 million for the wild meat harvested by hunters in Ohio in 1946.

The first nationwide survey of hunters and fishermen was conducted in 1955 by the U.S. Fish and Wildlife Service (U.S. Department of Interior 1955). The survey has been repeated each five years thereafter.

The imprint of these early studies remains intact. Not only does the primary interest in the national survey continue to be in the total expenditures of hunters, fishermen, and other users of wildlife, but the current textbooks in wildlife management cite total expenditures of sportsmen when identifying the economic values of the sport (Robinson and Bolen 1984, Bailey 1984).

Aldo Leopold wrote on wildlife economics in these proceedings 50 years ago (Leopold 1936). Chapter 16 of *Game Management* is devoted to "Game Economics and Esthetics" (Leopold 1933). Thirty four years ago wildlife economics was called a neglected tool of management (Stoddard 1951). Wildlife economics has not been a neglected research topic for the past 25 years, but we may ask whether it has become a much used tool of management. What follows is an attempt to describe the accomplishments of the past 25 years in the economics of game management, to indicate where the frontiers are, and to note areas which seem to be neglected. The goal, of course, is to identify the uses of economics in wildlife management.

Estimating the Value of Wildlife

By the middle of the 1960s a sufficient number of economists had worked on the problems of estimating the values of wildlife that a consensus was emerging: the expenditure surveys were missing the point. Use of wildlife has a value to consumers that exceeds their expenditures and is reflected in their willingness to pay more for their recreation. Studies of the problem of valuation must be concerned with estimating the value of the surplus accruing to the consumer (Crutchfield 1962, Hufschmidt et. al. 1961). Two basic methods emerged during this period, the travel-cost method (Knetsch 1963) and the survey method (Davis 1964). By 1978 both methods had become sufficiently developed and standardized that they could be adopted as the methods preferred and sanctioned by the U.S. Water Resources Council for the evaluation of recreation benefits in federal water resources projects (U.S. Water Resources Council 1979).

Notable applications of economic methods have been made by economists to valuation problems in a number of studies in the past ten years (Hammack and Brown 1974, Gum and Martin 1975, Brookshire et. al. 1978, Charbonneau and Hay 1978, Miller and Hay 1984, Bishop and Heberlein 1979, 1980). Not only have some usable results been obtained, but the work has resulted in refinement and verification of methods. In particular, the continued efforts of the economists in the Fish and Wildlife Service who have been responsible for designing and analyzing the 1980 and 1985 National Surveys are hastening the day when we may have regional models that will use values for local variables and produce estimates of the values for hunting, fishing, or wildlife watching in a particular state or region (U.S. Water Resources Council 1979).

Methods such as travel cost (TC) and survey or contigent value method (CVM) are by their very nature indirect. They are employed in the absence of being able to observe consumer evaluations directly in actual markets (Scott 1965). Economists, therefore, have been reluctant to claim that their results are a close approximation of the market. Typically the studies call for further verification of the results.

A series of experiments in Wisconsin has tested willingness to pay for hunting by actually offering to sell permits to a small sample of hunters. The technique seems to offer a method of directly estimating the price of hunting in controlled settings where permits are issued through drawings. The results also verify that the TC and CVM approaches can produce results reasonably close to the results of actual sales (Bishop et. al. 1983, 1984).

The usual economic test of consumer interest in an activity such as duck hunting is willingness to pay (WTP) for an additional duck bagged or day of duck hunting. Most of the development of the TC and CV methods has concentrated on WTP. However, many of the situations in which questions of value arise concern the value of hunting opportunities lost to a change in land use. In such cases, willingness to-sell (WTS) is a more appropriate concept than WTP (Dwyer et. al. 1977). Debate continues about whether theory leads us to expect measurable differences between WTP and WTS. However, studies of actual buying and selling of hunting permits have shown that WTS exceeds WTP (Bishop et. al. 1983, 1984). Experiments under controlled conditions confirm the difference. (Knetsch and Sinden 1984). Although experiment and common sense may agree, WTS may not be measurable by current methods (Kahneman 1984).

Economics has contributed two other ideas to the list of values that are included when the value of wildlife is discussed. These are option value and existence or bequest value. The first notion is that users of a good or service are willing to pay something in order to retain the prospect or option to use it at some time in the future. The second notion is that non-users may be willing to pay something in order to assure the continued existence of an asset during their lifetimes or for the benefit of future generations. It is argued that most forms of wildlife possess option and/or existence values (Krutilla and Fisher 1975). Experimental attempts to measure option and existence values have indeed been rewarded with positive responses (Brookshire et. al. 1978, 1983, Stoll and Johnson 1983). Wilderness values, which include wildlife values, have received more attention in this regard (Walsh et. al. 1984). Recent thinking about option values leads to caution about concluding that the value can be consistently measured or that it is necessarily always positive (Freeman 1984). A total WTP that includes use value as well as option value is the quantity we probably will be measuring for the foreseeable future (Bishop 1982). There may be ambiguities in existence values as well, but such information collected from well-run studies can be useful in making choices where wildlife resources are irreversibly destroyed (Brookshire et. al. 1983).

Economists continue to disapprove of the gross expenditure method, but estimates of the total consumer expenditures devoted to a wildlife activity are the first evidence that wildlife managers seek when they wish to achieve a wider appreciation of the importance of that activity. It happened to hunting and fishing in the 1940s and it is happening now to nonconsumptive uses and nongame species. The evidence being marshalled shows how many hundreds of millions of dollars are spent on birdseed, binoculars, birdbooks, and the like (DeGraaf and Payne 1975). Economists are not far behind. The 1980 National Survey is now providing a data base for analyzing the determinants of demand for wildlife watching (Hay and McConnell 1979, 1984), and the next survey will give more emphasis to participation in nonconsumptive wildlife recreation.

The emphasis on estimating a market price should not overshadow the study of the determinants of participation in wildlife sports. In addition to the work of Hay and McConnell cited above, which has shown that hunters are also wildlife watchers, Miller and Hay (1981) estimated the decrease in hunting in the Mississippi flyway as a result of the loss of waterfowl habitat. Statistical models based on the data from the national surveys could well turn out to have a powerful role in forecasting the future of wildlife sports as economic and social variables change and as supplies respond to habitat losses and management improvements.

What is the outlook for research in this area? We note that economists are not pushing their results for use in management nor are the managers eagerly adopting the results to their decisions. Research promises to continue as long as funding continues. New methods will doubtless develop.[3]

One possible new method might be to find out through some systematic studies what hunters are paying now in particular regional markets for the hunting privilege. We will also see more work along the lines of the Wisconsin experiments to verify and calibrate the TC and CV estimates of WTP and WTS. Refinements in estimation of the determinants of participation in wildlife sports will significantly enhance our abilities to simulate market demand for wildlife, and we will see some trial uses of simulated market demands, including WTP values, in management decisions.

Property Rights and the Problem of Private Incentives

The early wildlife preservation effort in the U.S. was concerned in large part with eliminating commercial exploitation of wildlife species which possessed value in markets for meat, feathers, and fur. It was a period when the relationship between well defined property rights and properly functioning markets was not well understood and exploitation of wildlife for commercial gain was simply attributed to excesses of the free enterprise system. As with an unruly beast, the situation seemed to call for a stiff dose of regulation. Wildlife conservation became a public enterprise as laws created agencies staffed with game wardens to protect wildlife from overexploitation, that is, from what we now call the tragedy of the commons.

Aldo Leopold was aware of the contradictions in the existence of wild game as public property on private land. His American Game Policy Committee of 1928-1930 considered ceding title in game to the landowner in order to induce management of game by landowners but rejected the notion as incompatible with American tradition and thought (Wildlife Management Institute 1973).

It was not until the 1950s that economists turned attention to the perverse economic incentives that exist in the exploitation of wildlife. The pioneering study examined the economic causes of overexploitation and gave us the concept of irreversible depletion of wildlife (Ciriacy-Wantrup 1952). If the "critical zone" in depletion could be identified, quotas for the catch could be assigned and the police power used to assure that the population of a species would not drop to the critical zone.

A case is made that time honored systems of common property rights have succeeded in preventing the depletion of critical zone resources in many parts of the world (Ciriacy-Wantrup and Bishop 1975). Another solution proposed to save

[3]One such method, the hedonic, has been applied to estimating values of hunting. (Livengood 1983)

wildlife which is in danger of over exploitation is to transform it into private property through the assignment of rights (Hanke 1975). A case is made that private property rights have worked to preserve wildlife in a number of locales outside the U.S. and that experiments with property rights systems are in order here (Smith 1981).

While the economists argue over systems for resolving the problems of perverse incentives for conservation where wildlife is concerned, America's game managers have shown remarkably little interest in experimenting with novel systems of property rights. Innovation has been left to private landowners who have found that they can privatize exotic species and so establish private reserves for wildlife (Burger and Teer 1981).

Nonmigratory species possessing high and fairly stable market potential and subject to inexpensive enforcement of property rights have been suggested as proper subjects for experimentation with private ownership (Stier and Bishop 1976). The following question might be asked about the Texas landowners who can sell deer hunting at the price of $224 per deer hunter (Burger and Teer 1981). Would management of the deer herds be improved if the property rights to the deer were ceded to the landowner?

The biologists do not find much evidence that the private landowners in Texas or elsewhere who receive income from hunting show much interest in applying game management to native species. This despite the evidence that in most years deer may produce more income per animal unit than cattle (Ramsey 1965). Generally only the landowners who look upon land and wildlife as personal consumption goods are investing in wildlife management (Applegate 1981).

There are questions here that offer fertile research topics for economists who are interested in property rights and private incentives but the paucity of research activities suggests that we are not close to the answers.

Economics of Wildlife Production

The Wildlife Society's *Manual of Conservation* points out that wildlife production involves both a supply side or the costs of production and a demand side or the returns from production (Nobe 1971).

Several studies of the returns from wildlife production to regions have been conducted. Non-resident hunting has been found profitable in the East Kootenay region of British Columbia (Pearse 1968). Unlike the standard gross expenditure study, Pearse's study netted the costs of serving the non-resident hunters from their expenditures.

A comparison of the annual values of hunting and general recreation per square kilometer of land in six different cattle producing areas of Arizona finds that deer hunting and other big game hunting exceeded the average annual value of cattle ranching in two of the six regions (Martin and Gum 1978). In the Arizona study, however, the "maximum collectible benefits" estimated for hunting accrued to the hunter, not to the rancher. The results give the resource administrator some useful guidance in arguing for expenditures for wildlife management on the public domain lands in Arizona but give little comfort to the rancher unless he has something to sell.

In Texas, on the other hand, a commercial hunting industry developed in the

1920s that is today the most highly developed commercial system of hunting in North America. Hunters paid landowners $108 million for leases in 1971 (Burger and Teer 1981).

Knowledge to the same degree of the costs of producing wildlife cannot be found. Few precise estimates of the production returns from game management practices are to be found. One such study finds that pheasants can be produced on irrigated farmland by planting six-foot (2m) strips on the edges of farms with better habitat at the cost of $3.19 per bird produced (Matulich and Bagwell 1979). Another study estimates the costs per duck fledged by a variety of waterfowl production measures in North Dakota (Lokemoen 1984).

Production decisions which maximize net returns depend upon considering costs and returns or supply and demand in the same calculation. There have been few attempts to combine models of the benefits from hunting with models of the costs of producing game. The classic study involved estimating the costs of producing waterfowl from privately owned wetlands and hunter willingness to pay for duck hunting and concluded that the wetlands are economically more productive in duck production than in cropland (Hammack and Brown 1974, Brown et. al. 1976). More recently, an Iowa study successfully relates land use characteristics to pheasant hunter activity, showing that certain land use practices have a measureable positive effect on hunting participation and benefits (Bender 1984).

The paucity of economic studies of wildlife production contrasts sharply with the abundance of production economic studies in agriculture and forestry. This is all the more surprising when we consider that many of the universities that stand out in agriculture and forestry are also standouts in wildlife management. What explains this imbalance in the research interests of economists? Is the problem in the attitudes of wildlife scientists or the economists or is it a lack of knowledge about the technical production relationships? Perhaps the cause traces to the lack of private landowner interest in the product. The few studies that have appeared in recent years may suggest that the drouth is broken. It is particularly significant that biologists are calling for costs and returns studies of wildlife production (Cringan 1971), but the activity here does not presage a deluge.

The Special Problem of Endangered Species

The economic paradigm has been brought sharply into focus on the problem of endangered species: resources are scarce; it is not possible to save every species threatened with extinction if there are resource costs in doing so. It therefore becomes necessary to judge which species will be important in the future and, lacking perfect foresight, the short run view is paramount in separating those to save from those to abandon. Furthermore, effort at preservation is indicated by the economics of production. The extent of production of a product, its profitability, and the interest rate all influence the preservation of genetic material that will support short term production of that product (Brown and Goldstein 1984).

The problem with a prescription so strongly rooted in economic efficiency is that it demands information on the benefits of preservation that cannot be developed. Consequently, Bishop (1980) would temper efficiency with considerations of justice and equity for future generations. He looks at three cases as an economist who inquires into the costs of species preservation and then is willing to judge the evidence in view of opinions about the values of preservation. The preservation of the California Condor is estimated by Bishop to cost $3.2 million annually. Preservation of the leopard lizard in Ballinger Canyon in Ventura County California is estimated to cost $140,000, or less, in foregone ORV recreational benefits.

On the other hand, the California Tule Elk was estimated to bring in net benefits if preserved (Ciriacy-Wantrup and Phillips 1970). Preservation of the snail darter was estimated to be beneficial to the nation on balance because of the economic infeasibility of the Tellico Dam (U.S. Department of the Interior 1979).

Other examples are accumulating. The preservation of a pair of northern spotted owls is estimated to cost $250,000 in foregone timber harvest values in western Oregon (Nelson 1982). The costs of preserving one hundred pairs would not be negligible.

In all these cases the role of economic analysis is not to force the decision to a particular outcome but to clarify the costs of the choices—the costs of not preserving as well as the costs of preserving. For those choices in the public sector we have laws and elected or appointed officials to guide us. Species preservation in the private sector where the market is the guide is not subject to direct social control. Only if a gene pool has commercial value to its owners are the market forces likely to guide behavior in the direction of preservation. The problems in both arenas are sufficiently challenging and important that we can be confident the economic studies will continue.

Conclusions: The Economics of Wildlife Policy

The payoff to studies in wildlife economics lies in the application of the results to management decisions. Economics is the science of choosing. Managers do not escape the economic realities of scarcity simply by not being economists. In Chapter 16 of *Game Management,* Leopold (1933) demonstrated an appreciation of cost effective game management. His sample calculations of the cost per unit of producing a variety of types of game are a lesson in practical economics. But in Leopold's time the greater emphasis was placed on the need for accumulating more information on the environmental factors in game management and in teaching the ethics of conservation. After 50 years of research and practical experience an impressive amount of know-how has been collected and the majority of public opinions are favorable. It is understandable that Leopold the philosopher-ecologist is remembered but puzzling that Leopold the practical economist is all but forgotten.

Wildlife managers practice with one hand on public land and with the other hand on private land. It is with good reason that game policy of the past 50 years has placed major emphasis on the acquisition and retention of public land for game management. Fifty years ago the policy documents not only stressed the absolute need to acquire waterfowl nesting and refuge lands, but also the need to acquire marginal farmlands that could be turned into low cost forest and rangeland game areas, while seizing every opportunity to preserve wilderness lands (U.S. Department of Agriculture 1934). Today's policy documents stress the importance of retaining these public lands and of extending public protection to critical habitats such as wetlands (Wildlife Management Institute 1973).

The work reviewed in this paper demonstrates numerous applications of economics to wildlife issues. The possibilities are illustrated succinctly by the problems of wetlands. Substantial acreages of prime wetlands have been placed in public ownership at considerable cost in public funds. Acquisition with limited public funds continues at a pace short of the rate of conversion of wetlands to other economic uses. Federal policies in agriculture have caused farmers in the prairie pothole region to drain more wetlands than would have been drained under the economic conditions of an undistorted market (Goldstein 1971). It is also very likely that the federal tax codes and other public policies encourage the conversion of Mississippi bottomland hardwoods to a greater extent than would an undistorted market (Shabman 1980).

We may believe that many wetlands are more valuable as wetlands than in converted uses. Federal and state programs require permits before certain wetlands can be altered. The powers given to public authorities in such cases imply that the economic gains and losses of an altered wetland will be weighed in the balance, but acceptable procedures for doing so are only now being proposed (Batie and Shabman 1982). When a unique wetland ecotype is threatened with irreversible disappearance, our abilities to evaluate the economic alternatives meet the acid test. While not perfect, the economic methods for wetlands evaluation are probably good enough to be useful.

The management of all wildlife lands is influenced by economics. Public land budgets are limited, forcing biologist-managers into cost analysis in order to get the most production from limited resources and leading public agencies to user fees and charges to enhance operating budgets. Private wetlands owners, while frequently receiving income from wildlife-related uses of the wetlands, are generally reluctant to practice management where the economic returns are contingent on the ups and downs of a waterfowl resource with a history of shrinking seasons and bag limits.

In all of wildlife management, the combined skills of biologist, social scientist, and economist are needed. We have seen that wildlife economists are the most active in the area of estimating market values and demand and least active on the problems of devising incentives for management of private lands, and in the economics of wildlife production. Attention to the problems of endangered species and the wetlands is somewhere in between. It may be that wildlife economics is still a neglected tool in wildlife management. We can't be certain why this possibility still exists. We can take encouragement from the fact that economists and wildlife managers are paying more attention to each other and that economic studies of wildlife may be accelerating. Perhaps before another 50 years has slipped past all of the neglected economic tools will be in use.

Acknowledgements

The opinions expressed in this paper are those of the author and not necessarily those of the Department of Interior. The author wishes to thank Diane Lim for much help in searching the literature and Richard Bishop, John Charbonneau, Warren Fisher, Jon Goldstein, Michael Hay, and Robert Nelson for their comments on an earlier draft.

Note: The references are a sampling of the literature. Readers can secure a more complete bibliography by writing to the author.

Literature Cited

Anderson, W. L. 1947. Wetland—how should it be used? Trans. N. Amer. Wildl. Conf. 12:425-429.

Applegate, J. E. 1981. Landowner's behavior in dealing with wildlife values. Pages 64-72 *in* Wildlife management on private lands. R. Dumke, G. Burger, and J. March, eds. Wisc. Chapter of the Wildlife Society, Milwaukee.

Arnold, L. W. 1954. The golden eagle and its economic status. Circular 27. U.S. Fish and Wildlife Service. IV +35pp.

Bailey, J. A. 1984. Principles of wildlife management. John Wiley and Sons, Inc., New York. 373pp.

Batie, S. S., and L. A. Shabman. 1982. Estimating the economic value of wetlands: principles, methods, and limitations. Coastal Zone Manage. J. 10(3):255-278.

Beal, F. E. L. 1904. Some common birds in their relation to agriculture. Farmers' Bulletin No. 54, March. U.S. Dep. of Agriculture, Washington, D.C.

Bellrose, F. C. 1945. Relative values of drained and undrained bottom land in Illinois. J. Wildl. Manage. 9(3):161-182.

Bender, R. L. 1984. Habitat characteristics and pheasant hunting participation: a household production function application. Unpublished M.S. thesis. Iowa State Univ., Dep of Economics, Ames.

Bishop, R. C. 1980. Endangered species: an economic perspective. Trans. N. Amer. Wild. and Natur. Resour. Conf. 45:208-218.

______. 1981. Economic considerations affecting landowner behavior. *In* Wildlife management on private lands. R. Dumke, G. Burger, and J. March, eds. Wisc. Chapter of the Wildlife Society, Milwaukee.

______. 1982. Option value: an exposition and extension. Land Econ. 58(Feb.):1-15.

______, and T. A. Heberlein. 1979. Measuring values of extramarket goods: are indirect measures biased? Amer. J. Agr. Econ. 61(5):926-930.

Bishop, R. C., and T. A. Heberlein. 1980. Simulated markets, hypothetical markets, and travel cost analysis: alternative methods of estimating outdoor recreation demand. Agr. economics, staff paper series, no. 187. Univ. of Wisconsin, Madison.

Bishop, R. C., T. A. Heberlein, and M. J. Kealy. 1983. Contingent valuation of environmental assets: comparisons with a simulated market. Nat. Resour. J. 23: 619-633.

Biship, R. C., T. A. Heberlein, M. P. Welsh, and R. M. Baumgartner. 1984. Does contingent valuation work? Results of the sandhill experiment. Joint meetings of the Assoc. of Envir. and Resource Economists, the Amer. Agr. Econ. Assoc., and the N.E. Agr. Econ. Council, August 5-8.

Brookshire, D. S., L. S. Eubanks, and A. Randall. 1978. Valuing wildlife resources: an experiment. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:302-310.

Brookshire, D. S., L. S. Eubanks, and A. Randall. 1983. Estimating option prices and existence values for wildlife resources. Land Econ. 59(1):1-15.

Brown, G. M., Jr., J. Hammack, and M. F. Tillman. 1976. Mallard population dynamics and management models. J. Wildl. Manage. 40(3):542-555.

Brown, G. M., and J. H. Goldstein. 1984. A model for valuing endangered species. J. Envir. Econ. and Manage. 11:303-309.

Burger, G. V., and J. G. Teer. 1981. Economic and socioeconomic issues influencing wildlife management. Pages 252-278 *in* Wildlife management on private lands. R. Dumke, G. Burger, and J. March, eds. Wisc. Chapter of the Wildlife Society, Milwaukee.

Campbell, H. 1958. The economic value of hunting and fishing in New Mexico. Final report on Federal aid project, N.M. FW-12-R-1, economic survey, bull. no. 7. New Mexico Dep. of Game and Fish, Santa Fe.

Charbonneau, J., and M. J. Hay. 1978. Determinants and economic values of hunting and fishing. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:391-403.

Ciriacy-Wantrup, S. V. 1952. Resource conservation: economics and policies. Univ. of California Press, Berkeley.

_____, and R. C. Bishop. 1975. "Common property" as a concept in natural resources policy. Nat. Resour. J. 15:713-727.

Ciriacy-Wantrup, S. V., and W. E. Phillips. 1970. Conservation of the California tule elk; a socioeconomic study of a survival problem. Biol. Cons. 3(1).

Cringan, A. T. 1971. Waterfowl areas—development and management. *In* R. D. Teague, ed. A manual of wildlife conservation. The Wildlife Society, Washington, D.C. 206pp.

Crutchfield, J. A. 1962. Valuation of fishery resources. Land Econ. (May) 145-154.

Dambach, C. A., and D. L. Leedy 1948. A recent evaluation of Ohio's wildlife resources. Trans. N. Amer. Wildl. Conf. 13:508-520.

Davis, R. K. 1964. The value of big game hunting in a private forest. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 29:393-403.

DeGraaf, R. M., and B. R. Payne. 1975. Economic values of non-game birds and some urban wildlife research needs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 40:281-287.

Dwyer, J. F., J. R. Kelley, and M. D. Bowes. 1977. Improved procedures for valuation of the contribution of recreation to national economic development. Water resources center, research report no. 128. Univ. of Illinois, Champaign. 218pp.

Errington, P. L. 1940. Muskrats in the corn. Farm Science Reporter, October.

Freeman, A. M., III. 1984. The sign and size of option value. Land Econ. 60(1):1-13.

Goldstein, J. H. 1971. Competition for wetlands in the midwest: an economic analysis. Resources for the Future, Johns Hopkins Univ. Press, Baltimore.

Gossard, H. A., and S. G. Harry. 1912. Some Ohio birds. Bull. Ohio Agric. Exp. Sta. no. 250, August.

Gum, R. L., and W. E. Martin. 1975. Problems and solutions in estimating the demand for and value of rural outdoor recreation. Amer. J. Agric. Econ. 57(4):558-566.

Hammack, J., and G. M. Brown, Jr. 1974. Waterfowl and wetlands: toward bioeconomic analysis. Resources for the Future, Johns Hopkins Univ. Press, Baltimore.

Hanke, S. H. 1975. How to save alligators. Policy Analysis 1:218-220.

Hay, M. J., and K. E. McConnell. 1979. An analysis of participation in nonconsumptive wildlife recreation. Land Econ. 55(4): 460-471.

Hay, M. J., and K. E. McConnell. 1984. Harvesting and nonconsumptive wildlife recreation decisions. Land Econ. 60(4):388-396.

Hines, L. G. 1951. Wilderness areas, an extra-market problem in resource allocation. Land Econ. (November):306.

Hufschmidt, M., chairman, with J. Krutilla, J. Margolis, and S. A. Marglin. 1961. Standards and criteria for formulating and evaluating federal water resources development. Report of a panel of consultants to the Bureau of the Budget, Washington, D.C.

Imler, R. H., and E. R. Kalmbach. 1955. The bald eagle and its economic status. U.S. Dep. of the Interior, Washington, D.C.

Kahneman, D. 1984. *In* R. Cummings, D. Brookshire, D. Coursi, and W. Schulze, Valuing environmental goods: a state of the art assessment of the contingent value method—vol. II. Office of Policy Analysis, USEPA, Washington , D.C.

Knetsch, J. L. 1963. Outdoor recreation demands and benefits. Land Econ. 39(4).

_____, and J. A. Sinden. 1984. Willingness to pay and compensation demanded: experimental evidence of an unexpected disparity in measures of value. Quart. J. Econ. 99(3):507-521.

Krutilla, J. V. 1968. Balancing extractive industries with wildlife habitat. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 33:119-130.

_____, and A. C. Fisher. 1975. The economics of natural environments: studies in the valuation of commodity and amenity resources. Johns Hopkins Univ. Press. Baltimore.

Latham, R. M. 1953. An analysis of the Pennsylvania bounty system. Trans. N. Amer. Wildl. Conf. 18:158-166.

Leopold, A. 1933. Game management. Scribner and Sons, New York.

_____. 1934. Conservation economics. J. Forestry 32(5):537-544.

_____. 1936. Restoration; management by private agencies. Trans. N. Amer. Wildl. Conf. 1:156-158.

Livengood, K. R. 1983. Value of big game from markets for hunting leases: the hedonic approach. Land Econ. 59(3):287-291.

Lokemoen, J. T. 1984. Examining economic efficiency of management practices that enhance waterfowl production. Trans. N. Amer. Wild. and Natur. Resour. Conf. 49:584-607.

Martin, W. E., and R. L. Gum. 1978. Economic value of hunting, fishing and general rural outdoor recreation. Wildlife Society Bull. 6(1):3-7.

Matulich, G. C., and G. Bagwell. 1979. On-farm pheasant enhancement potentials in irrigated agriculture. Western J. Agr. Econ. 4(2):99-109.

Miller, J. R., and M. J. Hay. 1981. Determinants of hunter participation: duck hunting in the Mississippi flyway. Amer. J. Agr. Econ. 63(4):677-684.

Miller, J. R., and M. J. Hay. 1984. Estimating substate values of fishing and hunting. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:345-355.

Nelson, R. 1982. The public lands. *In* Current issues in natural resources. P. Portney, ed. 1983. Johns Hopkins Univ. Press for Resources for the Future, Baltimore.

Nobe, K. C. 1971. Introduction to economics of game and fish resources. *In* R. D. Teague, ed. A manual of wildlife conservation. The Wildlife Society, Washington, D.C. 206pp.

Pearse, P. H. 1968. An economic evaluation of non-resident hunting and guiding in the East Kootenay. Canadian J. Agr. Econ. 16(2):100-111.

Ramsey, C. W. 1965. Potential economic returns from deer as compared with livestock in the Edwards Plateau region of Texas. J. of Range Manage. 18(5):247-250.

Robinson, W. L., and E. G. Bolen. 1984. Wildlife ecology and management. Macmillian Publishing Co., New York. 478pp.

Scott, A. D. 1965. The valuation of game resources: some theoretical aspects. Canadian Fisheries Reports, rep. no. 4, Dep. of Fisheries of Canada, Ottawa.

Scott, T. G. 1955. An evaluation of the red fox. Natural history survey division, Biol. Notes 35, July.

Shabman, L. A. 1980. Economic incentives for bottomland conversion: the role of public policies and programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:402-412.

Smith, R. J. 1981. Resolving the tragedy of the commons by creating private property rights in wildlife. Cato J. 1(2):439-468.

Stains, H. J., and F. S. Barkalow, Jr. 1951. The value of North Carolina's game and fish. Federal aid in wildlife restoration projects, NC 26-R, Game division of the N.C. Wildl. Resour. Comm., October.

Stier, J. C., and R. C. Bishop. 1976. Private property, market trade, and wildlife conservation. Univ. of Wisconsin-Madison.

Stoddard, C. H. 1951. Wildlife economics—a neglected tool of management. Land Econ. 27:248-249.

Stoll, J. R., and L. A. Johnson. 1983. Concepts of value, nonmarket valuation, and the case of the whooping crane. Nat. Resour. working paper series, Dep. of Agricultural Economics, Texas A&M Univ., College Station.

Thomas, D. W., and J. K. Pasto. 1955. A theoretical framework for understanding the deer management problems. J. Wildl. Manage. 19(1):143-147.

U.S. Department of Agriculture. 1934. Report of the president's committee on wild-life restoration. U.S. Govt. Printing Office, Washington, D.C.

U.S. Department of the Interior. 1955. 1955 national survey of fishing and hunting. Washington, D.C.

______. 1979. Tellico Dam and reservoir. Staff report to the endangered species committee. 73pp.

U.S. Water Resources Council. 1979. Procedures for evaluation of national economic development (NED) benefits and costs in water resources planning. Federal register, 44:242 (December 14):72, 950-965.

______. 1983. Economic and environmental principles and guidelines for water and related land resources implementation studies. Rep. No. DOI/WRC-84/01, Washington, D.C. 146pp.

University of Utah, Bureau of Economic and Business Research. 1957. A study of the economic value of fishing and hunting in Utah. Publ. no. 7. Federal aid division of the Utah State Dept. of Fish and Game, Salt Lake City.

Wallace R. F. 1952. Economic aspects of wildlife resources of the state of Washington. Economic and business studies, Bull. no. 19. State College of Washington, Pullman. February.

______. 1956. An evaluation of wildlife resources in the state of Washington. Economic and business studies, Bull. no. 28. State College of Washington, Pullman. February.

Walsh, R. G., J. B. Loomis, and R. A. Gillman. 1984. Valuing option, existence, and bequest demands for wilderness. Land Econ. 60(1):14-29.
Wildlife Management Institute. 1973. The North American wildlife policy 1973 and the American game policy 1930. Wildlife Management Institute, Washington, D.C.

Increasing Communication Between Research and Development Scientists and Operational Managers—The U. S. Fish and Wildlife Service Approach

William K. Seitz, Robert G. Streeter, Ronald E. Kirby, Alan R. Taylor, Thomas J. Cortese, and Diana H. Cross
Office of Information Transfer, Research and Development
U. S. Fish and Wildlife Service
2629 Redwing Road
Fort Collins, Colorado 80526

Introduction

The U. S. Fish and Wildlife Service, Department of the Interior, bears responsibility for an array of activities designed to accomplish a single mission: to provide the federal leadership to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of people. In efforts to address a mission of this scale the Service has historically based its management on scientific studies. Maximum use of available information is essential to efficient communication within the organization. In recognition of this, the Service established in 1983 an Office of Information Transfer to conduct an effective and responsive in-house Research and Development information transfer program. The Fish and Wildlife Service continues to commit major resources to Research and Development to support its multifaceted mission.

The Fish and Wildlife Service is not the originator of such efforts. The U. S. Forest Service has had several initiatives (SEAM, Technology Transfer, FIREBASE, WESTFORNET, etc.). The National Aeronautics and Space Administration has established State and Industrial Technology Utilization Centers. The Department of Commerce has established a Center for the Utilization of Federal Technologies. These are examples of several large-scale attempts to place critical data in the hands of managers. The Fish and Wildlife Service's approach has been able to capitalize on the ground-breaking work of other agencies, recent advances in efficient means to transfer information, and the particular needs of the Service to design and implement in short order an efficient and responsive nationwide effort tailored to the needs of the agency.

The purpose of this paper is to review the Service's experience in designing and implementing an Office of Information Transfer. We believe that this review is of both practical and heuristic value to other natural resource agencies interested in developing increased efficiency in the use of scientific and technical information. We will describe historical responses to information transfer needs in the Fish and Wildlife Service, the reasons for development of a specific office to perform this function, goals and objectives of the Office of Information Transfer, and the specific activities performed by this office with examples of effort to date and what it costs to provide this activity nationwide. We conclude with discussion of organization, funding, and suggestions to others with similar concerns.

Why an Office of Information Transfer

The Service is organized into the Washington, D. C. Directorate and seven geographic regions. The Research and Development component receives direction through the Washington, D. C. Central Office. Operational functions of the Service are National Wildlife Refuges, Wildlife Assistance Offices, Law Enforcement Offices, National Fish Hatcheries, National Fishery Development Centers, Fishery Assistance Offices, Ecological Services Offices, Resource Contaminant Assessment activities, Federal Aid, and Endangered Species. There are technical staffs in each of the 7 Regions and their 767 field stations. Research and Development is dispersed nationwide in 12 centers, laboratories, and teams; 45 Cooperative Fish and Wildlife Research Units; the Office of Extension and Publications; and the Office of Scientific Authority. These facilities conduct basic and applied research and provide technological development. Primary Research and Development products are scientific and technical papers, demonstrations, and technical assistance. The sheer number of entities, programs, and managers nationwide and the need to maximize interchange of technical ideas and data were the primary impetus for original and recent information transfer efforts.

Library and reference services have long been a cornerstone of the Service's information transfer activities. *Wildlife Review,* first published by the Service in 1935, and later, *Sport Fishery Abstracts,* provide field biologists and scientists with citations of recently published fish and wildlife literature. Since 1940, libraries have been established in nine Research and Development facilities and some Regions. The Research and Development libraries primarily serve local Research and Development staff, but also respond to operational requests. In 1967, federal funds were used to establish the Fish and Wildlife Reference Service, whose main function was to disseminate Federal Aid in Fish and Wildlife Restoration (Pittman-Robertson and Dingell-Johnson) Reports.

The Service broadened its information transfer efforts in the mid-1970s by creating the Biological Services Program to provide Department of the Interior capability to respond to rapidly expanding domestic energy development and related environmental impacts on public lands. The Service recognized that ready access to information and its adaptation to the exact needs of resource planners and decision makers were the keys to creating new technology necessary for solving many environmental problems. Vital to the success of this program was the transfer of synthesized information, together with techniques for its effective application, to a wide variety of federal, state, and private sector users. To accelerate this effort, a network of information transfer specialists was placed in the Biological Service's National Teams and in the Regions to (1) better define the users and their information and technology requirements, (2) improve the adaptation of information and technology to user's priorities, (3) package products and disseminate information and technology to meet users' needs, and (4) monitor the use of information and technology. This network of information transfer specialists served primarily Habitat Resources activities (Ecological Services).

In 1982, the Service incorporated the Office of Biological Services (renamed the Division of Biological Services), the Office of Extension Education, and Research to form Research and Development. About the same time, programmatic decisions caused the regional network of information transfer specialists to be dissolved. One National Team has maintained an information transfer specialist and several major

Research and Development facilities have added information specialists and technical assistance personnel (e. g., the Service's Columbia National Fishery Research Laboratory initiated the Contaminant Information Transfer Project in 1982 to provide nationwide access to environmental contaminants information; similar efforts exist in areas of aquaculture, chemical registration, wetland plant species identification, and extension education).

Despite the existence of substantial servicewide information transfer capability, criticism of the apparent inability of Fish and Wildlife Research and Development to meet operational needs increased into the early 1980s. This criticism and increased management concern that existing knowledge (research findings) be applied led the Service to charge its Research and Development function with the responsibility of implementing a nationwide program in 1983 to enhance the exchange of information between Research and Development staff and operational managers, to increase the feedback between field users and the developers of new information and technology, and to otherwise increase Service efficiency in identifying and responding to information needs. Thus, the Office of Information Transfer was founded.

Goals and Strategies of the Office of Information Transfer

The Service identified three goals as the responsibility of the newly created Office of Information Transfer: (1) to provide a centralized point of contact within the Service to expedite communications between Research and Development and operational components, (2) to learn information needs of Service regional and field station personnel and communicate these needs to Research and Development managers, and (3) to broaden the use of Research and Development products, techniques, and services by promoting the development of information transfer products in response to specific user needs. In addition to activities designed to address the above goals, this new office also was given responsibility for several other functions not the focus of this paper. These included editing Research and Development manuscripts, printing and publishing seven Fish and Wildlife Service Research and Development Series, compiling and printing *Wildlife Review* and *Sport Fishery Abstracts* and publication management (quality and cost control for printing and distribution).

Lessons learned from previous Fish and Wildlife Service experience and the successful implementation of information transfer activities in other agencies provided the basis for eight operational strategies to meet these goals:

1. Both Research and Development upper level management and operational components must support the effort.
2. Information to be transferred had to be of priority interest to the user.
3. Users must be active participants in the information transfer process.
4. Information transfer activity should be centralized within Research and Development.
5. The information transfer activity must represent all of Research and Development to all Service field users.
6. The information transfer effort must be flexible, responsive, and relatively free from organizational barriers to communication.
7. There must be continued accountability for products and services.

8. Personnel must have scientific credibility, ability to relate to field needs, problem-solving ability, highly developed communication skills, and a willingness to be pragmatic and innovative.

Implementation of the Information Transfer Activity

From July, 1983 through September, 1984, pilot information transfer activities were conducted in two Service Regions (14 southeastern and southwestern states). A major effort was made to inform Project Leaders of opportunities to receive technical assistance and information from Research and Development. Tactics used to establish the information transfer procedure within the Regions included: (1) presentations to Regional Directors, (2) presentations to groups of Project Leaders (e.g., Refuge managers), (3) personal visits by the Office of Information Transfer staff to selected field stations, and (4) frequent telephone communications with regional and field personnel. We found that a combination of these tactics was necessary to develop the appropriate environment for Regional Office and field personnel to feel comfortable about requesting technical assistance. Ecological Services, target of earlier Biological Services Program information transfer efforts, needed little encouragement to contact the Office of Information Transfer. Other organizational units, such as National Wildlife Refuges, required more effort on the part of Research and Development because many personnel were unaccustomed to any type of information transfer. Throughout, the Office of Information Transfer emphasized that communication between field personnel and their existing sources and contacts was to continue and that new efforts were intended to augment procedures already in place. One Office of Information Transfer staff member was assigned responsibility for activities in each Region. These Regional Assistance Biologists were charged with the responsibility of establishing communications with field personnel and for maintaining contact with Research and Development such that effective two-way feedback developed. Word-of-mouth contact between Service personnel receiving assistance and others not initially inclined to establish contact advertised the Office as an important source of information.

Daily efforts to provide information to field personnel and feedback to Research and Development fell into five major categories of effort: (1) identification of information needs; (2) servicewide referral; (3) library and reference service; (4) special information transfer projects; and (5) marketing Research and Development.

Identification of Information Needs

We emphasized identification of Regional Office and field Project Leader information needs. This was viewed as an ongoing process, with every interaction between information transfer staff and Regional Office or field station personnel presenting an opportunity to solicit information needs. Various mechanisms were used to identify important needs: review of management plans, review of research needs submitted for budget development, discussion of specific issues with field personnel and Regional Office staffs, and review of Regional staff meeting notes. Once needs were identified, we assessed their commonality between Regions and Programs, and ascertained the feasibility of providing Research and Development expertise or other types of assistance to satisfy the needs. Topics not strictly information needs, i. e., needs for new research, were forwarded to the appropriate

Research and Development facilities, thereby promoting an awareness of Regional research priorities.

The Office of Information Transfer attempted to respond to all regional information needs. When time and funding constraints were reached, we requested priorities from Regional Directors. The scientific resources of Service Research and Development provided the major source of technical assistance. When Research and Development could not adequately address a need, outside sources were used to assist the Region.

Agency funding levels will not support work on all Regional research problems. Therefore, only major, nationally significant Regional research problems become funded under research projects. The Office of Information Transfer has had some success in providing partial answers to needs that have not become "new research." Not only does the resource benefit, but the field gains awareness of the ability of Research and Development to provide tangible assistance within existing budgets, to immediate needs whether or not larger scale and longer term research and development can be provided.

Servicewide Referral

The Office of Information Transfer acts as a broker or linker between Service Research and Development scientists and Regional Office and field personnel. Of the 539 requests the Office received for technical information in an 18-month period beginning July 1983, 72 percent (387) were from Regional office or field personnel and were addressed through linking the requestor with the appropriate Research and Development expert (Tables 1 and 2). A broad range of questions was addressed by the cumulative expertise of Service Research and Development staff and other sources located and linked to the field by the Office of Information Transfer (Table 3).

Table 1. Sources of all technical information requests to the Office of Information Transfer, July 1983-February 1985.

Source	Number of requests
Service[a] Regions 1-7	387
Service Research and Development	50
Service Washington Office	27
Other federal, state agencies and private sector	75
Total	539

[a]Service means U.S. Fish and Wildlife Service

Table 2. Sources of *Service Regional* technical information requests to the Office of Information Transfer, July 1983-February 1985, by Service Program.

Program	Number of requests
Wildlife Resources	172
Habitat Resources	160
Fishery Resources	24
Federal Assistance	22
Other	9
Total	387

Table 3. Examples of technical information requests from U.S. Fish and Wildlife Service Project Leaders and the responses provided by the Office of Information Transfer.

Service program and information need	Response
Wildlife resources	
What are the environmental impacts of wild hogs on the native vegetation of a National Wildlife Refuge in southeastern U.S.?	Referred to R&D scientist; provided citations/abstracts; provided literature
Can ASCS aerial photography used to monitor compliance with PIK Programs also be used to monitor plant composition of moist soil units on National Wildlife Refuges?	Referred to R&D scientist
Habitat resources	
What technical information is available to develop a redbreast sunfish habitat suitability index model?	Referred to R&D scientist; provided literature
What are the most effective means to measure turbidity and bed-load in a southwestern stream with increasing sediment fractions?	Referred to R&D scientist; provided literature; provided citations/abstracts; provided industrial contacts
Fishery resources	
What information is available on microtaggants for fish marking?	Service Research Information Bulletins; referred to R&D scientist; provided literature
What technical information exists regarding the biology and artificial propagation of the common snook?	Referred to R&D scientist; referred to hatchery manager; provided citations/abstracts
Federal assistance	
What procedures must be followed to prepare seeds of an endangered plant species for long-term storage?	Referred to R&D scientist; provided literature
What biological information is available on means to age and permanently mark sea turtles?	Referred to R&D scientist; provided citations/abstracts; provided synthesis document

Our first priority when responding to a request is to ascertain whether Service Research and Development personnel possess the expertise to respond. To aid in identifying Research and Development expertise, we established a microcomputer database from a detailed questionnaire which addresses Service expertise in general biology, specific aquatic and terrestrial animal and plant science, biogeographical expertise, and foreign country experience (including foreign language skills). This database can be used to identify expertise not known to individual Office of Information Transfer staff. When a knowledgeable Service scientist is located and consents to provide technical assistance, he or she is linked directly to the person making the request. In our initial contact with scientists, we ensure that the context of the question and the expected form of the answer is understood. At a later date, we contact the requestors to see if their needs have been satisfied. If not, we continue to work on the need until the user is satisfied.

This initial linking provides requestors with knowledge of individuals that they call upon in the future. The Office of Information Transfer encourages continued direct contact with these Research and Development scientists, provided they have consented to this arrangement, thereby eliminating the Office of Information Transfer from the communication loop and increasing the efficiency of the entire operation. The Office of Information Transfer similarly provides linking in the opposite direction by coordinating contacts between Research and Development and field and regional personnel that can provide input for research proposal review, provide new ideas for research, and identify potential workshop attendees and symposia participants.

Library and Reference Services

Of the 539 technical requests we received, 24 percent (127) were for agency publications or important scientific papers needed to address specific problems. Eight percent (41) of the requests required a publication and a referral to a scientist. Since the Office of Information Transfer was not established to serve as a Servicewide library, our policy is to guide users to necessary information by demonstrating use of services offered by others whose major function is library and reference activity. The U. S. Department of the Interior's Natural Resources Library, libraries at Research and Development facilities, the National Technical Information Service, and the libraries and publications units of numerous federal and state agencies have been used to provide needed information. Requests from field stations for reprints of technical papers are honored by the Office of Information Transfer when other Research and Development facilities cannot provide the assistance.

We received 122 requests for literature searches during this same period. It seems that field personnel often choose literature search as a first and general means to obtain assistance. In many instances, we have obviated the need for literature review by providing names of Research and Development scientists with the necessary expertise, or by locating key documents that provide exactly what is needed. In this way, field staff are not overwhelmed with interesting but not immediately necessary information. Included with most searches provided to field personnel are annotations, short syntheses, and photocopies of pertinent recent literature.

Special Information Transfer Projects

When information needs are solicited, some may be identified that will require a significant effort by Research and Development to repackage existing information in a desired form. These needs are categorized as requiring "special information transfer projects" for proper completion (e. g. , Table 4). Because these special projects require considerably more effort and dollars to complete than daily referral activities, each Region submits a list of high priority special projects proposals to the Office of Information Transfer by the end of the first quarter of each fiscal year. We compile and analyze these regional submissions, and with input from Research and Development, judge whether it is feasible for Research and Development to complete the proposed projects in the current fiscal year. Regional Directors are notified of Research and Development selection of new starts midway through the second quarter of the fiscal year. Occasionally, Regional Directors request a reordering of project priorities when new, important issues result from unforeseen events. We try to maintain flexibility to respond to these critical requests. The funding of these special projects is generally borne by Research and Development unless major personnel, travel, or contract costs are involved.

Table 4. Examples of Special Information Transfer Projects initiated and/or completed in 1984 through the auspices of the Office of Information Transfer.[a]

Needs and products	
Printed products	
1. Need:	Inform the general public of the status of wetlands and their loss
Product:	Coastal Wetland Change Brochure
2. Need:	Provide information on and access to Fish and Wildlife Service databases
Product:	User's Guide to Fish and Wildlife Service databases
3. Need:	Inform the general public of the biology and management needs of a west coast marine endangered species—the sea otter
Product:	Guidebook for viewing sea otters on the California coast
Workshops	
1. Need:	Provide Service managers and biologists with an on-site update on the ecology and management of wintering waterfowl populations
Product:	Wintering Waterfowl Ecology Workshop with printed proceedings
2. Need	Integrate research results and management needs for important aquatic invertebrates in the southeast
Product:	Freshwater Mussel Workshop
Audio-visual products	
1. Need:	Provide a videotape for informing Service employees of the effects of management practices on larval fish
Product:	Larval Fish Ecology Training Videotape
2. Need:	Provide Service biologists and state and federal land managers with biological information about an endangered plant species of current high concern—the green pitcher plant
Product:	Green Pitcher Plant Slide-Tape

[a]Various Research and Development staff from Laboratories, Teams, Centers, and Cooperative Units, as well as non-Service scientists, were involved in the planning and conduct of the examples provided.

Marketing the Service's Research and Development Products

The Office of Information Transfer also "markets" Research and Development by enhancing the visibility of products and bringing specific expertise to bear on high priority issues. We assist Research and Development facilities to identify proposed audiences for publications and suggest formats that may be preferred by identified audiences. When opportunities arise, we survey groups of Service personnel for their important technical assistance needs and their preferred information transfer formats. For example, we can advise Research and Development managers that surveys show that the most urgent technical assistance desired by Refuge Managers in the southeastern United States is for means to estimate seasonal wildlife populations and conduct wildlife surveys. Their priority order of preferred formats for receiving information is: (1) user manuals, (2) brief "how-to" leaflets, and (3) training workshops.

Office of Information Transfer personnel visited nine annual regional Project Leader meetings and seven Regional Offices in FY 1984 during which they made short presentations about completed and ongoing research projects in Research and Development. These forums provided valuable interaction between scientists and operational personnel and provided notice of recent Research and Development products. Examples included: a one-day workshop at a Regional Project Leaders meeting that produced a valuable exchange between Service and other scientists and more than 60 operational personnel in the Southwest on the use of sewage effluent for wetland development; a two-day workshop on the ecological needs of wintering waterfowl presented to 35 project leaders in the Southeast; and technical presentations by three Research and Development scientists to more than 80 Project Leaders in the Southeast on state-of-the-art methods for inventorying selected wildlife species on National Wildlife Refuges. To emphasize Research and Development in a regular and formal context, our staff provides articles for the *Fish and Wildlife News* and submits articles to a monthly Regional Wildlife Resources newsletter. We also assist Research and Development facilities to develop informative brochures on such diverse topics as vanishing Gulf Coast Wetlands and the return of the lake trout (*Salvelinus namaycush),* and maintain a servicewide mailing list to distribute Research and Development products.

Critical Organizational Elements

Two aspects of the organization of our information transfer effort have proven critical in the success obtained to date: The staffing pattern and the designation of the Office within the Research and Development portion of the Service.

Staffing

Our observations show that it is important to mix persons having strong biological backgrounds with those who are knowledgeable in both traditional and state-of-the-art information transfer processes. Our regional assistance biologists, those persons assigned to work directly with Regional personnel, have had recent employment as scientists with Service Research and Development and have significant experience in operational programs at the Field, Regional Office, or Washington Office level. They are familiar with Research and Development organization and management, and know the scientists at many of the Research and Development facilities on both a personal and professional basis. Familiarity with the thought processes and methods used by scientists to tackle a problem greatly enhances the Office of Information Transfer's ability to obtain necessary information from Research and Development for operational personnel. We are convinced that former Research and Development scientists serving in an information transfer capacity have the highest probability of developing credibility with the major source of data available in the information transfer process we have chosen, the in-house personnel at facilities throughout the nation. Likewise, the scientist in this capacity has to be able to relate to the values and mode of operations used by field biologists and managers. There is no substitute for personal experience in this area. Such experience, in turn, assists the scientists in developing credibility with the field personnel who are the potential users of the information transfer function. Staff persons well versed in information transfer processes provide a needed balance to the scientific-operational approach used by regional assistance biologists and provide guidance on the best methods and formats for transferring information and identifying the varied sources of information. They also serve as backups to the regional assistance biologists. In sum, the means we chose to develop the Office's activities required close interpersonnel contact between our staff and Service personnel nationwide. The need for user involvement, the importance of developing trust, and the need for complete communication between Research and Development and operational personnel, our specific concerns, were reasons for this personal approach.

Important qualifications for all staff persons in information transfer include the aforementioned familiarity with the policies and operational mechanics of the organization as a whole, and well developed personal communication skills. Cross-program experience combined with an office policy of open communication has been invaluable for providing timely and quality responses to information requested. Treating users as "valued customers" has ensured that interactions have been positive.

The preferred staffing mix for our current information transfer efforts would include four scientists as regional assistance biologists, three technical support staff with biological or information transfer expertise, one microcomputer database specialist, and two secretaries. Total operating costs including salaries, supplies, equipment, travel, and product development funds would, under this configuration, be under $500,000. We feel confident that this staff could provide answers to all field questions within nine working days and that 14 special information transfer projects, 21 presentations to Regional personnel, regular contact with all field stations, and direct contact with every Research and Development facility could be accomplished. Ten percent of this staff's time could be allocated to nondirected innovative techniques development, five percent to major syntheses, and five percent to direct consultation within Research and Development. Eighty percent of the Office's effort would remain allocated to the daily addressing of information needs from the field.

Funding

The Office of Information Transfer is funded as an overhead assessment within the Research and Development organization. Such an arrangement makes the effort accountable to Research and Development and provides the services to the Regions with no immediate impact on their operating funds. Although this arrangement may seem tenuous, especially in austere times, it ensures that we try harder to be on target with the services provided and that we are accountable for the value of those services.

Office of Information Transfer staff represent Research and Development when conducting information transfer activities, not just their own Office. This likewise increases accountability, ensures that the information transfer activity remains focused on products, and prevents the organization from devoting energy to self-preservation and empire-building that otherwise would be spent on information transfer. Making the information transfer function accountable to all interested parties (users, parent body, organization as a whole) correctly places evaluation of performance on satisfaction of these parties.

Evaluation and General Application

After an initial 12 months of full-scale effort in two geographic regions, the Office of Information Transfer was evaluated by a review panel and by the Regional Directors and their staffs that had been working in the pilot program. All agreed that the program had been successful and that the activities of the Office of

Information Transfer should be expanded nationwide. Beginning in October, 1984, expansion was begun, and we now have active information transfer mechanisms established in all seven Regions of the Service.

The activities we have described were initiated in response to specific needs of the U.S. Fish and Wildlife Service. Fine-tuning of this effort over the past 24 months has resulted in development of an agency-specific program that has significantly expanded communication between operational and Research and Development personnel, increased utilization of Research and Development products, and placed in the hands of managers the information they requested to make day-to-day and long-term decisions. Despite the agency-specificity of our solution to information transfer problems, we believe there are several points worth emphasis as suggestions to other natural resource agencies with similar needs for an in-house mechanism to facilitate information transfer:

1. Do not recreate the wheel. Learn from the successes and failures of others with similar needs and efforts. Extract and modify what will work for you.
2. Have full support of the agency for the program. Support entails a clear mission statement, adequate budget, and latitude in staff selection. Support is important because establishing an aggressive, interactive program involves "teaching old dogs (traditional scientists and old line biologists) new tricks (new ways of doing business)." You will be agents for change and your actions will not necessarily be endorsed upon first meeting. Be prepared to educate your agency.
3. Locate the information transfer function within the Research part of the agency, if such a program exists. Because much of the technical expertise required to respond to needs is located within Research and Development, we feel it is easier to be the "insider" and overcome the biases of working with the operational part of the agency rather than vice versa. Regardless of where the information transfer function is located, avoid involvement in internal politics.
4. Involve operational personnel in the development of simple but effective procedures for requesting assistance.
5. Be opportunistic in the efficient use of travel funds and staff time to sell the information transfer program to field personnel in the agency. Make sure your products speak for you. Do not get discouraged if immediate results do not occur; it takes time to overcome old habits. Get people interested in new ideas and different ways of doing business.
6. Make a continual effort to provide timely and quality responses to all personnel in the agency. Follow up each request. Word-of-mouth success (and failure) stories travel quickly. If the information transfer group does not produce, support at all levels quickly erodes.
7. Implement tactics to utilize the full expertise of your agency's Research and Development staff. Be alert for sources of expertise you do not have in your agency.
8. Market Research and Development expertise and products. Seek innovative ways to announce Research and Development products and results of ongoing studies to the operational entities of the organization. Caution—carefully assess user needs so as not to burden field managers with unwanted and unnecessary material and your Research staff with nonpriority questions.

9. Explore ways to use state-of-the-art technology to transfer information. Depending upon agency needs, examples include software training packages for use on microcomputers, teleconferencing, videotaping of workshops, electronic bulletin boards, interactive video, teletraining, electronic mail, etc.
10. Explore new person-person and group communication techniques, and develop skills in interviewing, marketing, sales, conflict resolution, effective listening, memory, meetings management, project planning, etc.
11. Encourage innovation and change; do not establish inflexible routines or procedures.
12. Work simply, directly, and stay small.
13. Accept risk and be prepared for some failures.

Future Directions

Natural resource management and research organizations change through time as surely as do biological organisms and communities. Biological knowledge and related management techniques continue to be modified through interactions. The politics and national values affecting resource management continue to change. Administrators, managers, and biologists are continually trying to maintain currency with newly developing technologies and ideas. The trends in all parts of society are toward more intensive management and utilization of knowledge. The future for information management within the Fish and Wildlife Service and other entities of our size will probably involve at least the following:

1. Increased need for and emphasis on use of technical training or continuing education activities for operational personnel. This will require more efficient transfer of existing technical knowledge.
2. Rapid adaptation of information management technology in areas such as: electronic communications (including electronic mail, tele-and video-conferencing, videotape communications, interactive computer gaming,electronic databases, geographic information systems, specialized subject citation searches, on-line libraries, and computerized information networks); use of technical information analysis concepts; and adaptation of models as synthesis tools for management planning.
3. An increase in short-term research and development studies to meet specific data gaps.
4. An increase in the systematic application of existing knowledge in various decision processes.
5. A changing public that desires greater emphasis on integrated communication strategies that stimulate visual, aural, and other senses simultaneously.

To continue to manage the nation's natural resources in a world of competing demands will necessitate more efficient planning in personnel selection, facility design, long-term capital equipment acquisition, training, and other phases of implementation to take advantage of the expanding world of information management. Such planning will allow us to meet the changes and challenges facing natural resource managers of the twenty-first century.

Acknowledgments

We thank our associates in the Office of Information Transfer for their input, and acknowledge the useful comment of N.B. Kverno, E.-P. Multer, C. H. Halvorson, and J. D. Brown, on earlier drafts of this paper. We likewise thank the Service employees who agreed to participate in the pilot programs (Regional Directors J. W. Pulliam, Jr., and M. J. Spear and their staffs), the Research and Development managers and staff who agreed to try something new, and the members of our advisory committee who have provided input throughout. Lastly, we acknowledge the support of F. E. Hester, R. N. Smith, J. D. Buffington, and N. B. Kverno, who gave us responsibility to implement change and the latitude to shake free from old conventions.

Influencing Congressional Decisions on Wetlands Conservation: Information and Communication Needs

Robert P Davison
National Wildlife Federation
Washington, DC 20036

Introduction

Members of the U.S. Congress and their staff provide guidance, approve expenditures, and establish mechanisms to implement a broad array of federal programs that directly and indirectly affect the conservation or wetlands. These programs include those to fund the acquisition of wetlands, such as the Migratory Bird Hunting Stamp (Duck Stamp) Act and the Wetlands Loan Act; those to regulate the conversion of wetlands, such as Section 404 of the Clean Water Act; and those that provide incentives for either the conservation of destruction of wetlands, such as the Federal income tax deductions allowed for land donations for conservation purposes in the Tax Treatment Act of 1980, other provisions of the Internal Revenue Code that allow investment tax credits for equipment used to drain and clear wetlands, and the conservation and commodity programs in the Agriculture and Food (Farm) Act of 1981. The actions taken by Congressional policy makers with regard to wetlands conservation policies in these and other programs are a function of numerous political and economic factors. The most salient of these factors are constituent contacts, positions of key opinion leaders in the public and private sector, and impacts to the development and growth of business and industry, particularly those that directly affect the well being of constituents. Although all Congressional decisions on wetlands conservation are made within this context, sound scientific information is important to document the need for action by Congress, to guide the formulation of legislative language, and to aid Congressional oversight of ongoing federal wetlands programs.

Data on the magnitude and rate of wetlands destruction are being used successfully to demonstrate and initially define this problem to key Congressional leaders and staff. For example, release of the data from the recent U.S. Fish and Wildlife Service study on the status and trends of wetlands in the conterminous U.S., 1950s to 1970s, was a major contribution in the efforts of resource professionals and other conservationists to convince Congressional policy makers and the public of the need for emergency action to conserve wetlands (Frayer et al. 1983, Tiner 1984). Estimates by Frayer et al. (1983) that there had been a net loss of over 9 million acres (3.6 million ha) of wetlands, an average annual loss rate of 458,000 acres (185,350 ha), in the 20-year period examined were used repeatedly in the 98th Congress to advocate approval of legislation to provide increased funding for wetlands acquisition (Emergency Wetland Resources Act of 1983), to maintain effective regulatory protection of wetlands (amendments to the Clean Water Act Section 404 program in the Water Quality Renewal Act of 1984), and to create increased incentives for private efforts to conserve wetlands (Private Wetland and Critical Habitat Enhancement and Protection Act of 1984). The data of Frayer et al. (1983) and other estimates of wetlands destruction were effective in efforts to formulate a consensus on the need for new programs to fund state and federal wetlands acquisition, which led to unanimous passage of the Emergency Wetlands Resources Act of 1983 by the U.S. House of Representatives. Only an extraneous amendment prevented adoption of similar legislation in the U.S. Senate.

Information on the value of wetlands to humans also has been important in building a consensus for increased wetlands protection efforts. Documentation of the dependence of marine and estuarine fisheries (finfish and shellfish resources) on wetlands for habitat, nutritional needs, or because of the ability of these areas to recycle and export nutrients has been used successfully to generate support for wetlands protection among commercial fishermen (cf Turner 1977, 1978). These interests in turn have told Congress that their livelihoods depend on maintenance of wetlands along this nation's coasts. For instance, in 1982 the Texas Shrimp Association testified in support of the Section 404 program before the Senate Subcommittee on Environmental Pollution (Rayburn 1982). Similarly, documentation of the importance of wetlands for storing flood waters and desynchronizing the release of flood waters from numerous basins within a watershed has been effective in generating support for wetlands protection among interests not primarily concerned with the conservation of fisheries and wildlife habitat (cf Novitski 1979, Brun et al. 1981). In 1983 the Passaic River Coalition in northern New Jersey testified before the House Subcommittee on Water Resources that the Clean Water Act's Section 404 program to protect wetlands from filling was important to their interests because wetlands have "enormous value for flood control" in the Passaic River Central Basin (Filippone 1983).

The increasing amount and quality of data on the goods and services provided by wetlands and the rate of wetlands destruction has produced greater awareness and broader support among the public of the need for increased wetlands protection. As a result, Congressional policy makers are contacted increasingly by their constituents and key opinion leaders on behalf of wetlands protection. The response of Congressional policy makers to these contacts largely has been to provide mechanisms for funding increased land acquisition, such as the proposed Emergency Wetlands Resources Act of 1983. Better documentation on the causes and rates of wetlands destruction, the values of wetlands, and the adequacy of present wetlands protection programs will be necessary to convince Congressional policy makers that increased land acquisition is only a first and inadequate step in conserving a significant diminishing resource. Such information and improved communication of that information to Congressional policy makers is needed to demonstrate that Congress must take additional action, beyond land acquisition, to conserve wetlands adequately and that failure to act will be costly to their constituents and to society as a whole.

Information Needs

Existing information adequately demonstrates that wetlands provide valuable products and services to society and that the extent of previous and current destruction of these resources is a serious national problem. More specific information is needed to enable Congressional policy makers to identify federal programs that individually and cumulatively induce significant destruction of wetlands, to construct legislative language that realistically is capable of being implemented, to assess accurately the impact of proposed legislative language, and to evaluate how well existing laws have been implemented.

Federal agricultural programs and Internal Revenue Code provisions are frequently identified as contributing significantly to the destruction of wetlands (Shabman 1980, Barrows et al. 1982, Anonymous 1984). However, hypotheses that the presence of investment tax credits for property used to destroy wetlands results in higher rates of wetlands destruction or that the presence of agricultural price and income support programs has a similar effect remain untested. Moreover, there is a need to formulate and test more specific hypotheses that describe how the relationship between one or more federal programs and the rate of wetlands destruction varies by the size, type and location of wetlands. A test of the hypothesis that the presence of investment tax credits and deductions encourages conversion of bottomland hardwood wetlands in the Lower Mississippi River Valley may not be equally applicable to destruction of wetlands in the Prairie Pothole Region. Bottomland hardwood conversion frequently involves single projects emcompassing hundreds or thousands of acres by large diverse corporations, whereas drainage of prairie wetlands may involve projects less than 10 acres (4 ha) by family-operated farms. Similarly, the effect of agricultural price supports, loan and storage programs on the rate of wetlands destruction may be expected to vary between large tracts of converted bottomland hardwood wetlands planted to soybean (the market price of which historically has exceeded the support price) and small tracts of converted prairie potholes planted to corn. Additionally, more extensive federal flood control programs in the Lower Mississippi River Valley may significantly reduce the risk of bottomland hardwood wetland conversion and may alter to a greater extent the effect of tax code provisions and agricultural programs on wetlands destruction in that region.

Formulation and tests of hypotheses regarding the individual and cumulative effect of federal programs on wetlands destruction must recognize these differences that exist among wetlands with respect to size, type, location and conversion activity and purpose. However, present information is inadequate on how the magnitude and rate of loss vary according to these variables. To convince Congressional policy makers that it is realistic to implement more effective wetlands conservation programs through elimination of federal inducements for conversion or through expanded federal regulation may require just such identification of those wetlands, by size, type, and location, that are most seriously jeopardized and the corresponding conversion activities responsible for the identified losses. Better documentation of the proportion of wetlands destroyed or degraded by activities other than the discharges of dredged or fill material, such as draining, clearing, or excavation would be a major contribution to current efforts to convince Congressional policy makers to expand the activities regulated under Section 404 of the Clean Water Act. Improved estimates of how rates of wetlands destruction vary by wetlands size (area) and location also would aid efforts to define the appropriate minimum number of acres that should be subject to full regulatory coverage under Section 404 or to other provisions of wetlands conservation measures developed by Congressional policy makers. Continued evaluation of methods of assessing functional values of wetlands such as that developed by Adamus (1983) also is required to determine whether it is both possible and appropriate to vary the protection afforded wetlands of similar size according to their relative value.

In addition, Congressional policy makers must be provided with properly designed scientific studies that evaluate how well existing laws have been implemented. Instead, too often Congressional policy makers are provided with vague unsubstantiated statements or isolated examples as demonstrations of how a program is working. While Congressional decisions always will be made in a political context, objective assessments of whether a federal program is providing effective resource protection are an essential starting point in influencing those decisions.

In the area of wetlands conservation one pressing need is to obtain scientifically valid answers to the questions of how effective the present system established under Section 404 of the Clean Water Act has been at controlling wetlands destruction and conserving fish and wildlife resources. Congressional policy makers must be provided with sound estimates of the proportion of total annual wetlands destruction due to the discharge of dredged or fill material, which currently should be regulated under Section 404. Similar information is needed on the proportion of wetlands destruction from such discharges (i.e., filling) that occurs without triggering the protective provisions of Section 404, either because of unauthorized, and therefore illegal, activities or because of statutory exemptions or regulatory conveniences such as general permits. Where wetlands fills were subject to conditions in Section 404 permits to protect fish and wildlife resources or water quality, estimates similar to those of Lindall and Thayer (1982), but independent of the participating federal and state agencies, are needed on the proportion of those discharges of fill that comply with the permit conditions. Moreover, independent information is needed on the effectiveness of permit conditions in achieving the intended protection of fish and wildlife resources or water quality. In addition, greater attention should be directed toward investigating the cumulative impacts to wetlands resources that result from reduced scrutiny of less than 10 acre (4 ha) fills in isolated wetlands and wetlands located above stream headwaters.

Estimates for the above Section 404 program parameters should be obtained from field studies that monitor wetlands activities and impacts in sample areas within selected ecoregions (Bailey 1978). In addition, resource scientists should become familiar with the Freedom of Information Act process as an effective means of obtaining data on federal agency administration of regulatory programs like Section 404.

The quality of Congressional oversight and decisions on federal implementation of other programs such as the Fish and Wildlife Coordination Act and Migratory Bird Hunting Stamp Act also would benefit from scientifically sound evaluations by independent researchers.

Communication Needs

Even if the information needs identified above are answered in a scientifically supportable manner, that information will not be effective in influencing Congressional decisions on wetlands conservation policies unless it is communicated effectively to the key policy makers, i.e., members of Congress and, equally importantly, professional staff of relevant House and Senate Committees and Subcommittees. The decisions on wetlands conservation policies by members and staff of Congress are influenced through direct contacts, media coverage, constituent pressure, and various forms of rewards.

Conservation organizations and societies for resource professionals are key in communicating information on wetlands and wetlands conservation policies developed by resource scientists to Congressional policy makers not only directly but also indirectly through the media and Congressional constituents. To be an effective link in this critical communication process, conservation organizations and professional societies need to play a greater role as clearinghouses that locate, compile, summarize, and disseminate information obtained from the scientific community and other sources. These other sources should particularly include state and federal agencies. Conservation organizations and professional societies should make far greater use of informal requests for data from these agencies, or failing that, formal requests from federal agencies under the Freedom of Information Act. All too frequently federal agencies have considerable data on the implementation or resource effects of their programs but have not had the time and money or allocated the necessary time and money to summarize and analyze this information.

Conservation organizations and professional societies must step in, retrieve this information, objectively analyze it, and put it in a form that can be communicated to the media and Congressional policy makers and their constituents.

The means of communicating scientific data and information on implementation of federal programs to Congressional decision makers, their constituents, key opinion leaders, and the media must vary to insure that it reaches the intended audience and is readily understood and useful. Efforts to communicate information directly to Congressional policy makers must differ between members of Congress and professional staff. Successful communication strategies with members of Congress should focus on developing and identifying supportive individuals with ready and friendly access to these members. Resource professionals, particularly those of prominence, need to recognize the importance of building an easy rapport with one or more members of Congress. Other individuals with such access to members who are not resource professionals are important as 'door-openers' to allow a message on wetlands conservation to be conveyed to members in a favorable and attentive setting. Regardless of whether an individual with such access is present, information for members must be capable of being presented in less than 15 minutes. Once the important exchange of personal inquiries is completed, the wetlands conservation problem, including an illustration if possible from the appropriate district or state, must be stated at the outset without lengthy background statements, followed by a succinct statement of what is needed to correct the problem in whole or in part and a brief justification. The intent is only to generate interest in the member which can be followed up later with the appropriate staff.

Effective communication with professional Congressional staff hinges on their recognizing individuals as reliable and substantive sources of information. Major presentations of information on problems of wetlands destruction or changes in wetlands policies should be prepared as a concise briefing package including a problem statement, a suggested solution (including, if possible, conceptual language to establish legislative mechanisms realistically capable of being implemented), a short justification for the solution, and an assessment of the extent to which the recommended solution would alleviate the problem. Conservation organizations and professional societies can aid here, as with members of Congress, in packaging and communicating information or in connecting resource professionals directly with professional Congressional staff.

Resource professionals should not only rely on conservation organizations, in particular, for establishing contacts and communicating information directly to Congressional policy makers, they also should use these organizations more as a means of packaging, targeting, and distributing information to the media and Congressional constituents. Responses by individuals in these two arenas to such information can have a major effect on shaping the perceptions Congressional policy makers have towards wetlands conservation. Through the use of press releases, 'tip sheets,' newsletters, magazines, 'action alerts,' and other communication mechanisms, conservation organizations have access to thousands of newspapers and radio and television stations and millions of Congressional constituents.

Conclusion

More effective influence of Congressional decisions on wetlands conservation begins with increased development of scientifically valid information on (1) the magnitude and rate of destruction of wetlands by size, type, location, and conversion activity; (2) the methodologies to delineate and assess relative values of wetlands more readily; and (3) the effectiveness of present wetlands conservation laws. Development of such improved information on these subjects will be far more likely to influence Congressional decisions in favor of improved wetlands conservation if it is packaged, targeted, and distributed according to the intended audience: members of Congress, professional Congressional staff, their constituents, and the media. Conservation organizations and professional societies must be utilized to a greater extent as a means of communicating information from those resource scientists who have recognized the need to be involved increasingly in research with policy implications to Congressional policy makers directly or indirectly through their constituents and the media.

Literature Cited

Adamus, P. R. 1983. A method for wetland functional assessment: volume II. Rep. No. FHWA-IP-82-24. Office of Research, Development and Technology, Federal Highway Administration, U.S. Dept. of Transportation, Washington, D.C. 138 pp.

Anonymous. 1984. Wetlands: their use and regulation. Rep. No. OTA-O-206. Office of Tech. Assessment, U.S. Congress, Washington, D.C. 208 pp.

Bailey, R. G. 1978. Description of the ecoregions of the United States. Intermt. Reg., For. Serv., U.S. Dep. of Agric., Ogden, UT. 77 pp.

Barrows, R., D. Henneberry, and S. Schwartz. 1982. Individual economic incentives, the tax system and wetland protection policy: a study of returns to wetland drainage in southeastern Wisconsin. Presentation at 1982 Summer Meeting, American Society of Agricultural Engineers.

Brun, L. J., J. L. Richardson, J. W. Enz, and J. K. Larsen. 1981. Stream flow changes in the southern Red River Valley of North Dakota. N.D. Farm Res. 38(5):11-14.

Filippone, E. F. 1983. Statement of Ella F. Filippone, Ph. D., Executive Administrator, Passaic River Coalition on the Clean Water Act before the Subcommittee on Water Resources of the Committee on Public Works and Transportation, U.S. House of Rep., Washington, D.C.

Frayer, W. E., T. J. Monahan, D. C. Bowden, and F. A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950's to 1970's. Dep. of Forest and Wood Sciences, Colorado State University, Ft. Collins. 32 pp.

Lindall, W. N., Jr., and G. W. Thayer. 1982. Quantification of National Marine Fisheries Service habitat conservation efforts in the southeast region of the United States. Marine Fish. Rev. 44(12):18-22.

Novitski, R. P. 1979. The hydrologic characteristics of Wisconsin wetlands and their influence on floods, streamflow, and sediment. Pages 377-388 *in* P. Greeson, J. R. Clark, and J. E. Clark, eds. Wetland functions and values: the state of our understanding. Amer. Water Resour. Assoc., Minneapolis. 674 pp.

Rayburn, R. 1982. Statement of Ralph Rayburn, Executive Director, Texas Shrimp Association on Section 404 of the Clean Water Act before the Subcommittee on Environmental Pollution of the Committee on Environment and Public Works, U.S. Senate, Washington, D.C.

Shabman, L. 1980. Economic incentives for bottomland conversion: the role of public policy and programs. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 45:402-412.

Tiner, R. W., Jr. 1984. Wetlands of the United States: current status and trends. National Wetlands Inventory, U.S. Fish Wildl. Serv., Dep. Interior, Washington, D.C. 59 pp.

Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. Amer. Fish. Soc. 106:411-416.

——. 1978. Community plankton respiration in a salt marsh estuary and the importance of macrophytic leachates. Limnol. Oceanography 23(3):442-451.

Early Career Development of Fisheries and Wildlife Biologists in Two Forest Service Regions[1]

James J. Kennedy and Joseph A. Mincolla
College of Natural Resources
Utah State University
Logan, UT 84322

Wildlife and fisheries biologists claim the status of a profession because their knowledge is founded upon scientifically tested evidence. Much professional knowledge believed true of wildlife behavior or population dynamics 30 years ago has been altered by the challenge of new scientific evidence. This is the way professional knowledge should evolve.

Wildlife/fisheries biologists study how animals adapt to changes in their life cycles and environments, but rarely turn such scientific curiosity to study themselves—to research their professional attitudes and behavior at various stages in their careers (Cutler 1982). Our study (Kennedy and Mincolla 1982) counters this tradition in examining the early career development of biologists recently hired by two Forest Service regions. How biologists are fitting into their profession and the Forest Service organization is compared to their forester and range conservationists (range-con) colleagues.

Our research is based on the organizational behavior tradition of Van Maanen (1977) and Schein (1978). It adopts the career stage perspectives of Dalton et al. (1977) and Levinson et al. (1978). Elements of these career development theories will be described below as they apply to the study's findings. For a good introduction to career development see Hall (1976) and, especially, Schein (1978).

The Study

In fall 1981 the USDA-Forest Service (USFS) and Utah State University (USU Agricultural Experiment Station, MacIntire-Stennis Project 712) collaborated to study the career development of entry-level wildlife/fisheries biologists (hereafter called biologists), foresters and range-cons in Regions 4 and 6. Entry-level was defined as 1 to 3 years in a permanent USFS professional appointment. USFS Region 4 consists of the intermountain states of Utah, Nevada, southern Idaho and western Wyoming. More timber-oriented Region 6 (Oregon and Washington) contrasts the range-wildlife-watershed focus of Region 4.

To obtain a different perspective of young professionals' attitudes and performance, their immediate supervisors were also surveyed. Return rates on the mailed questionnaires were 81 percent for young professionals (hereafter labeled YPROS) and 71 percent for their immediate supervisors (SUPERS). This yielded a 50 percent sample of all biologists, foresters, and range-cons in Regions 4 and 6 hired between 1979 and 1981. We judge this an adequate sample to make inference to Region 4 and 6. No pretense is made that our data represents a larger population.

[1]Utah Agricultural Experiment Station Journal Paper 3119.

Thirty-eight biologists (79 percent return-rate) responded to both volumes of the questionnaire. Twenty were from Region 4 and 18 from Region 6. About half (55 percent) the biologists hired in Regions 4 and 6 between 1978-81 were women. Due to higher return-rates, 66 percent of biologists returning both volumes of the questionnaire were women.

The findings presented below begin with biologists' selection of a university major leading to their permanent USFS appointment, examine how (and how not) these biologists are fitting into that job, and look at their career commitments to the USFS organization and to their profession.

Selecting a Major and Getting a Forest Service Job

At about age 20 most biologists (72 percent) had decided to pursue their career—although many (38 percent) received general biology BS degrees. Motivations for a fisheries or wildlife career were explored in an open-ended question that easily coded into six categories, of which 80 percent were in the following three (in descending order of popularity):

1. Concern for fish-wildlife conservation and/or protection.
2. Desire to work in/with natural environments (outdoors).
3. Work/career that's challenging, enjoyable and/or rewarding.

Biologists expressed significantly more heart-felt "concern for. . ." or "desire to protect. . ." the resources they were to manage than their forester and range-con colleagues ($X^2 = 27.0$, 8 df, $P = <0.001$).

To explore the importance of future USFS employment when selecting their college major, YPROS were asked: "Was the Forest Service, as a possible place for you to work, an important influence when you made the decision to pursue a natural resource occupation?" Fifty-six percent of foresters and 71 percent of range-cons recall a future USFS appointment as an important consideration in choosing their college major; only 22 percent of the biologists felt this way ($X^2 = 17.3$ df, $P = < 0.001$).

Biologists also had much more graduate education. Sixty-eight percent of biologists completed MS degrees—only 23 percent of foresters and 11 percent of range-cons did so. This means biologists were generally 3 years older when joining the USFS, and had more exposure to academic-oriented socialization (conditioning) than foresters and range-cons.

All biologists received their permanent USFS appointment since 1979. They reported to that job highly educated, strongly motivated, and with considerable professional job experience—96 percent having had two or more temporary jobs in their professional area (mostly with the USFS). When surveyed in 1981, most (71 percent) were still on their first permanent USFS assignment. On a 7-point scale ranging from extremely high to extremely low, with a neutral position, biologists rated their first permanent USFS job rather highly. About 70 percent rated overall job satisfaction in the high ranges. Eighty-five percent said that job had positive to extremely positive impacts on commitment to their professions; less (69 percent) rated its impact on their commitment to the USFS in that positive range. There were no significant differences in impact on first permanent job between biologists and foresters or range-cons. But women in these three professional-types experienced significantly lower overall job satisfaction (X^2 = 16.6, 6 df., P = 0.01) and less commitment to stay in the USFS than their male colleagues (X^2 = 15.4, 6 df., P = 0.02).

YPROS were asked to rate what they expected of their first permanent USFS job versus found on items like: job challenge, group morale, chance to pursue personal career goals, opportunity to serve the public, etc. Satisfaction can be defined as existing when desired events *experienced* on the job are greater than *expected* (e.g., group morale found was greater than expected). On all items, YPROS had higher expectations than what was experienced on the job. The negative disparity (viz., disappointment) was small between "overall job satisfaction" expected versus found, but great negative disparity was experienced on more specific items like "chance to pursue skills learned in college."

Professional-types varied significantly on "opportunity to serve the public" expectations versus what was experienced (X^2 = 21.3, 12 df., P = 0.05). All three professional types had similar expectations of serving the public, but only 40 percent of foresters rated their chance to do so in the high ranges. Seventy-four percent of biologists and 65 percent of range-cons experienced a high to extremely high "opportunity to serve the public." These two types of professional recruits felt more in contact with the public and catering more directly to their needs than foresters involved more in technical timber management or planning.

We have just examined the age-old phenomena of recruits' (often naive) expectations being shocked by the "real world" of organizations. Such shock seems to be experienced by most recruits to industrial, military, or religious organizations. Hughes (1958) labeled this phenomena "reality shock." Finding YPROS had more optimistic expectations than what was encountered, and experienced negative "reality shock," was no surprise. Several studies of professional recruits discovered this (Campbell 1968, Lodahl and Kejner 1965, Hall and Schneider 1972). The questions of interest are how the majority of YPROS seem to cope with this reality-shock, and manage to adjust to their jobs and to the USFS organization.

Fitting Oneself into Forest Service Time and Space Dimensions

Van Maanen (1977:38) has observed, ". . . a newcomer to an organization cannot participate in the organization unless he first locates himself in space and time." A young biologist in the early months of their first permanent job is relatively disoriented, and has a great need to *position* him or herself in organizational space and time. Space-orientation requires recruits to identify superiors and get positioned relative to them. New recruits must also decipher what are the important attitudes and behaviors for a person in their position—a role that tends to evoke complimentary and conflicting professional versus organizational loyalties.

Time-orientation requires one to learn the organization's clock. The immediate need is to understand times to arrive at work or how soon certain tasks are expected to be accomplished. In the longer time dimension, recruits must also dertermine the time norms for advancement in their careers, how often one normally is transferred, and so forth.

How well entering biologists are "positioning" themselves with their supervisors and USFS values is the subject of the next sections.

Positioning Oneself Into Authority and Respect Relationships

Max Weber (1947) observed that organizational authority comes from a person's (1) rank and (2) subordinates' perceived legitimacy. One can have organizational rank but little legitimacy, and thus little authority. Another person (e g., a master sergeant or a technician) can have less rank, but more legitimacy and posses more authority than the person in charge (e. g., the captain or district ranger).

A biologist positioning him/herself in USFS organizational space can easily see who has official rank. Deciding on legitimacy is a more complex and personal decision. We asked, "In your current position, whose praise, compliments, or criticism would have the greatest effect on you?", trying to locate perceived legitimacy—an important aspect of authority orientation. An open-ended question followed, asking, "Why would this person's praise/criticism have such an effect on you?"

The majority of the "most influential people" in YPROS' professional lives (70 percent) were on the same job location, and the type of person varied significantly between professionals ($X^2 = 64.0$, 10 df. $P = 0.01$). Biologists listed another biologist 30 percent of the time and other staff professionals 32 percent (usually a staff biologist at the National Forest level). Foresters were much more likely (66 percent) to be "most influenced" by persons of their own profession. Of course, there are many more foresters to choose from in the USFS. Range-cons cited another range-con in only 22 percent of the choices; they were much more influenced by their district ranger.

Few YPROS and only 13 percent of biologists cited their immediate supervisor as the person of greatest influence over them. When we asked why their "most influential person" had such effect on them, 38 percent of the YPROS said it was their position/rank, 59 percent said it was because of respect/admiration (3 percent have other reasons). The heavy reliance on respect-based legitimacy to determine authority relationship did not vary with professional-type or sex.

Forest Service Values YPROS Do and Do Not Accept

To orient oneself in organizational space, recruits must decipher what attitudes/values are held in high esteem (and rewarded)—for such are the ties that bind groups. Rewarded organizational attitudes/values could be production efficiency, service to the public, or being politically compatible within the organization. Once identified, it's a personal decision for professional recruits to accept those organizational values and practice appropriate behavior, or to resist them.

Much literature (e. g.., Dalton 1950, Homans 1950, Miller 1967, Gill and Bennis 1968) cites the common conflict between organizational values and those of scientists or professionals in their employ. For example, psychologists want to cure people and hospital administrators want to move patients through the system, chemists want to do theoretical research and the organization only wants an additive that makes their cereal more crisp, USFS fisheries biologists want to collect needed spawning data and agency administrators have them scheduled for five months of planning meetings with the Central Utah Project, etc. The surprising USFS cohesion a generation ago (Gulick 1951, Kaufman 1960) was dependent upon organizational values being consistent with one's profession; although Leman (1981) judges these studies failed to note much USFS value diversity of the 1950s. If agency values are consistent with employee's professional values, high cohesion and productivity usually occurs (Hall et al. 1970). If there is value conflict, alienation and in-fighting often result (a dominant theme of doctors versus administrators in hospital T. V. shows).

What YPROS See as the Three Most Rewarded Forest Service Values

YPROS were asked to identify the values most rewarded by the USFS. The question was open-ended and there was little disagreement in the values stated by women and men—not so with different professional-types.

Table 1 presents the first or second most rewarded USFS values/attitudes. The differences are statistically significant, but note the big similarity first. All three professional-types stated "organizational loyalty" as the most rewarded USFS value. Now observe the differences.

Biologists and foresters stated productivity/work-ethic as the second most rewarded USFS value (total of rank 1 or 2 citings). Range-cons were unique in giving open-ended responses that fit the professional competency category (e.g., "be able to contribute to multiple use decisions in my area of expertise," etc). No biologists and only 2 percent of foresters gave open-ended replies in this professional competence category. Getting along with people was also an important USFS value.

What SUPERS See As The Most Rewarded Forest Service Values

YPROS' immediate supervisors were asked the identical question on the "most rewarded USFS values"—recall that YPROS' immediate supervisors (another USFS generation) were also surveyed.

Apparently YPROS already "know the score" about rewarded USFS values/attitudes, listing identical values as their SUPERS (Table 1). YPROS gave a more diverse spread of values, and recall that YPROS' perceptions differed by professional-type. Also note how rarely "commitment to the resource" was directly stated—a value that natural resource students, their professors, and the USFS are supposed to cherish.

Most SUPERS (70 percent) personally agree with the three values/attitudes most rewarded by the USFS. SUPERS believed two-thirds of the YPROS they supervise

Table 1. Organizational values cited as either first or second most rewarded by the USFS[a].

Rewarded values/attitudes[b]	Foresters	Range-cons	Biologists	SUPERS
		(Percent citing)		
1. Production/work ethic	28%	16%	27%	28%
2. Get along with people	10	12	11	22
3. Good, flexible attitude	8	0	8	4
4. Loyalty to USFS	47	44	51	46
5. Commitment to resources	0	0	3	0
6. Do quality work	5	4	0	0
7. Professional competence	2	24	0	0
Totals:	100%	100%	100%	100%

[a]Chi Square test between foresters, range-cons and biologists = 19.2, 10 df., $P = 0.05$; row 5 not included to reduce number of cells with 0.05 percent expected value.
[b]This was an open-ended question; 90 percent of replies easily fell into these seven categories.

also accept these values as legitimate. From the disagreement actually stated by YPROS (below), this SUPER perception is optimistic. Notice also that YPROS' acceptance of rewarded USFS values differ by professional-type.

YPROS' Acceptance of Three Most Rewarded Forest Service Values

Given the values rewarded by the USFS, do YPROS agree with them? Biologists are least accepting of what they see as rewarded USFS values (Table 2). Only 31 percent accept all three (versus over half of foresters and range-cons, and 70 percent of SUPERS).

Table 2 also shows about twice as many biologists disagreeing with all three most rewarded values than the other two professional-types (a noticeable but not statistically significant difference). It appears that biologists find USFS values more inconsistent with their personal and professional values than foresters and range-cons. Gulick (1951) and Kaufman's (1960) USFS studies, almost completely dominated by foresters in those days, cited no such conflict. But much time, legislation, and USFS organizational change has occurred since the 1950s.

Long-Run Career Development

Career development is an on-going process of fitting oneself into a profession and an organization. Basic career development texts (Hall 1976, Schein 1978) present this process as passing through common stages. Dalton et al. (1977) define four stages—that Kennedy (1984) has applied to Aldo Leopold's career. Ginzberg et al.'s (1951) model begins with a fantasy stage, then a tentative choice stage, and ultimately realistic choice stages, as one settles into a career. Women's career stages seem to share similar (Hennig and Jardim 1977) and different (Gilligan 1979, 1982) than men.

Previous sections have shown how YPROS are fitting into their first permanent job. The time frame was the past and present: how/why YPROS got their present USFS position and what they are experiencing in terms of job satisfaction, commitment to their profession, etc. The focus was *job*, the time dimension was *short-run*. This section focuses on YPROS' *career*. The time dimension is the *long-run* (the future).

Table 2. YPRO agreement and disagreement with three values/attitudes they preceive as most rewarded by the USFS.[a]

Acceptance of rewarded USFS values:	Foresters	Range-cons	Biologists	All YPROS
	(Percent answering)			
1. Accept all three	51%	56%	31%	45%
2. Disagree with one	17	20	19	19
3. Disagree with two	20	8	25	18
4. Disagree with three	12	16	25	18
Totals:	100%	100%	100%	100%

[a] $X^2 = 6.9$, with 6 df and *not* significantly different at 5 percent level. Data presented because it fits the pattern of biologists differing from their range-con and forester colleagues.

YPROS' Commitment to Career in Their Current Profession

YPROS haven't been in their professions that long. When asked, "If you could go back and begin your education again, what profession would you choose?" the majority (77 percent) would choose the same profession again. For women it was 72 percent, and 82 percent for men (not a statistically significant difference). Those choosing another profession generally named one in some other natural resource field.

Another set of questions further pursued professional commitment: "If we define career as a long-term commitment to a profession and/or an organization, have you made such a commitment to your *profession*?" Most YPROS (83 percent) state they have a long-term professional commitment. Less women have made such a commitment (75 percent) than men (92 percent); $X^2 = 4.3$, 1 df. $P = 0.04$. YPROS rated the strength of their professional commitment on a 7-point scale ranging from extremely strong, very strong, strong, through neutral to extremely weak. Biologists again stood out with 65 percent checking the extremely or very strong professional commitments spots. Only 5 percent of range-cons and 22 percent of foresters stated such strongly professional commitment ($X^2 = 15.6$, df., $P = 0.05$).

Those stating a long-term professional commitment were asked what year and under what circumstances it was made. Only 2 percent of YPROS judged they made a professional commitment before entering college. Upon graduation from college, however, 60 percent were committed to a career in their profession. For the remainder (32 percent), it took rewarding experiences in temporary or permanent employment until they were sure of their professional career choice.

Commitment to a Career in the USFS Organization

Recall that most YPROS had decided their current profession at age 20. When making this choice, future employment in the USFS was important for only 22 percent of biologists versus 71 percent of range-cons and 56 percent of foresters. Future USFS employment was important to 62 percent of men YPROS in selecting their professional major, but to only 35 percent of women ($X^2 = 16.3$, 6 df. $P = 0.07$).

Asked if they are *currently* committed to a USFS career, only 40 percent of biologists checked "yes"; versus 57 percent of foresters and 56 percent of range-cons (a noticeable but not statistically significant difference). Several questions explore USFS commitment further.

YPROS were asked, " If you could start your professional career over, with what organization would you choose to work?" Most (69 percent) checked the USFS, with considerable differences between professional-types. Forty-three percent of biologists, able to turn back the clock, would start in another organization; 37 percent of range-cons and only 19 percent of foresters would do so ($X^2 = 5.8$, 2 df. $P = 0.06$). Sixteen percent of foresters and 22 percent of range-cons would seek self-employment or private industry (no biologists would do so). Many would try another federal natural resource agency. Biologists were unique in 23 percent starting over again in a state agency.

Agreement and Conflict Between Professional and Organizational Values

We conclude by examining how professional and USFS values are complimentary or conflicting. Two questions (above) asked a yes or no response to (1) do you have a long-term commitment to your profession, and (2) do you have a long-term commitment to the USFS organization. The yes and no replies to these commitment questions produces a 2 x 2 matrix:

		Do you have a USFS career commitment: Yes	No
Do you have a professional career committment:	Yes	Type I	Type II
	No	Type III	Type IV

This matrix yields four potential types of YPRO career commitments:

TYPE 1. *Both Professional and USFS Commitment.* YPROS committed to both their profession and USFS organization.

TYPE II. *Professionally But Not USFS Committed.* Professional committment, but YPROS not yet fitted into USFS; they may or may not want to resign.

TYPE III. *Committed to USFS Career But Not One's Profession.* YPROS presently committed to USFS but not their professions.

TYPE IV. *Searcher.* Currently not committed to either career in their profession or USFS.

The above types are generalizations or stereotypes. It will take more testing to see if a Type II YPRO might more strongly pursue a professional (say wildlife) staff position than a more generalist, line administrative position (as Type I or III might). With these caveats, let's see how YPROS fit into these categories.

Only 35 percent of biologists were Type I (both USFS and professionally committed), while 57 percent of foresters and 52 percent of range-cons were Type I. More biologists (49 percent) were Type II and committed to their profession but *not* the USFS, than were foresters (32 percent) or range-cons (22 percent). Almost no YPROS were Type III (the stereotyped organization man)—5 percent biologists, 4 percent range-cons and no foresters were type III. Range-cons had the greatest percent of Type IV (searchers) at 22 percent (versus 11 percent for biologists and no foresters). These differences between professional-types were not statistically significant.

SUPERS were asked the identical two questions used to categorize YPROS into four types; comparing these two generations produced highly significant differences (X^2 = 37.5, 3 df., $P = < 0.01$). The majority of SUPERS (88 percent) were highly committed to *both* the USFS and their profession (were Type I), versus only 48 percent of YPROS. Only 5 percent of SUPERS were Type II, compared to 35 percent of YPROS. SUPERS have a mean of 9 years in the USFS and few felt they had to give up their professional values, becoming administrative-oriented company people (only 4 percent of SUPERS were Type III). By that time in their careers, few SUPERS (3 percent) were searchers (Type IV).

In the entry-stage of their professions and the USFS organization, SUPERS may have had doubts and uncertainities about their commitments, like the YPROS they currently supervise. They don't now. Most SUPERS (88 percent) see little or no conflict between their professions and the USFS, they were TYPE I. Studies of Catholic priests (Hall and Schneider 1973) and USFS managers (Hall et al. 1970) found organizational loyalty tends to increase with tenure. Hall et al. (1970) also found professionals who personally held values in high esteem that were also valued by the USFS (e. g., service to the public) were bound more tightly to the organization than those with personal values not highly valued by the USFS.

Some Closing Comment

The majority of YPROS surveyed in our study enjoy their job and are fitting into a career with the USFS and with their profession. Early career orientation appears more difficult for biologists recruits (and some women), but most are finding their place in the USFS organization. Some are not. About 24 percent men and women biologists are experiencing considerable stress, alienation, and second thoughts about a USFS career. Such generalizations apply only to our particular sample. We have no way of knowing if this is true for the entire USFS. A current study of career development and training needs of biologists (Kennedy and Mincolla 1985) will provide more representative information from all USFS regions.

In a way, the stress found in our sample of USFS biologists, should not be surprising. The USFS currently employs more biologists and other specialists in response to external social and political pressures to broaden their expertise—policies initiated in the environmental decade of the 1970s. Laws like the National Environmental Policy Act (1970) legislated interdisciplinary decision making, hoping it would inject more diversity of values and expertise in agencies dominated by professional monoculture (e. g., the Corps of Engineers or USFS). One could have anticipated the higher stress and uncertainity biologists are experiencing in such "change-agent" roles. For our society, the USFS and the wildlife/fisheries profession, some of this tension is *good.* But cannot the USFS supervisors who hire biologists (and the universities that train them) recognize and respond to the early career orientation problems? Some of this personal stress can be anticipated and better resolved, while *still* protecting fish and wildlife values.

First, let's look at biologists' university training. Their education focused almost completely on the biological-physical sciences (Eastmond and Kadlec 1977, Hester 1979). They took few courses that explored the social-political-organizational environments with which they must not cope. One respondent wrote,". . . I was a biological romantic trying to cope with strange, confusing organizational realities." Young, idealistic professionals often perceive normal bureaucratic processes as strange and evil. Biologists seem to have much more valid knowledge about wildlife behavior than they do normal human behavior in organizations like the USFS (Cutler 1982). For biologists to better adapt to and be productive in the USFS (and other multiple resource agencies), their university training should nurture knowledge, attitudes, and temperament more conducive to learning on-the-job how they can be successful and productive change-agents, operating from *within* the system (Donaldson 1979).

The USFS, especially new recruits' supervisors, may also have to recognize and respond to biologists as a unique type of professional (not as just a forester subspecies). Biologists begin their first permanent job with a masters degree and are largely socialized to the academic world (Schein 1967)—often with romantic values and crusading professional images of (as one respondent wrote) "protecting wildlife through intervention, courage and research data." They also experienced more "entry-shock" than their forester and range-con colleagues, and find more personal/professional conflict with rewarded USFS values. Conclusion: Wildlife/fisheries biologists may have to be more consciously integrated into the USFS management and decision-making mainstream, so they feel less like isolated staff specialists—often developing an antagonistic or devil's advocate posture.

We conclude by taking the subject of our research, the theme of this special session, and converting them into two questions: understanding wildlife/fisheries managers' professional career development—is there (1) a *need* and (2) the *capability* to do such research? We examine the capability question first, and answer is yes. The fields of sociology, industrial psychology, or organizational behavior offer a wide choice of theory and methods to examine wildlife/fisheries managers' professional behavior and career development. We selected the organizational behavior approach (Schein 1978), but other research approaches in studying physicians, lawyers, or engineers are adaptable to wildlife/fisheries managers. All that's needed is motivation and some investment of resources.

Perhaps the reason so few studies of wildlife/fisheries managers exist is there was no need of them in the past. Professional career development may have been so simple and obvious in single purpose state wildlife/fisheries agencies that it could be understood intuitively and discussed anecdotally. But there are more and varied specialists in wildlife/fisheries management today—many are women. More professionals than ever work for multiple-resources agencies like the Bureau of Land Management or USFS. If career development was a more simple "checker game" in the past, it may becoming a "chess game" today. If so, there may be a greater need than ever for research to better understand ourselves.

If one cares about the condition of the resources that professionals like biologists manage, one had better care about the condition of their careers. For we believe that fish and wildlife resources can only be well managed by men and women who feel good about their profession, themselves, and the agency for which they work. Perhaps some good painting originates from alienated and frustrated people, who occasionally cut off an ear. But we doubt if that holds for good wildlife management plans or professional-client relations. Kennedy and Mincolla (1982) is only a first step in wildland resource managers understanding ourselves better. Kennedy and Mincolla (1985) is another. Responding to this knowledge with changes in university education or hiring-agency counseling/training, remains to be done.

Literature Cited

Campbell, R. J. 1968. Career development: the young business manager. Pages 32-46 in J. R. Hackman, Longitudinal approaches to career development. Symposium of Amer. Pscyh. Assoc. Convention, San Francisco, CA.

Cutler, M. R. 1982. What kind of wildlifers will be needed in the 1980s? Wild. Soc. Bull. 10(1): 75-79.

Dalton, M. 1950. Conflicts between staff and line managerial officers. Amer. Sociol. Rev. 15:342-51.

Dalton, G. W., P. H. Thompson, and R. L. Price. 1977. The four stages of professional careers. Organizational Dynamics 6(1):19-42.

Donaldson, J. R. 1979. Fisheries education from the state perspective. Fisheries 4(2):24-26.

Eastmond, J. N., and J. A. Kadlec. 1977. Undergraduate educational needs in wildlife science. Wild. Soc. Bull. 5:61-66.
Gill, P. P., and W. G. Bennis. 1968. Science and management: two cultures? J. App. Beh. Sci. 4(1):75-108.
Gilligan, C. 1979. Women's place in man's life cycle. Harvard Educ. Rev. 49(4):431-45.
_____. 1982. In a different voice. Harvard University Press, Cambridge, Mass. 184pp.
Ginzberg, E., J. W. Ginsberg, S. Axelrad, and J. L. Herma. 1951. Occupational choice. Columbia Univ. Press, New York. 227pp.
Gulick, L. H. 1951. American forest policy. Duell, Sloan and Pearce. New York. 295pp.
Hall, D. T. 1976. Careers in organizations. Goodyear Publishing Co. Santa Monica, CA. 236pp.
Hall, D. T., and B. Schneider. 1972. Toward specifying the concept of work; climatic study of Roman Catholic Diocesan Priests. Appl. Psyc. 56(6):447-85.
Hall, D. T., B. Schneider, and H. T. Nygren. 1970. Personal factors in organizational identification. Adm. Sci. Quart. 15(2):176-90.
Hennig, M., and A. Jardim. 1977. The managerial woman. Anchor Press/Doubleday, New York. 221pp.
Hester, F. E. 1979. Fisheries education from the federal perspecive. Fisheries 42(2):22-23.
Homans, G. C. 1950. The human group. Harcourt Brace, New York. 242pp.
Hughes, E. C. 1958. Men and their work. Free Press, Glencoe, IL. 235pp.
Kaufman, H. 1960. The forest ranger. Johns Hopkins Press, Baltimore. 259pp.
Kennedy, J. J. 1984. Understanding professional career evolution—an example of Aldo Leopold. Wildl. Soc. Bull. 12(3):215-26;
_____, and J. A. Mincolla. 1982. Career evolution of young 400-Series U.S. Forest Service professonals. Career Development Project Report 1. College of Natural Resources, Utah State University. Logan, UT. 86pp.
Kennedy, J. J., and J. A. Mincolla. 1985. Career development and training needs of entry-level wildlife/fisheries managers in the USDA Forest Service Career Development Project Report 4. College of Natural Resources, Utah State University, Logan, UT, 81pp.
Levinson, D. J. et al. 1978. The seasons of a man's life. Ballantine Books, New York, 363pp.
Leman, C. K. 1981. The Forest Ranger revisited: administrative behavior in the U.S. Forest Service in the 1980s. Paper at Annual Meeting Amer. Pol. Sci. Assoc., New York (3-6 Sept.).
Lodahl, T., and M. Kejner. 1965. The definition and measurement of job involvement. J. Appl. Psych. 49:24-33.
Miller, G. A. 1967. Professionals in bureaucracy: alienation among industrial scientists and engineers. Amer. Sociol. Rev. 32(4):755-67.
Schein, E. H. 1967. Attitude change during management education: a study of organizational influence on student attitudes. Adm. Sci. Quart. 11:601-28.
_____. 1978. Career dynamics: matching individual and organizational needs. Addison-Wesley, Reading, MA. 276pp.
Van Maanen, J., ed. 1977. Organizational careers: some new perspectives. Wiley & Sons, New York. 199pp.
Weber, M. 1947. The theory of social and economic organization. (Trans. by A. D. Henderson and T. Parsons) Free Press, New York. 420pp.

Aquatic Habitats: Conservation and Management

Chairman:
HANLEY K. SMITH
Ecologist
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

Cochairman:
KENNETH R. ROBERTS
Chief
Habitat Conservation Division
National Marine Fisheries Service
Washington, D.C.

Opening Statement

Kenneth R. Roberts
Habitat Conservation Division
National Marine Fisheries Service
Washington, D.C.

Introduction

The purpose of the session is to take stock of aquatic habitat conservation and management at this Golden Anniversary of the North American Wildlife and Natural Resources Conference. When approached by Bo Smith to serve as Co-Chairman, I was excited at the prospect of working with him on this session. Because it is the 50th Anniversary, we wanted the program to be a special one. Narrowing the list of proposed papers and making the final selections were difficult. The experience has been a rewarding one, because of the interest and assistance we received and because the program that we have well serves the purpose of this conference and special session.

It is my assignment to examine (1) where we have come over time; (2) where we stand in 1985; and (3) where are we headed in using aquatic habitats. While I have no illusion that I have any unique, new, or innovative concepts to express, I have organized some observations that bear directly on our topic.

Before beginning an examination of where we have been, I would like to define one term. Yesterday, Durward Allen quoted Pogo, who said, "We have met the enemy and he is us." Therefore, let us examine who "we" is. For the purpose of this session, *we* are everyone who works in, participates in, or is interested in the conservation and management of aquatic habitats. We are found throughout academia, government, industry, organizations, and the lay public. I hope that it will become clear that the more cooperatively we are able to work together, the more all of us shall be able to accomplish.

Also, while my experience deals primarily with the United States, I am aware that those of you from Canada and Mexico have or are experiencing many of the same or similar trends.

Experience as We Enter the 51st Year

To summarize our experience over the past several decades, I am going to focus on four observations.

The first is that we have learned about and are more aware than ever of the finite nature of our living aquatic resources and their habitats. For example, we are aware that we have only so many acres of productive, unpolluted shellfish beds. As our remaining beds become polluted, the shellfish diminish in numbers and quality for consumption.

The second observation is that the public has developed an appreciation and understanding of the vulnerability of habitats. I was pleased yesterday to hear Mr. Louis Harris cite recent evidence that public awareness in favor of controlling environmental degradation is as strong as ever — and perhaps stronger. This appreciation has been reflected over 20 years in a national commitment which has resulted in programs costing billions of dollars and placed human resources throughout the country to address water pollution and other human impacts on aquatic habitats.

The third observation is that there is in place a plethora of laws, regulations, guidelines, policies and procedures to insure that living aquatic resources receive consideration in development. Programs now exist at the federal, state, and local levels to address problems of water pollution, physical alterations, erosion, and development of the coastal zone. Within these regulatory systems there has been established an infra-structure designed essentially to protect and preserve aquatic habitats.

The fourth observation is that despite the aforementioned public awareness, laws, regulations, and financial and human resources, we are now aware that the structure we have built is not keeping up with the adverse impact of human population growth on aquatic habitats. Despite our experience, resources, and successes in protection and preservation of aquatic habitats, we are in 1985 losing our North American aquatic habitats and their values in many places and many ways. We are observing an unquantified loss each year of socially and economically important aquatic habitats and their values due to wetlands development, acid rain, non-point and point discharges, eutrophication, waste dumps, and other causes.

Where Will We be Going in the Future?

In looking to the future, I am going to address three additional observations.

The first is the continuing need for research and development. All levels of government require data on fish and wildlife resources and habitats to make public interest decisions on proposed developments, plans, and policies. It is given that we need to continue to develop and maintain inventories of our habitats and the consequences of human activities on productivity. We need to also continue development of our understanding of the mechanisms and processes that control habitat productivity. Our long range effectiveness also will depend on the development of socio-economic information as well.

The second observation for the future deals with protection and preservation. We need to maintain and improve the existing infrastructure to protect and preserve aquatic habitats. Each year will bring a continuing evolution in laws, regulations, rulemaking, guidelines, policies, procedures, etc. This presents many opportunities to conserve habitats through improvements in federal, state, and local regulatory and planning programs. I am referring to such improvements as inter-agency joint processing of Corps of Engineers permits, which both increase efficiency and enable further concentration of efforts and talent on particularly troublesome issues.

The third and final observation deals with the need for restoration and enhancement of habitats. Restoration and enhancement have great potential to substantially offset the current unavoidable losses of habitats. Later on in the program, we will be hearing about this subject as it applies to estuaries and to mitigation banking.

We have been restoring habitats for years. Two examples include: restoration of salmon runs on the Snake River, Idaho, and striped bass in the Hudson River. Sometimes restoration can be relatively inexpensive, such as on the Snake River where only regulation of flows was required. Other times the financial and human resources required are staggering, as in upgrading the water quality of the Hudson River.

Restoration and enhancement may well be the largest wave of the future for conservation and management of aquatic habitats. We are now well aware that, as long as our human population continues to grow there will always be continuing losses of fish and wildlife habitats. Unless we become able to entrain our public awareness, laws, resources, science, and technology *to replace these losses as they occur*, I'm afraid we will do little to offset our annual losses of productivity.

Our more immediate role as fish and wildlife professionals is to demonstrate that much restoration and enhancement can be done with present technology and to provide cost-benefit information. With such information, it will be possible for our leaders and the public to see the potential of restoration and enhancement and translate this knowledge to public policy, programs, further technology development, and conservation of aquatic habitats.

Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s

National Wetlands Inventory Group
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Washington, D.C. 20240

Introduction

In 1974, the U.S. Fish and Wildlife Service (FWS) directed its Office of Biological Services to design and conduct an inventory of the nation's wetlands. The mandate was to develop and disseminate technically sound and comprehensive information concerning the characteristics and extent of the nation's wetlands. The purpose of this scientifically generated information is to foster wise use of wetlands by providing the information needed to make sound decisions. To accomplish this mandate, state-of-the-art principles and methods pertaining to all major aspects of wetland inventory were assimilated and developed by the newly formed National Wetlands Inventory Project.

By 1979, it was clear that two very different kinds of information were needed. First, national statistics on the current status and trends of wetlands were needed in order to provide improved information for modification of existing federal programs and policies or the development of new programs and policies. Second, detailed wetland maps for geographic areas of critical concern were needed for impact assessment of site-specific decisions. These critical areas initially are the coastal zone (including that of the Great Lakes), the prairie potholes, and the floodplains of major rivers.

In order to obtain national statistics, the National Wetlands Inventory Project, assisted by an interagency group of statisticians from the Fish and Wildlife Service, Forest Service, Soil Conservation Service and the Corps of Engineers, developed, and the FWS subsequently awarded, a competitive procurement to construct a statistical design for a national survey and to analyze the data. Data acquisition and generation were done by the National Wetlands Inventory Project.

This paper presents the statistically sound data without contemplating about the causes for the changes or the impacts the changes have had on the nation's fish and wildlife populations. It will take time to study the data before the causes and impacts can be fully and accurately explained. This study documented the acreage of wetlands in the mid-1950s and in the mid-1970s, as well as the natural and man-induced wetland and deepwater habitat gains and losses. Having two data points does not allow for the establishment of rates of change by years, but it does allow for the calculation of average annual losses during the period of study.

Gains or losses prior to the mid-1950s or after the mid-1970s are not revealed by this study. While the report provides estimates of the abundance of the nation's wetlands and deepwater habitats, it does not provide information on their quality. This report presents findings primarily at the national level, although with additional data collection reliable acreage estimates could be obtained for flyways, states, or even Hammond's physical subdivisions within states.

Classification of Wetlands and Deepwater Habitats

The classification and definition of wetlands and deepwater habitats used in this report are described by Cowardin et al. (1979). Groupings of categories were made to accommodate: (1) the special interests of the study, and (2) the detail to which available aerial photography could be interpreted.

In general, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Technically, wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (i.e., water loving plants); (2) the substrate is predominantly undrained hydric soil; or (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. Common terms used to describe various wetlands include marshes, swamps, bogs, small ponds, sloughs, potholes, river overflows, oxbows, mud flats, and wet meadows.

Deepwater habitats are permanently flooded lands lying below the deepwater boundary of wetlands. In saltwater areas, the boundary betweeen wetlands and deepwater habitats coincides with the elevation of the extreme low water of spring tide. In other areas, the boundary occurs at a depth of two meters (6.6 feet) below low water. This is the maximum depth in which emergent plants normally grow.

Within the classification structure that follows, wetlands and deepwater habitats are grouped according to systems. A system consists of environments of similar hydrological, geomorphological, chemical, and biological factors. Each system is further divided by the driving ecological force, such as ebb and flow of tide, and by substrate material and flooding regions, or on vegetative life form.

The *Marine System* extends from the outer edge of the continental shelf to the extreme high water level of spring tides or to the boundary of other systems as defined later. *Marine Subtidal* includes the portion of the system that is continuously submerged. However, because of relatively small expected change in this portion, it was excluded from this study. *Marine Intertidal* includes areas in which the substrate is exposed and flooded by tides, including the associated splash zone.

The *Estuarine System* consists of subtidal deepwater habitats and adjacent intertidal wetlands which are usually semi-enclosed by land, but have open, partially obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by fresh water runoff from the land. Offshore areas with typically estuarine plants and animals, such as mangroves and oysters, are also included. *Estuarine Subtidal* is that portion of the system that is continuously submerged (considered deepwater habitat), while *Estuarine Intertidal* is the portion exposed and flooded by tides, including the associated splash zone. For the purposes of this study, *Estuarine Intertidal* is the portion exposed and flooded by tides, including the associated splash zone. For the purposes of this study, *Estuarine Intertidal* wetlands are shown by the following groups: *Nonvegetated, Emergent, Scrub/Shrub* and *Forested. Nonvegetated* contains no emergent vegetation but does include vegetation in the form of aquatic beds, while *Emergent* contains primarily those erect, rooted herbaceous plants typically found in wet environments. *Scrub/Shrub* includes areas dominated by shrubs and small or stunted trees, and *Forested* is characterized by the presence of trees.

The *Lacustrine System* includes wetlands and deepwater habitats situated in topographic depressions or dammed river channels. Each depression must exceed 20 acres (8ha), have depths in excess of two meters or have an active wave-formed or bedrock shoreline feature. The *Lacustrine System* consists mostly of open water (considered deepwater habitat) and lacks trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30 percent areal coverage.

The *Riverine System* includes wetlands and deepwater habitats contained within a channel. Because of the lack of wetlands within most channels and the difficulties of sampling for both small circular and long, thin, linear land surface forms, it was not sampled and was included in *Other Surface Areas.*

The *Palustrine System* includes all nontidal wetlands not included within any of the other four systems. There are no deepwater habitats included. For this study, the *Palustrine* wetlands are shown by the following groups: *Unconsolidated Shore, Open Water, Other Palustrine Nonvegetated, Emergent, Scrub/Shrub,* and *Forested. Unconsolidated Shore* includes wetlands generally having unstable substrates with less than 75 percent cover of stones, boulders, or bedrock and little or no vegetation. *Open Water* includes small inland open water bodies that are too small to be part of the *Lacustrine System. Other Palustrine Nonvegetated* includes other inland wetlands with little or no vegetation other than aquatic beds, and the remaining terms are defined as they were under the *Estuarine System.*

In addition to *Other Surface Area,* two more categories were used in the study. These are *Urban* and *Agriculture,* and, together with *Other Surface Area* (forests, rangeland, all other kinds of uplands not qualifying as wetland), they account for all other surface areas not considered wetlands or deepwater habitats.

This is only a brief discussion of the classification used in the study. It is difficult to differentiate the categories further without introducing highly technical terms. For those interested in detailed descriptions and exact definitions, see Cowardin et al. (1979).

Procedure

The study's main objective was to estimate statistically the total acreage of wetlands and certain deepwater habitats, by category, for the lower 48 states during the 1950s, the 1970s, and the acreage change for that period. The goal for reliability was national statistics for the 1970s that had, on the average, a probability of 90 percent that established totals are within 10 percent of the true totals, by category.

The sampling design and data compilation procedure were developed to generate flyway (Figure 1), state, and Hammond physical subdivision within state estimates. Although these estimates are less reliable than the national statistics, they provide a basis for designing flyway or state studies to obtain statistically reliable estimates by sampling more areas in the future.

A stratified random sample of 3,635 units was used with the basic strata being formed by state boundaries and the 35 physical subdivisions described by E. H. Hammond (1964). Additional strata specific to the study were a special coastal stratum encompassing the Marine Intertidal category and Estuarine System and another stratum encompassing the Great Lakes. This resulted in over 200 strata for the study. Sample units were allocated to strata in proportion to the expected

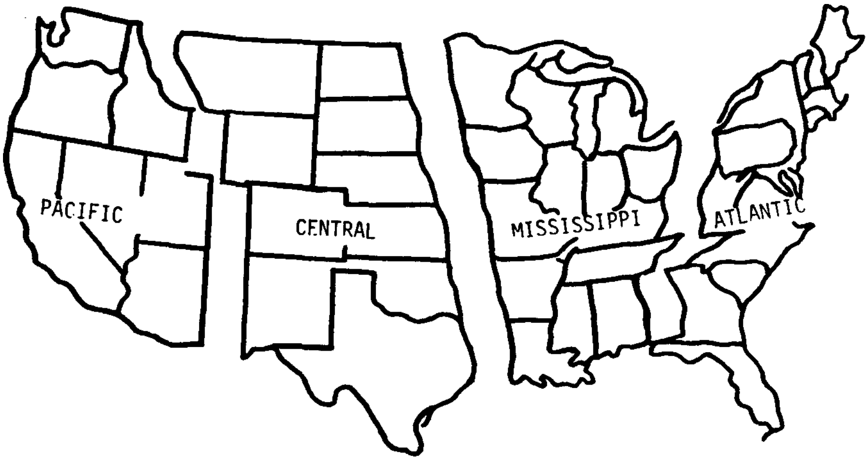


Figure 1. Flyways of the United States.

amount of wetland and deepwater habitat acreage as estimated by earlier work (including Shaw and Fredine 1956).

Each sample unit was a four-square-mile (10.3 km^2) area, two miles (3.2 km) on each side. After the units were selected at random within strata and plotted on U.S. Geological Survey topographic maps, aerial photography were obtained for the 1950s and 1970s. The median years of the photography were 1954 and 1974, with over 98 percent of the photo coverage within five years of the median years. The median and mode interval was 20 years, and the average interval was 20 years. Thus, the results should be interpreted in terms of a 20-year interval. The majority of the 1950s photography was 1:20,000 scale black and white, and for the 1970s it was 1:40,000 black and white. Scales were adjusted using Bausch and Lomb stereo zoom transfer scopes. The units were photointerpreted in entirety for the 1950s and a map was produced. The changes were photointerpreted on the 1970s photos and an overlay to the 1950s map was produced. All wetland and deepwater habitat changes were marked as to cause, either natural or human induced. The wetland information on the 1950s map and the 1970s overlay was area measured and prepared for computer analysis. Several quality control checks were routinely made to eliminate photointerpretation and data preparation errors.

Photo interpretation and data compilation were completed in July 1982. The estimates produced acreages with standard errors and coefficients of variation.

Results and Survey Highlights

The survey determined that there was a total of 179.5 million acres (72.6 million ha) of wetlands and deepwater habitats in the 48 conterminous United States in the 1950s. The total for the 1970s was 171.9 million acres (69.6 million ha), or a net loss of 7.6 million acres (3 million ha). This decline translates to an average annual net loss for the 20-year period of 380 thousand acres (153,780 ha)

There were important gains in deepwater habitats. It was determined that there were 71.3 million acres (28.8 million ha) of deepwater habitats in the 1950s compared to 72.9 million (29.5 million ha) in the 1970s, or a net increase of 1.6 million acres (647,500 ha). This is a net average annual gain for the 20-year period of 78 thousand acres (31,565 ha). The majority of the gain occurred in Lacustrine deepwater habitats (lakes) which had a net national gain of 1.4 million acres (566,570 ha), 1.2 (485, 630 ha) of which came from non-agricultural and non-urban areas due to the construction of lakes and reservoirs. Estuarine Subtidal deepwater habitats (bay bottoms) also increased 200 thousand acres (80,940 ha).

In contrast, when focusing on wetlands, it was determined that there were 108.1 million acres (43.7 million ha) of wetlands in the 1950s compared to 99.0 million acres (40 million ha) in the 1970s, a net loss of over 9 million acres (3.6 million ha). This translates into a net average annual loss of 458 thousand acres. The net average loss of Palustrine wetlands (inland wetlands) is 439 thousand acres (177,660 ha), and the remaining loss is from Estuarine wetlands (coastal wetlands).

The major loss in Palustrine wetlands was experienced by Palustrine Vegetated wetlands. The total of 99.8 million acres (40.4 million ha) in the 1950s fell to 88.8 million acres (35.9 million ha) in the 1970s, or a net average annual loss of 553 thousand acres (223,790 ha). Palustrine Forested wetland (swamps) losses accounted for 300 thousand acres (121,400 ha) of net average annual loss, while Palustrine Emergent wetland (inland marshes and wet meadows) losses accounted for a net average loss of 234 thousand acres (94,700 ha) a year.

Palustrine wetlands also experienced an increase in Palustrine Open Water wetlands (ponds). There were 2.3 million acres (930,790 ha) of Palustrine Open Water wetlands in the 1950s. This increased to 4.4 million acres (1.8 million ha) in the 1970s, or a net increase of 2.1 million acres (849,850 ha). Only non-vegetated wetlands experienced increases.

The 99.0 million acres (40 million ha) of wetlands that remained in the mid-70s occupied 5 percent of the total surface area of the conterminous United States and represent an area the size of the State of California.

Significant Trends in the Estuarine and Marine System

Changes in Estuarine Subtidal Deepwater Habitats (bay bottoms)

The overall net change in Estuarine Subtidal deepwater habitats resulted in a gain of 200 thousand acres (80,940 ha)

Some changes occurred between Estuarine Subtidal deepwater habitats and Estuarine Nonvegetated wetlands; however, the net change was small.

Change with Estuarine Vegetated wetlands resulted in a net gain of 212 thousand acres (85,740 ha), where 204 thousand acres (82,560 ha) shifted from Estuarine Intertidal Emergent wetlands (coastal salt marshes) to bay bottoms. The vast majority of this net change occurred in Louisiana (183 thousand acres [74,060 ha]) with most of the remainder (15 thousand acres [6,070 ha]) in Florida.

There was a loss of 30 thousand acres (12,140 ha) from Estuarine Subtidal deepwater habitats to urban development. Over half of this was in the Atlantic Flyway with Florida having almost 11 thousand acres (4,450 ha) of loss. Louisiana, in the Mississippi Flyway, experienced 10 thousand acres (4,050 ha) of loss.

Some gain in Estuarine Subtidal deepwater habitats came from areas that originally were land other than urban or agriculture. The net gain was 18 thousand acres, of which 13 thousand acres (5,260 ha) are in Florida. Some additional gain came from Estuarine Intertidal Forested and Scrub/Shrub wetlands. This net gain was 7 thousand acres (2,830 ha), all of which occurred in Florida.

Changes in Estuarine Nonvegetated Wetlands

The net change in Estuarine Nonvegetated wetlands was small. The only change of significance was a loss of 21 thousand acres (8,500 ha) to urban development. Texas, in the Central Flyway, accounted for almost 10 thousand acres (4.050 ha) of loss and Florida, in the Atlantic Flyway, over 9 thousand acres (3,640 ha).

Changes in Estuarine Vegetated Wetlands

The change in Estuarine Vegetated wetlands resulted in a net loss of 372 thousand acres (150,540 ha). Most of this loss (353 thousand acres [142,850 ha]) was in Estuarine Intertidal Emergent wetlands (coastal salt marshes). Most of the loss was to Estuarine Subtidal deepwater habitats (bay bottoms) as described earlier.

Most of the remaining loss was to urban development which accounted for over 106 thousand acres (42,900 ha) (the size of a square area almost 13 miles (21 km) on each side). Two-thirds of the loss was from Estuarine Intertidal Emergent wetlands with the remainder from Estuarine Intertidal Forested and Scrub/Shurb wetlands (mostly mangroves). The majority of this change occurred in the Atlantic Flyway, with Florida accounting for 43 thousand acres (17,400 ha). Louisiana, in the Mississippi Flyway, lost 34 thousand acres (13,760 ha).

Some Estuarine Intertidal Emergent wetlands changed to Estuarine Intertidal Forested and Scrub/Shrub wetlands. The net change was 21 thousand acres (8,500 ha), of which 18 thousand acres (7,280 ha) were in Florida. Some additional Estuarine Intertidal Emergent wetland changes were due to shifts to Estuarine Nonvegetated wetlands. The net change was 19 thousand acres (7,690 ha).

Changes in Marine Intertidal Wetlands

The changes in Marine Intertidal wetlands were not statistically significant.

Significant Trends in the Palustrine and Lacustrine Systems

Changes in Palustrine Nonvegetated Wetlands

The overall net change in Palustrine Nonvegetated wetlands was a gain of 2.3 million acres (930,790 ha).

A significant net gain came from agricultural land. Over 200 thousand acres (80,940 ha) were gained, mainly in Palustrine Open Water wetlands, due to construction of farm ponds. The vast majority of gains were in the Central and Mississippi flyways.

A large net gain, mainly in Palustrine Open water wetlands, came from lands not originally classified as agriculture or urban. Over 1.7 million acres (687,970 ha) were gained, mostly due to construction of ponds. Half of these areas were in the Central Flyway.

Another net gain in Palustrine Open Water wetlands came from Palustrine Forested wetlands—108 thousand acres (43,700 ha).

Changes occurred between Palustrine Nonvegetated wetlands and Palustrine Vegetated wetlands. These changes balanced out for the most part.

Changes in Palustrine Vegetated Wetlands

The net change in Palustrine Vegetated wetlands was a loss of 11 million acres (4.4 million ha). This loss is an area 15 times the size of Rhode Isand; twice the size of New Jersey; as large as the combined states of Massachusetts, Connecticut, and Rhode Island. Nearly all the loss was due to agriculture. The overall net loss consists of 6 million acres (2.4 million ha) of Palustrine Forested wetlands (swamps), 4.7 million acres (1.9 million ha) of Palustrine Emergent wetlands (inland marshes and wet meadows) and the remainder from Palustrine Scrub/Shrub wetlands.

Mississipi Flyway losses were larger than the losses experienced by other flyways in terms of size; in that Flyway, a net loss of 4.5 million acres (1.8 million ha) occurred in Palustrine Forested wetlands. The vast majority occurred along the lower Mississippi River in Louisiana, Mississippi, and Arkansas. The next largest loss in the Mississippi Flyway occurred in Minnesota.

The states that experienced the greatest losses in the Atlantic Flyway are Florida and North Carolina. Large losses in the Central Flyway occurred in South Dakota, North Dakota, Nebraska, and Texas. The largest loss in the Pacific Flyway was in California. In general, the states along the lower Mississippi River lost acreage from Palustrine Forested wetlands, while losses in other states were predominantly from Palustrine Emergent wetlands.

Net losses to urban development consisted of 367 thousand acres (148,520 ha) from Palustrine Forested wetlands, 396 thousand acres (160,260 ha) from Palustrine Emergent wetlands, and 124 thousand acres (50,180 ha) from Palustrine Scrub/Shrub wetlands. This total, larger in acreage than the size of Rhode Island, is concentrated in the Atlantic and Mississippi Flyways. The largest loss in the Atlantic Flyway occurred in Florida. Large losses in the Mississippi Flyway took place in Louisiana, Michigan, and Minnesota.

There was a net change of 927 thousand acres (375,150 ha) of Palustrine Emergent wetlands to Palustrine Scrub/Shrub wetlands and a net change of 693 thousand acres (280,450 ha) of Palustrine Scrub/Shrub wetlands to Palustrine Forested wetlands.

Net change of Palustrine Emergent wetlands to Palustrine Unconsolidated Shore wetlands occurred on 131 thousand acres (53,010 ha), of which 124 thousand acres (50,180 ha) are in the Central Flyway.

Changes in Lacustrine Deepwater Habitats

The net change in Lacustrine deepwater habitats was a gain of 1.4 million acres (566,560 ha).

Most of the gain is the result of construction of dams and reservoirs on 1.2 million acres (485,630 ha) of land not considered wetlands, deepwater habitats, urban or agricultural land in the 1950s.

Conclusion

This report is based on a study designed to determine changes in the amounts of wetlands and deepwater habitats between the 1950s and 1970s in the 48 conterminous states. The results document major net losses of wetlands, and gains of deepwater habitats, and provide insights to where these losses and gains occurred.

This report does not document the significant reduction in quality of many wetlands or deepwater habitats. Some of the factors that cause this reduction in quality are: canals and inlets that cause changes in water chemistry due to saltwater intrusion; mosquito ditching along the Atlantic coast; polluted runoff from adjacent uplands or polluted inflow from rivers and streams; urban encroachment; and dissection by transportation corridors.

Some results are very clear—such as huge wetland losses in the lower Mississippi River states of Louisiana, Mississippi, and Arkansas. The next largest loss in the Mississippi Flyway was in Minnesota, with losses also occurring in Michigan, Wisconsin, Illinois, and Alabama. States that experienced the greatest decline in wetland acreages in the Atlantic Flyway were Florida and North Carolina, with significant losses also occurring in Georgia, South Carolina, Maryland, New Jersey and Delaware. Large losses in the Central Flyway occurred in South Dakota, North Dakota, Nebraska, and Texas. The largest loss in the Pacific Flyway was in California.

Other changes are also clear, but involve less acreage. The importance of change, however, is not necessarily reflected by the magnitude of change alone. Some of the smaller wetlands and deepwater habitats—particularly along the coastline of the United States—are extremely important habitats for plant and animal life. A state could lose one-fourth or even one-half of its coastal wetlands and not have a loss large enough to significantly affect the national statistics. Obviously, however, such a loss would be significant to the state in question.

Very significant increases have occurred in large and small open water areas. These newly created habitats were mostly constructed on land not originally classified as agriculture or urban. The full importance of these new habitats of fish and wildlife populations is yet to be determined, while the losses documented above involved major known waterfowl nesting (Dakotas, Minnesota, and Nebraska) and wintering (California, Louisiana, Texas, Mississippi, Arkansas, Maryland, New Jersey, and the Carolinas) areas.

The vast majority of the loss of Estuarine Intertidal Emergent wetlands (coastal salt marshes) occurred in Louisiana. This resulted from a shift to Estuarine Subtidal deepwater habitats (bay bottoms). The remaining loss of Estuarine Intertidal Emergent wetlands was to urban development, mostly in Florida and Louisiana.

Nearly all the loss of Estuarine Intertidal Forested and Scrub/Shurb wetlands occurred in Florida to urban development.

The greatest single net loss was in Palustrine Vegetated wetlands, with a decrease of 11 million acres (4.4 million ha); an area 15 times the size of Rhode Island, twice the size of New Jersey; as large as the combined states of Massachusetts, Connecticut, and Rhode Island. Nearly all the net loss was due to agriculture.

As the need for agricultural crops continues to grow and urban areas continue to expand, the total acreage of wetlands will continue to decline. Monitoring of wetlands is needed to provide the information needed for making wise decisions. In addition, these documented losses clearly indicate the need for more intensive research and management on existing wetlands in order to maintain current levels of valuable fish and wildlife resources.

Literature Cited

Cowardin, L. M. 1978. Wetland classification in the United States. J. For. 76(10):666-668.

_____, V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. OBS-79/31. U.S. Fish and Wildl. Serv., Washington, D.C. 103pp.

Hammond, E. H. 1970. Physical subdividisions of the United States. *In* National atlas of the United States. U.S. Geological Survey, Washington, D.C. 417pp.

Horwitz, E. L. 1978. Our Nation's Wetlands. Council on Environmental Quality, Washington, D.C. 70pp.

Shaw, S. P., and C. G. Fredine. 1956. Wetlands of the United States. Circ. 39. U.S. Fish and Wildl. Serv., Washington, D.C. 67pp.

Federal Tax Code Opportunities to Maintain Wetlands

Michael Dennis
The Nature Conservancy
1800 North Kent Street
Arlington, Virginia 22209

Introduction

In the United States, more than in most other countries, the federal tax system, through tax incentives, encourages the performance of publicly oriented social services by the private sector. Using charitable contributions, individuals, corporations, and estates can lessen their respective tax burdens while selectively supporting the charities of their choice. In addition, other types of tax incentives such as business credits and deductions play a major role in directing economic and social policy.

The application of these tax incentives has played a critical role in both the preservation and destruction of this nation's wetlands. By encouraging deductible gifts of interests in conservation land, public and private entities such as the United States Fish and Wildlife Service and The Nature Conservancy have protected thousands of acres of threatened wetlands and other natural systems. At the same time, federal tax-code provisions have encouraged detrimental activities by allowing special tax credits and deductions for activities such as clearing, ditching, and draining of wetlands.

Historically, conservation has received a very small percentage of charitable giving. However, more and more private nonprofits, such as The Nature Conservancy, and public agencies, such as United States Fish and Wildlife Service, are utilizing the federal tax system to preserve America's threatened wetlands. For example, at the Federal level, the Department of Interior has encouraged land conservation agencies to study federal tax policy as a management alternative for the conservation of fish, wildlife and other natural resources of the Coastal Barrier Resources System.[1]

In the private arena, The Nature Conservancy's National Wetlands Conservation Project, which is being funded by the largest private conservation grant in history—$25 million from the Richard King Mellon Foundation—will attempt to more than match this grant with donations of lands and cash from other sources.[2]

Overall, between 10 and 20 percent of all wetlands protected through acquisition by the U.S. Fish and Wildlife Service and The Nature Conservancy is the direct result of charitable contributions. While this is an impressive statistic, it loses much of its glimmer when the overall need for wetlands protection is analyzed. Based upon statistics made available by the United States Fish and Wildlife Service, over the next 10 years, to adequately protect the most significant wetlands in this country,

[1]Asst. Secretary of Interior to author, memo and letter of Aug. 22, 1984, covering tax policy as a management alternative for the conservation of the natural resources of the Coastal Barrier Resources System.
[2]The Nature Conservancy, National Wetlands Conservation Program, spring 1983.

approximately 1.5 million acres (607,000 ha) of wetlands must be saved. This statistic becomes more significant when compared to the 300,000 acres (121,400 ha) of wetlands currently being destroyed annually. For this reason new tax incentives such as those discussed below must be developed.

Existing Tax Incentives

Before discussing some of the potential new tax initiatives, it will be helpful to review some of the existing tax incentives that have been applied to wetland protection projects. Current federal tax code incentives which encourage the protection of wetlands can be broken down into three categories: general charitable deduction provisions, charitable deduction provisions specifically earmarked for conservation gifts, and general tax incentives other than charitable deduction provisions. Keep in mind that when we discuss charitable contributions below, public agencies are treated in the same manner as public charities. This is an important point that is often overlooked by potential donors.

1. *General Charitable Deduction Provisions.* Charitable contributions to public agencies and public charities by individuals, corporations, and estates can be deducted from income, thereby lessening their respective tax burdens. Gifts of cash can be deducted against up to 50 percent of an individual's adjusted gross income,[3] up to 10 percent of a corporation's pre-tax income,[4] and up to the full amount of an estate.[5]

   For corporations and estates, gifts of appreciated property (which is the category of most conservation land gifts) are subject to the same deduction levels as cash; and are deductible against a maximum of 30 percent of the adjusted gross income level for individuals.[6]

   In the case of corporations and individuals, if a gift of cash or appreciated property cannot be fully utilized in the year of the gift, it can be carried forward consecutively for up to five additional years in an attempt to exhaust the full amount of the deduction.[7]

   The following examples demonstrate the application of these rules. If an individual taxpayer with an adjusted gross income of $200,000 donates land valued at $100,000 to a public agency or public charity, the taxpayer can deduct up to $60,000 for the year of gift since $60,000 is equal to 30 percent of the taxpayer's adjusted gross income. Assuming that the taxpayer is in the 50 percent tax bracket, this deduction will shield $60,000 of income and save the taxpayer $30,000 in taxes (50 percent times $60,000). The unused portion of the gift ($40,000) will be carried forward consecutively year to year against 30 percent of the taxpayer's adjusted gross income until it is used up, provided that it cannot be carried forward for more than five additional years. If the taxpayer is a corporation and the pre-tax income figure is $200,000, then the deduction would be limited to $20,000 during the year of the gift because $20,000 is equal to 10 percent of the corporation's pre-tax income. However, the corporation

[3]Internal Revenue Code of 1954 as amended (IRC), Section 170(b)(1).
[4]IRC Section 170(b)(2)
[5]IRC Section 2055(a)
[6]IRC Section 170(b)(1)(C)(i)
[7]IRC Section 170(b)(1)(C)(ii)

may also carry forward the remaining $80,000 of the gift for up to an additional five years.

The same charitable deduction rules apply to a bargain sale, a sale to a public agency or public charity at less than full fair market value. The difference between the appraised fair market value of the property and the actual sales price is treated in the same manner as any other charitable contribution. If a taxpayer sells property valued at $100,000 to a public agency or public charity for a sales price of $75,000, then the taxpayer has made a charitable contribution in the amount of $25,000. The tax attraction is twofold: the taxpayer has a charitable deduction that will shelter income from taxes and, since the price has been reduced, any tax due on the sale will be reduced. Although the sales prices in the above example differ by $25,000, when comparing the two sales the net proceeds to a taxpayer in the 50 percent bracket after taxes would differ by less than $8,000.

2. *Charitable Deductions For Conservation Gifts.* Currently, the Federal tax system includes few tax incentives that provide special treatment for conservation gifts of land. Of the few such provisions, the most common and most widely used is the conservation easement. A conservation easement is a partial interest in real property whereby a landowner agrees to refrain from certain activities on his land that would interfere with the conservation qualities of the land. As a general rule, partial interests in real estate are not deductible when donated to charities. However, a partial interest that satisfies certain conservation-purpose tests under the Internal Revenue Code will be allowed for charitable deduction purposes.[8]

   To satisfy the tax requirements for a deductible conservation easement, the easement must be in the form of legally enforceable restrictions, it must be perpetual, and it must be donated to a public agency or a public charity that is in the business of protecting conservation lands.[9]

   The last two of these three requirements are pretty much self-explanatory. The first requirement takes the form of a recordable deed of conveyance where the landowner covenants (agrees) to refrain from ever conducting certain activities or allowing certain activities on the property and grants the right to enforce these restrictions to a third-party public agency or public charity.

   The value of the conservation easement for deduction purposes is generally determined by looking at the value of the land before it is encumbered with the conservation easement and comparing this value with the value of the land after it has been encumbered with the conservation easement. The value of the deduction is equal to this difference in values. Depending on the actual market value of the land and the type of restrictions, the easement value can range from 10 percent to 90 percent of the pre-easement value. For example, in the case of a conservation easement which prevents the conversion of a bottomland hardwoods swamp or other wetlands systems to prime agricultural land, the deduction value can range as high as 60 to 70 percent of the pre-easement value.

3. *General Tax Incentives.* Although they do not apply specifically to conservation land, there are several general tax incentives which, if understood and applied

[8]IRC Section 170(f)(3)(B)(iii)
[9]IRC Section 170(h)

correctly, can make the difference between success and failure in protecting a piece of conservation land. Two of the more common tax incentives found in land transactions are the tax-free exchange and the involuntary conversion benefits found in the Internal Revenue Code.

The tax-free exchange provisions allow a landowner to exchange his property for like-kind property and defer any tax that would normally have been due. To satisfy the tax-free exchange provisions a taxpayer must exchange property held for investment or for productive use in a trade or business for similar or like-kind property.[10]

To defer any present tax implications, the exchange properties must be of equal value. In addition, the like-kind requirements have been very loosely interpreted so that real property held for investment purposes in exchange for any other type of real property held for investment purposes will satisfy the requirements. For example, timberland held for investment purposes can be exchanged for commercial real estate held for investment purposes. The tax-free exchange principles have been used successfully by conservation organizations such as The Nature Conservancy when acquiring wetlands in exchange for nonecologically significant timberlands or farmlands.

Under current law, a landowner can reinvest the proceeds of an involuntary conversion (condemnation, theft, destruction, etc.) of investment property withing three years of the conversion date and defer any tax liability on the transaction.[11] The proceeds must be used to buy property similar to the converted property to get the benefit of the tax deferral. The like-kind tests used in tax-free exchanges are used to determine whether or not the replacement property is similar to the converted property. The threat of condemnation is enough to satisfy the involuntary conversion requirements of the tax Code.[12]

The courts have interpreted the threat of condemnation quite loosely so that a reasonable expectancy of a taxpayer that his property may be condemned at some point by a public agency may be enough to trigger the tax deferral benefits.[13] For example, if a taxpayer has a reasonable expectation that his property will at some point be condemned by a public agency, any sale by the taxpayer thereafter may qualify as an involuntary conversion, even if the property is not sold to the potential condemning authority. The fourth example below illustrates the sale under a threat of condemnation.

Real Life Examples

1. *Alligator River National Wildlife Refuge.* In the summer of 1983, the Prudential Life Insurance Company approached The Nature Conservancy about the possibility of transferring approximately 120,000 acres (48,560 ha) in Dare County, North Carolina, for conservation purposes. This tract included a major portion of one of the largest wetland ecosystems in North Carolina. Included within this parcel are high-quality examples of fresh and salt water marshes, low, middle, and high pocosins, and palustrine swamp forest com-

[10]IRC Section 1031
[11]IRC Section 1033
[12]IRC Section 1033
[13]Internal Revenue Service Revenue Rulings 63-221, and 71-567

munities. The Conservancy described the various tax benefits that would be available to Prudential if it made a gift of this property, and after Prudential compared the tax benefits of a gift versus the long-term sale work out, it decided to go ahead with the donation. Shortly thereafter this $50-million property was transferred by donation to the United States Fish and Wildlife Service to become a National Wildlife Refuge.

2. *Lower Escambia River, Florida.* Over the past decade, The Nature Conservancy, working in cooperation with several different public agencies, has acquired several critical wetland parcels from the St. Regis Paper Company. (St. Regis Paper Company has recently merged with Champion International Corporation, and The Nature Conservancy's strong working relationship continues with Champion.) In almost all of these transactions, St. Regis Paper Company has been willing, at a minimum, to bargain sell the property. The most recent example of this type of transaction occurred in 1983. St. Regis Paper Company owned approximately 18,000 acres (7,280 ha) along the Lower Escambia River in Santa Rosa and Escambia Counties, in the state of Florida. This property represents one of the truly outstanding bottomland hardwood swamp sites in the Southeast. The Conservancy met with representatives of St. Regis Paper Company and discussed the tax benefits of a partial donation. Even though St. Regis had not experienced one of its better years, the company sold the property to the Conservancy for $4 million, despite the fact that the property had been valued at $7 million. However, the combination of the charitable donation of $3 million real estate coupled with net proceeds on the sale put St. Regis in a position that was almost identical to a sale at full fair market value on the open market. This property is now in the process of being transferred to the Northwest Florida Water Management District under the State of Florida's Save the Rivers Program.
3. *Adirondacks—Spring Pond Bog.* Over the past decade, The Nature Conservancy has acquired, through purchase and gift, interests in over 100,000 acres (40,470 ha) of the Adirondack wilderness. Some of the more noteworthy of the acquisitions were four gifts of conservation easements, totaling close to 70,000 acres (28,330 ha). These easements will protect in perpetuity some of the most outstanding examples of boreal bog and spruce grouse habitat in the United States. All of the donors have been leaders in the Adirondack protection effort, but the approximately $3.5-million charitable deduction for the value of the easements was certainly instrumental in closing these transactions. In addition, since the easements do not involve a change in ownership, the long-term management responsibilities and costs stay with the donors and their successors.
4. *Mississippi Sandhill Crane National Wildlife Refuge.* This is another example of The Nature Conservancy and St. Regis Paper Company working with a public agency to protect a critical natural habitat. St. Regis Paper Company owned an approximately 6,000-acre (2,430 ha) parcel in Jackson County, Mississippi, which was critical habitat for the sandhill crane. This property, which was valued at approximately $4.5 million by the U.S. Fish and Wildlife Service, had been identified as a potential addition to the Mississippi Sandhill Crane National Wildlife Refuge. The Nature Conservancy negotiated a bargain sale with the St. Regis Paper Company and acquired the property for approxi-

mately $3.7 million, substantially less than its full fair market value. In addition, because of the high level of interest in this property demonstrated by the U.S. Fish and Wildlife Service, St. Regis Paper Company was able to treat the sale as an involuntary conversion, thereby deferring any tax due and giving the compnay three years to reinvest the proceeds. The company received the involuntary conversion benefit because, although the property was not sold directly to the federal government, it was sold under the reasonable expectancy or threat of condemnation.

5. *Apalachicola Bluffs—St. Joe Paper Company.* St. Joe Paper Company owned a 3,200-acre (1,300 ha) parcel within the boundaries of one of the most critical natural areas ever protected by The Nature Conservancy, the Apalachicola Bluffs Preserve. This property includes representatives of the unique, steephead ravines of the Apalachicola River, which harbor a number of land and animal species found nowhere else in the world. St. Joe Paper Company was willing to sell this property to The Nature Conservancy provided that the Conservancy could identify an exchange parcel so that the transaction would be structured as a tax-free exchange. The Nature Conservancy found a parcel that was idenfified as suitable timber land by St. Joe Paper Company and proceeded to trade properties on a value-for-value basis. St. Joe Paper Company was able to defer any tax due because the exchange satisfied the tax-free exchange rules of the Internal Revenue Code.

New Proposed Tax Provisions

Going back to one of the earlier themes in this paper, federal tax code incentives have been used both to protect and to destroy wetlands. The new proposed tax provisions discussed below can be categorized as new tax incentives which help protect conservation lands and the removal of old tax incentives which currently encourage the destruction of conservation lands.

1. *New Tax Incentives.* The best example of new tax incentives to encourage the acceleration of the preservation of wetlands in this country are found in HR 5900, which was introduced in the spring of 1984 by Congressman John Breaux of Louisiana. Senator Malcom Wallop of Wyoming introduced the companion bill in the Senate in 1983 as SB 1675.

   Passing legislation which will add additional tax incentives will be extremely difficult in today's political climate. However, HR 5900 has some special features which will make it more palatable than most tax incentive bills.[14] The tax incentives will specifically benefit a limited class of conservation lands such as endangered species habitats, additions to a federal wildlife refuge or national park, properties with the Coastal Barrier Resource System, priority wetlands, and lands indentified as part of a state's natural heritage inventory.[15] In addition to limiting the qualifying lands and thereby minimizing the revenue impact, the bill presents a balanced combination of tax deductions, tax incentives, and tax credits.[16] Rather than simply encouraging gifts, the bill encour-

[14]Dennis, Michael, Testimony before House Subcommittee on Fisheries and Wildlife Conservation and the Environment House Committee on Merchant Marine and Fisheries.
[15]Dennis, Michael, "Federal Tax Initiatives," *National Wetlands Newsletter*, Vol. 5, No. 5, pp. 3-5.
[16]Dennis, Michael, "Federal Tax Initiatives," *National Wetlands Newsletter*, Vol. 5, No. 5, pp. 3-5.

ages less affluent landowners to transfer their lands for conservation purposes, and it encourages certain types of landowners, through tax credits, to continue to own and manage their lands as wetlands.

One of the new charitable deduction incentives would increase the individual deduction level of qualifying conservation lands from 30 percent of the adjusted gross income to 50 percent of adjusted gross income. This provision becomes more significant when coupled with another new charitable deduction provision that would replace the 5-year carry-forward period discussed earlier with an unlimited carry-forward of gifts of conservation lands such as wetlands. To close the loop, when looking at the carry-forward period, HR 5900 also includes a provision that will allow a deceased's estate to take as a charitable deduction any unused lifetime gifts of conservation lands. Under current law, if a taxpayer dies with any unused charitable deduction carry-forward, this carry-forward can never be utilized for tax purposes. This new estate tax provision will eliminate one of the unnecessary gambles that an elderly taxpayer must take when donating a highly valued conservation land gift.

HR 5900 also includes some general tax incentive provisions which are geard to landowners who cannot take advantage of the charitable deduction. For example it will increase the current capital gain deduction for sales of conservation lands to conservation agencies from 60 to 70 percent. It would also allow a taxpayer selling conservation lands to a conservation agency to defer any tax due if the proceeds of the sale are reinvested in like-kind property within a 3-yerar period. Like-kind property for the purposes of HR 5900 follows the same definition as the tax-free exchange provisions discussed above and found under Section 1031 of the tax Code.

HR 5900 also includes some new tax credit provisions that apply to conservation lands. Tax credits are dollar-for-dollar deductions that are taken against the taxpayer's tax liability, compared to the less beneficial dollar-for-dollar reduction in income that is provided by a tax deduction. One of the new credit proposals will allow an estate to satisfy its federal estate tax liability by making estate tax payments with conservation lands in lieu of cash. Other new tax incentives would allow lanowners to take as a tax credit up to 15 percent of the cost of expenditures that they make to enhance their wetlands or endangered species habitat, provided that the Secretary of the Interior has signed off on the enhancement activities.

2. *Removal of Tax Incentives*. While the political climate may be bad for additional tax incentives, spurred on by the recent tax simplification proposals, the climate could be right for removing some of the current tax incentives which result in the destruction of wetlands. A simplified "flat tax" proposal weakens the tax expenditure concept and removes many of the current tax benefits found in the Internal Revenue Code. However, discouragement of wetland destruction through the elimination of certain tax write-offs could be the silver lining in tax simplification. For example, without special business deductions and credits, such as accelerated depreciation and the investment credit, the conversion of wetlands to agricultural lands would no longer be profitable in many cases. This would also hold true for many of the development activities taking place on sensitive ecosystems such as coastal barriers and saltwater marshes. At

present the Environmental Defense Fund is working on legislative proposals that will remove some of these tax incentives that are used to destroy wetlands.[17] These proposals, at a minimum, will take a hard look at eliminating the investment tax credit,[18] the accelerated depreciation deduction (A.C.R.S.)[19], and the soil and water conservation deduction[20] for any activities or expenses that will result in the destruction of critical conservation lands such as priority wetland sites. These proposals could even go as far as to eliminate all business deductions and credits that would result in the destruction of priority wetlands and other natural habitats. There is no doubt that these types of proposals would have a significant impact on the economy, especially the agricultural community. However, the economic loss attributable to the loss of wetlands in this country is just as significant.

Conclusion

The importance of preserving our wetlands is no longer an issue. It can safely be stated that the majority of our citizens view this as a noble goal. Both the private and public sectors contribute to the wetlands protection mission to the best of their abilities within the limitations of economic reality. When one protection tool, such as federal land acquisition dollars, is cut back, it is incumbent that other available protection tools are more fully utilized. For natural resource professionals in the private and public sectors, it is important to recognize and understand the existing tax code provisions that can assist in the preservation of our critical wetland resources. As importantly, because the magnitude of this preservation effort is so huge, we most continually look for new ways to get the job done. Support for new wetland protection incentives is just as critical as understanding and using the existing incentives.

[17]Brown, W., "Federal Initiatives for the Preservation of Wetlands," *Federal Bar News and Journal*, Vol. 31, No. 2, pp. 70-74, Feb. 1984.
[18]IRC Section 38
[19]IRC Section 168
[20]IRC Section 175

Estuarine Habitat Enhancement and Restoration

John B. Pearce
NOAA Estuarine Programs Office
National Marine Fisheries Service
Washington, D.C.

The Issues

Coastal habitats, especially wetlands, have been recognized to have extraordinary value to production of wildlife and fish and shellfish. The values, and losses, of wetlands have been well summarized for certain coastal regions and states (Redelfs 1983, Josselyn 1982). Given the often rapid loss of habitat, many states are developing management plans for habitats, sanctuaries and living marine resources (LMR). A good example is the management plan for the State of Connecticut marine resources (Blake and Smith 1984). This plan discusses the issues, resources at risk and their uses, and objectives for management. It treats the matter of access to fishing areas, including construction of fishing piers and barges. This and most plans stop short, however, of recommending large scale or even local habitat enhancement or restoration. As habitat alterations contribute to the decline of fishery production and product quality, it becomes necessary to think in terms of *multiple-use* of estuarine and coastal waters. In recent years, it has become obvious that steps can be taken which result in environmental improvement by which fisheries production can be continued at present levels, or even enhanced. This is especially true for certain physical habitat alterations made to estuarine and coastal habitats, e.g., destruction of wetlands, dredging, diking, channelization, alteration of natural sedimentation processes, freshwater discharge into estuaries, and covering benthic habitat with wastes. Indeed, activities now carried on in estuaries and coastal waters can be modified so as to maintain and, in some cases, enhance the productivity of these waters.

Estuaries and coastal waters offer many opportunities for habitat enhancement and restoration with resultant increases in the production of LMR. On the other hand, with the exception of artificial reefs and drilling platform modification, there are few easy ways to increase the productivity of offshore or shelf waters. Since estuaries serve as principal spawning and nursery areas for many species of fish, modifications which increase the areal extent and quality of such areas can be made which would lead to increased reproduction, recruitment, growth, and survival.

It should be recognized that in many instances changes would occur on a small or local scale (e.g., increasing flushing volumes and rates or setting areas for larval fish or invertebrates). The cumulative productivity increase of many such small scale efforts would, however, be significant. In other instances, restoration or enhancement would occur on a greater scale. For example, planning to increase the size and scope of urban ports and other harbor developments could be done in a manner which would result in large increases in productivity.

It is well demonstrated that both natural and altered areas can be modified or biological stocks manipulated to increase production. Artificial reef construction and wild stock enhancement are being used to concentrate, maintain, or enhance present levels of yield of LMR. Other methods are also applicable. For example, restoration has been achieved through the use of clean sediments to "cap" otherwise heavily contaminated areas of the sea floor. In other instances, restoration has occurred through physical removal of polluted surficial sediments.

The Goal

Since habitats can be enhanced or restored, several agencies are looking to increase estuarine and coastal productivity through the use of habitat restoration and enhancement strategies.

The Strategy

As already indicated, the author believes that the way forward in coastal management includes working through the multiple-use concept, enphasizing issue identification followed by planning which includes enhancement and restoration, in addition to the more traditional objectives embodied in preservation and classical management strategies. The following are recognized as ideas essential to effective enhancement and restoration planning and implementation:

1. As an overall strategy, it is desirable to reduce degrading activities which presently affect estuaries. Without pollution abatement and a reduction in actual estuarine or marshland habitat losses, the benefits of habitat enhancement and restoration efforts will be less useful and cost effective. The following abatement efforts are seen as being most important: (a) prevention of soil erosion in critical basin or construction areas leading to major rivers and estuaries; (b) upgrading of waste treatment processes and effluents (including non-point sources such as agricultural runoff) and pretreatment of industrial wastes; (c) reduction of development in marshland and wetland; (d) implementation of appropriate designs for structures associated with harbor and industrial development, i.e., piers, docks, channels, etc; (e) design and construction of channels to provide improved patterns of water flow within estuaries and riverine systems; (f) design of jetties and bulkheads, with proper allowance for adequate water flow to crucial habitats; (g) timing of dredging and related activities so as to reduce impacts on crucial life history stages; and (h) proper scheduling of water release from dams and other structures to provide best conditions for anadromous fish migration, egg and larval development, and associated reproductive processes and recruitment.
2. Habitat restoration and enhancement should include planning to rehabilitate degraded areas and "build with nature." For instance, where existing dikes, banks, and other structures have been shown to affect productivity, and the life history of LMR, these areas should be upgraded by installing channels, culverts, and other structures that would increase water flow to contained areas or allow access of LMR to contained waters. This would allow proper drainage and flushing of wastes and other noxious materials as well as ingress and egress of nutrients, eggs and larvae, migrating adults, and other ecosystem components necessary to the proper functioning of estuaries and wetlands.
3. Habitat restoration and enhancement activities should be considered on both local and wide-scale bases. Some activities would occur within specific small estuaries or port and harbor areas, while others would involve entire water-

sheds, basins, or states. For instance, development of major interstate harbor areas, such as those for the lower Hudson River or the Columbia River basin, should be considered in total. It makes little sense to propose abatement procedures in waters common to New Jersey and not consider similar efforts in New York waters on the eastern side of the Hudson River system. By having proper coordinated strategies in hand for use within states, and interstate areas, it becomes possible to have a cumulative, positive effect on wildlife and fish populations which are migratory or common to numerous small estuaries or areas within a particular state.

4. The following enhancement and restoration techiques should be planned, promoted, and implemented where possible, and with proper issue identification and planning, to increase the production of fish, shellfish, and wildlife:

   4.1 *Proper placement and construction of shore protection features.* Jetties, groins, breakwaters, and wave energy dissipators properly placed, can lead to protection of beaches and subtidal sediments and can also result in increased aeration of the water, diversion of stressful current systems, and other benefits. Bridges, piers, and similar structures should be designed and constructed in ways which are known to attract fish and increase productivity. Resulting increases of fouling invertebrates would provide additional forage for both juvenile and adult finfish. With proper location, construction, and manipulation of such structures, new habitat niches can be provided that would result in increased standing stocks of crabs, lobsters, and other commercially and recreationally valuable shellfish and finfish. Research papers, guides, and industry and agency public relations brochures are too numrous to list *in toto* here, but the paper by DeYoung (1984), concerned with floating tire breakwaters, is especially interesting and contains numerous additional references, some highlighting how these breakwaters can enhance fish production. The brochure by the U.S. Army Corps of Engineers (1981), "Low Cost Shore Protection," includes basic how to do it ideas, and also pays some attention to the need for improving habitats through revegetation, limiting access to marshes, and other means.

   4.2 *Physical Habitat Manipulations.* Clams, oysters, and other bivalves also can be enhanced through physical manipulations of the habitat. For instance, the seabed can be "plowed" so as to resuspend and thus eliminate accumulated sediments and organic debris and to return oyster shell or gravel to the surface, to serve as cultch for future settings of larvae. In some instances, this has occurred naturally due to runoff and flushing accompanying major storms or hurricanes. In addition, it is possible to locate seawalls, jetties, and other structures so as to direct water currents over selected portions of the sea floor, thus resulting in scouring, which prevents sedimentation and smothering of shellfish beds.

   It has also proven possible physically to remove *contaminated* sediments in areas where toxic debris has settled over long periods. If these materials are removed, fresh, acceptable sea floor is opened up for future recruitment of shellfish or forage species important as food for finfish. Moreover, with the removal and proper disposal of contaminated sediments, a continuous "source" of future toxic material to be transported to other areas is eliminated. As a result of such physical manipulations and control of suspended matter, it becomes possible to revegetate areas that have lost their normal floras. Experience in both Chesapeake and San Francisco bays has demonstrated that revegetaton can be employed to improve habitats for specific species of shellfish and finfish. In Denmark, it was shown that a change in sediment type could result in changes in vegetation which provided improved habitat for shrimp and other organisms. Thus, it is possible to manipulate the habitat to provide renewed opportunities for native species of plants, or for the introduction of non-indigenous species of plants. Two exceptional papers dealing with the use of vegetation and revegetation in wetland restoration and enhancement are those by Josselyn (1982) and Josselyn and Buckholtz (1894). While addressing the issue in California, and more specifically San Francisco Bay, many of their concepts and methodologies would have generic application in Casco Bay, Maine, or Tampa Bay, Florida. The former paper, Josselyn (1982), discusses the ongoing dilemmas of the engineer and ecologist and the imbalance in their plans. The need for proper arrays of vegetation in wetlands, streams (both fresh and salt), and other habitats was noted in a brief research report by Leh (1984). Thus, construction involving bulkheads, riprap, and jetties must often be accompanied by planning to manipulate physically the habitat and place vegetation in crucial locations. Large numbers of papers are becoming available which give great detail as to where, when, and how specific species should be planted or introduced or transplanted. One recent paper (Fonesca et al. 1984) purports to have a process which will be ". . . effective for restoring areas damaged by coastal engineering activities . . ." Yet another paper (Adams and Dove 1984) offers advice on the potential to create wetland habitats during the implementation of management practices for controlling urban storm-water runoff.

Finally, however, it must be recognized that all revegetation projects may not be equally successful. A recent report from the Commissioner of New Jersey's Department of Environmental Protection suggests that artificial salt marshes created by developers are incapable of sustaining vegetation (*Asbury Park Press* 1985). This may be the result of several factors, including the use of inappropriate species, wrong time of planting, a mismatch between sediment type and vegetation species, or simply the time allowed for vegetation to occur and floral communities to stabilize. It also suggests that research and monitoring must accompany regional enhancement and restoration programs.

4.3 *Shellfish restoration.* Shellfish can be reintroduced to areas from which they have been eliminated. Such reintroduction, done in concert with pollution abatement and habitat restoration, results in increases in standing stocks of wild, native populations. These activities can be fully successful only after pollution abatement or restorations of physical environments have occurred, however. The literature is replete with reports on such studies. Most coastal universities have marine extension services which can direct those interested to appropriate reports, often of a local nature.

4.4 *Modification of currents and tidal flows.* In certain habitats, decades or centuries of sedimentation have resulted in the shoaling of channels which formerly provided for entrance of tidal flows to marshlands and shallow estuarine and coastal areas. It is now known that through selective deepening of channels, it is possible to improve water flow, aeration of water, and the nature of other physical and chemical variables important to reproduction and maintenance of shellfish and finfish stocks. In addition, there are sometimes side benefits (e.g., control of mosquitos through proper ditching and channeling of marsh areas). Thus, mosquitos and other pest populations may be controlled at the same time that the original productivity of estuaries is restored. It is most important to note that if sources of sediments are controlled, sedimentation and consequent degradation of spawning areas, shellfish beds, and resting habitat can be avoided. The means to accomplish reduction in erosion have long been known (U.S. Department of Agriculture 1970); only the recognition for the need and a national will is missing.

4.5 *Use of non-polluting materials.* Certain construction materials, such as wood impregnated with creosote, toxic metals, or other antifouling or preserving materials, may have an adverse impact on fish populations. A range of alternatives exists. By substituting concrete for toxin impregnated wooden bulkheads during construction, it is possible to eliminate toxic effects and enhance bulkheaded areas in regard to reproduction, maintenance, and survival, as well as recruitment of important living marine resources. Properly designed bulkheads can provide numerous new niches for a range of important species which are either valuable as food stuffs or as forage for local or migratory fish populations. The use of non-wood or resistant (to boring organisms) woods in fishing gear has been advocated as a way to avoid wood-boring organisms in vulnerable fishing gear (pots and traps) (Smith 1982). Similar methods can be used in marine construction projects so as *not* to compromise the fisheries in a significant manner.

4.6 *Positive regulation of effects.* There are numerous techniques that can be used in special areas to minimize impacts of waste discharge while enhancing fishery production. For instance, thermal discharges for steam-electric and nuclear power plants can be designed and controlled to augment productivity. Discharges into shallow estuarine areas having limited circulation should be avoided; however, such discharges, when injected into deeper coastal waters, result in changes that will enhance the production of food-chain organisms that culminate in fish stocks. Such discharges must be carefully planned so that the best use can be made of the energy in these waters and so that the adverse impacts of increased temperature can be minimized or eliminated. Likewise, discharges for domestic sewage treatment systems can be controlled to enhance the productivity of coastal waters. In many areas, there are seasonal deficits of certain essential nutrients. Organic waste materials could be managed (discharged seasonally) in a way to eliminate toxic organic and inorganic contaminants in the sewage discharges, and minimize the negative effects of added nutrients.

5. In all instances, strategies developed to provide for habitat enhancement and restoration should take into consideration mitigation of unavoidable adverse impacts through the augmentation of natural floras and faunas. Where society

is engaged in developing particular portions of rivers, estuaries, and coastal zones, there should be an assurance that negative effects, where these cannot be avoided, be accompanied by mitigation to compensate for negative effects. One of the best examples is where a particular area might be degraded in some unavoidable manner because of the development of a new and enlarged harbor area. Where this is being planned for, it would be most appropriate to establish sanctuaries, free of any further development, in areas in reasonably close proximity to those being degraded. This would provide opportunities for fish ranging within the developed areas to have refuges, as well as areas where reproduction, growth, and recruitment to the stocks can occur. Moreover, the degraded areas and associated sanctuaries would provide research sites useful in evaluating ecological effects of physical and chemical variables and cost/benefit ratios related to mitigation, pollution abatement effects, and sanctuary establishment in estuaries and coastal waters.

Conclusions

There are more than sufficient data, information, and scientific and technical reports to permit federal, state, and local authorities to begin to take steps to develop policy and implement habitat enhancement and restoration plans. For instance, scores of assessments, profiles, and reports have been developed on the more important, or politically prominent, estuaries. The U.S. Fish and Wildlife Service has printed an estuarine profile for Albemarle Sound, N.C. (Copeland et al. 1983). It is quite representative of such reports, pointing out the resources at risk, the major issues and management needs, and making recommendations in regard to many of the aforementioned. One of the summary items indicates that a prominent area of human activity in the Sound has been the construction of dams on the major riverine systems carrying freshwater to the Sound. This has had the effect of drastically decreasing spawning runs of anadromous fish. Another recent report, however, discusses the feasibility of fish passage facilities on the James River, Virginia (Loesch et al. 1983). It notes the applicability of such enhancement and restoration construction to a range of species in the mid-Atlantic area, their efficacy nation-wide, and the costs and sources of funding. The two documents taken together identify a specific issue and steps required to rectify it. The final lines of the profile on Albermarle Sound also make the important point that often more than one government agency (and often more than one government) have leads in management of an estuary. This results in several agencies or governments having ". . . overlapping jurisdictions over different resources of the Sound, sometimes raising conflict in setting goals." Therefore, implementation of enhancement and restoration activities must be accomplished through agreement and consensus, with an aim to improve aquatic habitats, *not* to protect institutional or agency "turf." Finally, in this regard it is important to recognize that there must be a national oversight or policy in regard to habitat enhancement and restoration. Many migratory species of finfish are dependent upon passing their life history in several or even scores of estuaries. This is especially true on the east coast where species such as bluefish, striped bass, shad, and others move along the entire length of the shoreline from the Carolinas to the Gulf of Maine, spending varying periods in several major estuarine systems. The well-being of these forms is *not* dependent upon one single estuary but on the habitat conditions that obtain in several.

In spite of numerous institutional and philosophical difficulties, it is possible to implement habitat enhancement and restoration programs that will eventually lead to "zero habitat loss," the goal of at least one federal agency. Growing awareness of the issues is leading to the release of documents such as "Geologic Principals for Prudent Land Use—A Decision-Maker's Guide for the San Francisco Bay Region" (Brown and Kockleman 1983). Such documents set the scene for making decisions in regard to habitat use and modification based on sound scientific and economic information. The success of at least one endeavor is reflected in a recent (6 December 1984) article in the *Connecticut Shore Line Times.* After documenting a 200-year decline in a salt marsh near Guilford, known as Long or North Cove, the article concludes that, while over 50 percent of Connecticut's tidal wetlands were filled before legislation began to protect them, Long Cove "will become one of the first marshes to have been restored." This will be accomplished through restoration construction designed to improve the flow of tides through existing dikes.

Finally, not all attempts at restoration will be 100 percent successful. While many artificial reefs have been reported to enhance productivity, or at least standing stocks of finfish, one recent study suggests that an artificial reef apparently attracted fish from close at hand natural reefs (Matthews 1983); there is the suggestion that, by concentrating fish on the artificial reef, subsequent heavy fishing pressure could have ". . . detrimental effects on natural reef fish populations." Thus, the planning for habitat enhancement and restoration should include allocations for research, monitoring, and the transfer of knowledge gained to other projects.

Recommendations

1. Governments, academia and the interested public should promote restoration and enhancement programs and activities by federal, state and local resource, construction, and regulatory agencies;
2. Agencies, including the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service, should provide scientific support and advice to restoration and enhancement programs; and
3. Agencies with aquatic habitat interests should conduct research into the development and evaluation of existing and new restoration and enhancement techniques.

Literature Cited

Adams, L. W., and L. E. Dove. 1984. Urban wetlands for storm water control and wildlife enhancement. National Institute for Urban Wildlife, Columbia, MD. 15 pp.

Asbury Park Press. 1985. Man-made salt marshes found barren. Asbury Park Press, Asbury Park, NJ. 3 January 1985.

Blake, M. M., and E. M. Smith. 1984. A marine resources management plan for the State of Connecticut. Connecticut Department of Environmental Protection, Hartford, CT. 244 pp.

Brown, R. D., and W. J. Kockelman. 1983. Geologic principals for prudent land use—A decision-makers guide for the San Francisco region. Geological Survey Professional Paper 946. U.S. Department of the Interior, Washington, D.C. 97 pp.

Copeland, B. J., R. G. Hodson, S. R. Riggs, and J. E. Easley. 1983. The ecology of Albemarle Sound, North Carolina: An estuarine profile. FWS/OBS-83/01. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D.C. 68 pp.

DeYoung, B. 1984. Enhancing wave protection with floating tire breakwaters. Extension Publication, Physical Sciences, Sea Grant 1. Information Bulletin 139. New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, NY.

Fonesca, M. S., W. J. Kenworthy, K. M. Cheap, C. A. Currin, and G. W. Thayer. 1984. A low-cost transplanting technique for shoal grass (*Halodule wrightii*) and manatee grass (*Syringodrium filiforms*). Instruction Report EL-84-1. U.S. Army Corps of Engineers, Washington, D.C. 16 pp.

Josselyn, M., ed. 1982. Wetland restoration and enhancement. Report No. T-CSGCP-007. California Sea Grant College Program, LaJolla, California. 110 pp.

_____, and J. W. Buchholz. 1984. Marsh restoration in San Francisco Bay: A guide to design and planning. Technical Report No. 3. Tiburon Center for Environmental Studies, San Francisco State University, San Francisco, CA. 104 pp.

Leh, P. 1984. Habitat conservation—salmon in the Sacramento River. American Institute of Fishery Research Biologists, BRIEFS 13(6):4.

Loesch, J. G., S. M. Atran, and W. H. Kriete. 1983. Feasibility study of fish passage facilities in the James River, Richmond, Virginia. VIMS Special Report No. 269. Virginia Institute of Marine Science, Gloucester, VA. 109 pp.

Matthews, K. R. 1983. Species similarity and movement of fish assemblages on artificial and natural reefs in Monterey Bay, California. American Institute of Fishery Research Biologists, BRIEFS 13(6):9.

Redelfs, A. E. 1983. Wetlands values and losses in the United States. Thesis for M.S. Degree. Faculty of the Graduate College of the Oklahoma State University, Stillwater. 143 pp.

Smith, C. F. 1982. Wood fishing gear preservation for profit. Paper 8/82 CP 3M 8144. N.Y. State Sea Grant Cooperative Extension, Cornell University, Ithaca, N.Y. 5 pp.

U.S. Army Corps of Engineers. 1981. Low cost shore protection. U.S. Army Corps of Engineers, Washington. D.C. 36 pp.

U.S. Department of Agriculture. 1970. Controlling erosion on construction sites. Agriculture Information Bulletin 347. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C. 32 pp.

Mitigation Banking: A Mechanism For Compensating Unavoidable Fish and Wildlife Habitat Losses[1]

David M. Soileau
U.S. Fish and Wildlife Service
Lafayette, Louisiana 70502

James D. Brown
U.S. Fish and Wildlife Service
Atlanta, Georgia

David W. Fruge
U.S. Fish and Wildlife Service
Lafayette, Louisiana

Introduction

The Fish and Wildlife Coordination Act (16 U.S.C. 661-667 [e]) requires that wildlife conservation be given "equal consideration" with other features of federal water resources development programs, including private projects constructed under federal permit or license. The Act also requires the determination of means and measures to prevent the loss of or damage to such wildlife resources. Out of this requirement has evolved the concept of mitigation (Bean 1978).

Numerous definitions have been assigned to mitigation; however, it is generally considered to include avoiding or minimizing adverse impacts on fish and wildlife and their habitat and compensating for unavoidable losses of those resources. Historically, the lack of a common, consistent definition of mitigation has resulted in uncertainties regarding what should be considered necessary or justifiable mitigation (Rappoport 1979). Consequently, the U.S. Fish and Wildlife Service (1981) promulgated a Mitigation Policy to guide its involvement in the planning of federal water resources development activities. This policy embraced the definition of mitigation contained in the National Environmental Policy Act regulations (40 CFR Part 1508.20[a-e]). By that definition, mitigation can include:

> (a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments.

This definition incorporates both the need to modify project design to avoid or minimize impacts and to compensate for impacts that cannot be avoided.

In the past few years, a concept known as "mitigation banking" has been developed as a mechanism for achieving compensation for unavoidable habitat

[1]The findings, conclusions, opinions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views or position of the U.S. Fish and Wildlife Service.

losses associated with certain wetland resources development projects. In the U.S. Fish and Wildlife Service's Mitigation Policy (1981) and Interim Guidance on Mitigation Banking (1983), mitigation banking is defined as ". . . habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable, necessary losses from specific future development actions." In simplified terms, mitigation banking is similar to maintaining a bank account. A developer undertakes measures to create, restore, or preserve fish and wildlife habitat in advance of an anticipated need for mitigation for project construction impacts. The benefits attributable to these measures are quantified, and the developer receives mitigation credits from the appropriate regulatory and/or planning agencies. These credits are placed in a mitigation bank account from which withdrawals can be made. When the developer proposes a project involving unavoidable losses of fish and wildlife resources, the losses (debits) are quantified using the same method that was used to determine credits, and a withdrawal equal to that amount is deducted (debited) from the bank. This can be repeated as long as mitigation credits remain available in the bank.

This paper presents mitigation banking policy and management considerations, and discusses advantages and potential disadvantages associated with mitigation banking. Specific implementation and operational procedures associated with a 5,000-acre (2,023 ha) Tenneco Oil Company mitigation bank established in the south-central Louisiana coastal area are described to illustrate the concept better and to highlight some of the problems that can be encountered in the development of a mitigation bank.

Tenneco Oil Company Mitigation Bank

On October 29, 1982, Tenneco Oil Company (Tenneco) hosted a federal/state interagency meeting to discuss the possible establishment of a mitigation bank on approximately 7,000 acres (2,833 ha) of fresh to brackish marsh (palustrine emergent wetlands and estuarine intertidal emergent wetlands, respectively, according to Cowardin et al. 1979) within Terrebonne Parish (county) in south-central Louisiana (Figure 1). Approximately 5,000 acres (2,023 ha) of the area are owned by Tenneco; the remaining 2,000 acres (810 ha) are under other private ownership.

The marsh of the mitigation bank area was formed as a result of the deposition of Mississippi River sediments during the past 6,000 years (Gagliano and van Beek 1970). These sediments formerly entered the area via Bayou Lafourche, a distributary of the Mississippi River. However, in 1904 this avenue of freshwater and sediment was eliminated by a closure constructed by the U.S. Army Corps of Engineers at the confluence of Bayou Lafourche and the Mississippi River. Subsequently, natural subsidence and other factors such as excavation of major navigation canals, canalization for oil and gas exploration and production, and saltwater intrusion via these man-made waterways have led to the conversion of fresh marsh to open water and more saline vegetation types. Records indicate that the mitigation bank area was essentially a homogeneous fresh marsh dominated by maidencane (*Panicum hemitomon*) until the mid-1950s. Since that time, much of the area has converted to brackish marsh and open water (Figure 1), and this deterioration is expected to continue.

At the initial meeting the Soil Conservation Service proposed a structural water management plan that would reintroduce freshwater and sediment flow, improve

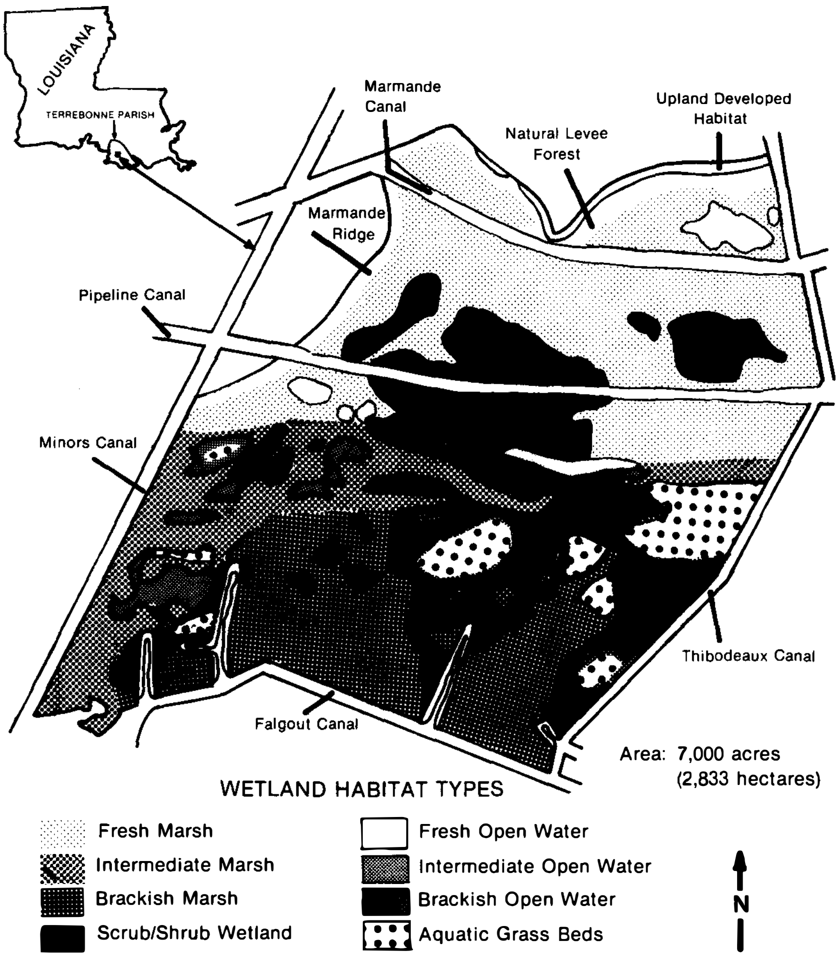


Figure 1. Tenneco mitigation bank area, showing wetland habitat types.

water circulation, and dramatically reduce saltwater intrusion. It was anticipated that the proposed Tenneco management program would significantly retard the rate of marsh loss, hence increase the life of the marsh, and enhance the productivity of the remaining marsh within the mitigation area. The interagency group (consisting of the Fish and Wildlife Service, National Marine Fisheries Service, Soil Conservation Service, Louisiana Department of National Resources, and Louisiana Department of Wildlife and Fisheries) measured those anticipated benefits via the Fish and Wildlife Service's Habitat Evaluation Procedures (HEP).

Intense interagency/industry negotiations continued during all of 1983. The following is a list of the salient issues that emerged and a brief explanation of how those issues were resolved. The manner in which these issues would be handled formed the nucleus of the formal Memorandum of Agreement (MOA) that was executed between the interagency group and Tenneco in December 1983. That MOA functions as the guide to the operation of the Tenneco mitigation bank.

1. *Life of the Mitigation Bank.* Consistent with the Fish and Wildlife Service's Interim Guidance on Mitigation Banking, the interagency group supported the position that the mitigation bank have a period of effectiveness at least equal to the life of any project which it was to mitigate. Projections made during the HEP analysis indicated that all marsh within the hydrologic unit (as defined by Wicker 1980) containing the mitigation bank area would be converted to open water within 77 years due to erosion, subsidence, and saltwater intrusion. It was assumed that adverse impacts from development actions implemented within that hydrologic unit would not occur beyond that time (i.e., 77 years), as no marsh would remain to be impacted. Accordingly, the interagency group agreed that the life of the mitigation bank should be 77 years. Tenneco's reluctance prevented it from guaranteeing intensive management for longer than 25 years, although it did agree to maintain, at least passively, the integrity of the mitigation bank area for a 77-year period.
2. *Geographic Area of Applicability of Mitigation Benefits (credits).* The HEP analysis was based on projected marsh loss rates within the hydrologic unit containing the mitigation bank area. Therefore, the interagency team agreed to allow credits to be applied as in-kind mitigation for unavoidable habitat losses within that hydrologic unit (an area containing approximately 500,000 acres [202,350 ha] of marsh). It further agreed that any request by Tenneco to apply credits outside that hydrologic unit would be considered on a case-by-case basis, but under no circumstances could credits be applied outside the State of Louisiana.
3. *Selling/Trading Mitigation Credits.* The interagency group concluded that the selling or trading of credits by Tenneco would be a reasonable extension of the mitigation banking concept. However, the acceptability of those credits for mitigating development actions of another party must be ruled on by the interagency group.
4. *Computing Debits for Development Actions.* The interagency group agreed to use HEP, or a mutually agreeable and credible methodology, to compute the debits required for each proposed development action.
5. *Accounting Responsibilities.* Although all crediting to or debiting from the mitigation bank requires the concurrence of all parties to the MOA, the Fish and Wildlife Service agreed to maintain a permanent record of each credit and debit transaction and to provide each participating agency with summary transaction data sheets on an annual basis.
6. *Monitoring the Mitigation Bank.* A preliminary assessment of the mitigation bank will be conducted after one year to evaluate the management program's effectiveness. Operational and/or structural changes can be recommended by the interagency team as appropriate to improve the program; Tenneco will implement those changes to the extent practicable. Five years, and again 25 years after implementation of the mitigation bank, the interagency team will conduct a complete evaluation of the management program and negotiate with Tenneco on the desirability of extending the intensive management period.
7. *Credit Accrual.* The completed HEP analysis provided a measure of the average number of credits (measured in average annual habitat units) that would be

available to Tenneco on an annual basis. The obvious question to follow then was what would become of credits generated one year but not used that same year (i.e., would they accrue to the next year)? The interagency team ruled that accruing unused credits for use in mitigating future actions would not be appropriate as adverse impacts should be mitigated as they occur. In effect, accrual would allow "front-end loading," such that future adverse impacts to fish and wildlife resources would occur without concurrent mitigation.

8. *Number of Credits to be "Banked."* The HEP analysis indicated that the management program would produce credits within the entire 7,000-acre (2,833 ha) mitigation bank area. The total number of credits generated over the entire area was reduced by 30 percent, however, because Tenneco actually owned and controlled only 5,000 acres (2,023 ha) of the 7,000-acre (2,833 ha) mitigation area. That lower number of credits was again reduced by 52/77's (68.5 percent) as protection against the unlikely possibility that Tenneco may abandon the mitigation bank after the first 25-year period of intensive management. Reducing the number of credits usable during the first 25 years of mitigation bank life accommodated the concern of the interagency group that Tenneco might be receiving too many usable credits "up-front." Tenneco accepted the compromise under the condition that this reduced number of credits would be guaranteed even if the management program unexpectedly failed to produce those credits during the first 25 years. This guarantee was granted as a result of the large investment being made by Tenneco to implement, operate, and maintain the management program.
9. *When Credits Can be Used.* Establishment of the mitigation bank was never intended to be a means for Tenneco to secure "carte blanche" approval of all of its development activities in the wetlands of coastal Louisiana. It was heralded by Tenneco officials as a mechanism for reducing the uncertainty associated with obtaining Section 10/404 permits, for obtaining credit for (marsh) management activities implemented by that company, and for integrating the concept of mitigation into future land management options to be considered by Tenneco decision makers. The formal MOA best defines the proper application of credits in a statement which indicates that mitigation by debiting ". . . is appropriate and will be used to offset only unavoidable impacts on fish and wildlife when the applicant can demonstrate to the satisfaction of all parties to this agreement that there are no onsite alternatives which are available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."

The details of the complete analysis of the Tenneco mitigation bank, including a copy of the formal interagency MOA, are contained in a report by Soileau (1984). That report concludes that a voluntary mitigation banking program should be viewed as a viable option for compensating for the unavoidable losses associated with permitted actions, particularly oil-and gas-related and other small industrial developments, in coastal Louisiana. That conclusion is based on the past failures to obtain full mitigation for Section 10/404 permitted activities and on the questionable potential for improving this situation via the Corps of Engineers' present regulatory program. In addition to providing measurable benefits to fish and wildlife resources, mitigation banking affords private landholders and industry with a multitude of tangible benefits which should serve as an incentive to manage further productive but deteriorating coastal wetlands.

The results of recent Fish and Wildlife Service studies have shown that the coastal wetlands of Louisiana are being lost at a rate exceeding 40 square miles (104 km^2) a year. Management efforts by private interests intended to reduce the land loss rate can often be modified to include features to enhance the fish and wildlife habitat value of the area. That enhanced value can be used to fulfill future mitigation needs of the individual or company managing the property or be sold to other individuals or companies needing the mitigation credit. The ability to sell credits allows the land manager to recoup habitat improvement expenditures, and thus may provide extra incentive to initiate or intensify wetlands management programs. Additional monetary benefits from enhanced hunting and trapping leases may also accrue to the landowner.

Policy and Management Considerations

Mitigation banking provides only one method of attaining compensation for unavoidable habitat losses from water resource development projects, and may be applicable only in limited circumstances. In most cases mitigation banking should be limited to use with projects requiring federal and/or state wetlands permits, although it may be adaptable for use with some small federal projects. In any event, mitigation banks should be planned and strictly operated in accordance with applicable federal and state regulations. The following are recommended as the minimum requirements that a development project, involving loss of or damage to wetlands habitat, should meet before mitigation bank credits should be applied:

1. *Public need.* There should be a demonstrated public need for the project, and its expected benefit to the public interest should outweigh foreseeable detrimental impacts on fish and wildlife resources.
2. *Water dependency.* The proposed activity should require access or proximity to or siting in the aquatic environment.
3. *Least damaging alternative.* Practicable alternative locations or construction methods may be available that would have less adverse consequences to wetlands while allowing accomplishment of other project objectives. Only projects incorporating the least damaging alternative should be eligible for use of mitigation bank credits.
4. *Unavoidable impacts.* Use of mitigation bank credits should be allowed only after all other avenues of impact avoidance and minimization have been exhausted.
5. *Onsite mitigation.* Since mitigation banking inherently involves offsite mitigation, mitigation bank credits should be used only when onsite mitigation means are unavailable.

To be successful, a mitigation bank should be organized as simply as possible and be easily understood. Ideally, the bank should be administered via a formal interagency agreement that defines the bank area, habitat improvement measures to be implemented, the crediting and debiting process and methodology, the life of the bank, and provisions for monitoring and reevaluation. This agreement would help to avoid future misunderstandings about the organization, implementation, and operation of the bank. Smooth operation of the bank also is more likely if a central coordinator or manager is designated to be responsible for maintaining the credit/

debit account and for keeping the other participants informed of the status of the bank.

In general, mitigation requirements should be assessed via a credible habitat-based methodology such as HEP, rather than the more conventional user-day analysis or on an acre-for-acre basis. The methodology selected should be technically defensible, applied consistently, and replicable. For credits to be applicable to a development proposal, "in kind" credits from wetland habitat of equal or superior value than that being adversely impacted should be included in the mitigation bank area. Moreover, the credits should have a period of effectiveness equal to or greater than the life of the project impacts. Project impacts that are expected to last longer than a bank agreement may preclude use of mitigation bank credits, although it may be acceptable to include provisions in the bank agreement for reevaluation and renegotiation of credits at the end of the shorter management period. If mitigation requirements have not been fully met by the end of the management period, then additional mitigation could be required.

Establishment of a mitigation bank, including site selection, development of a management program, analysis of credits, and the establishment of guidelines for administration of the bank (e.g., an interagency/industry MOA), can be extremely time consuming. In the case of the Tenneco mitigation bank, the Fish and Wildlife Service expended an estimated one person-year of effort in completing the analysis of credits, coordinating with agency/industry representatives in developing implementation guidelines, and in preparing a formal report to document the effort. Such an expenditure of time and money should be carefully weighed against the expected benefit of the mitigation bank. However, as is the case with most new endeavors, the first effort is likely to be the most time consuming and costly. Much was learned in this initial effort that will certainly allow future efforts to be completed more expeditiously and cost-effectively.

One approach that would reduce the likelihood of wasting valuable staff time and money on the evaluation of a given mitigation banking proposal would be to present a preliminary MOA to the potential participants during initial discussions. If the critical elements of that MOA were deemed unacceptable to one or more of the participating parties, then serious consideration should be given to rejecting the proposal.

Discussion

Fish and wildlife habitat is continuously being destroyed in the United States by water resource projects and other development activities. Some of these habitat losses can be avoided or mitigated. Unfortunately, many attempts to mitigate habitat losses effectively have been controversial, and results have been generally inadequate. Loss of habitat now is the most critical fish and wildlife problem in the United States, and the lessening or replacement of these losses is an absolute necessity.

Mitigation banking provides a mechanism by which fish and wildlife habitat losses associated with certain water resource development projects can be offset, and it is being employed in a number of areas. Table 1 provides data on 11 mitigation banks known to be operational or in planning within six states. This information was obtained by a 1984 Fish and Wildlife Service survey of its Division of Ecological

Table 1. Status of wetland banks in the United States.

Sponsor	Location	Manager	Status	Size	Habitats
Louisiana Department of Transportation and Development	Grant and LaSalle Parishes, Louisiana	Not specified	Active	3,000 acres (1,214 ha)	Forested wetlands (bottomland hardwoods)
Tenneco Oil Company	Terrebonne Parish, Louisiana	Interagency team	Active	5,000 acres (2,023 ha)	Coastal fresh and salt marshes
Virginia Department of Highways and Transportation	Elizabeth River system, Chesapeake, Virginia	Virginia Department of Highways and Transportation	Active	11 acres (4 ha)	Coastal salt marsh
Minnesota Department of Transportation	Minnesota (seven separate areas)	Interagency Team	Active	338 acres (137 ha)	Freshwater wetlands
Bureau of Reclamation	Wasatch and Dechense Counties, Utah	Bureau of Reclamation and Utah Division of Wildlife Resources	Active	9,523 acres (3,854 ha)	Sagebrush, aspen, woodland conifer, forest, pinyon-juniper forest
Port of Long Beach, California	Upper Newport Bay Ecological Reserve, Newport Beach, Orange County, California	Interagency team	Active	29 acres (12 ha)	Subtidal and intertidal mudflats, saltmarsh
Port of Los Angeles, California	San Pedro Bay, Los Angeles County, California	Interagency team	Active	17 acres (7 ha)	Subtidal open water
California Coastal Conservancy[2]	Bracut Marsh Humboldt Bay, Humboldt County, California	California Coastal Conservancy	Active	13 acres (5 ha)	Riparian and upland habitat
Port of Oakland, California	San Francisco Bay Complex, San Mateo and Napa Counties, California	Undetermined	Planning	Undetermined	Coastal seasonal wetlands (diked)
Port of Astoria, Oregon	Clatsop Airport, Astoria, Clatsop County, Oregon	Oregon Division of State Lands	Planning	27 acres (11 ha)	Brackish marsh and uplands
Weyerhaeuser Company	Coos Bay, Coos County, Oregon	Interagency team	Active	420 acres (170 ha)	Fresh and saltwater wetlands

[2]Two additional areas in Humboldt and Sonoma counties involving coastal seasonal wetlands (diked) are under consideration.

Services offices. Ten of the reported mitigation banks involve private, state, or local development interests; only one bank involves a federal development agency (i.e., Bureau of Reclamation). Interestingly, this mitigation bank involves upland habitat, whereas the other ten involve wetland habitats. The survey suggests that local or state public entities, such as port and highway agencies, that have recurring development needs are the most likely candidates for the development of a mitigation bank.

In the past, wetland mitigation efforts have often involved small, site-specific efforts that have resulted in varying levels of success (Fehring 1983). In contrast, mitigation banking can offer an opportunity to plan a number of larger management programs designed to meet mitigation needs, while accomplishing long range goals for improving fish and wildlife habitat. However, this requires that water resource development planners have a thorough understanding of the ecosystem and be able to identify correctly and articulate long range needs and goals. Extreme care should be exercised to insure that only benefits generated from actions taken expressly for mitigative purposes be credited to a bank; fish and wildlife resource benefits generated incidental to normal land management practices should not be considered for crediting as mitigation.

Mitigation banking provides several benefits and advantages to planners, regulators, and developers. It is an early planning measure that puts mitigation up-front, minimizing developer/regulator conflicts while providing financial and time savings. It can also provide a landowner with public credit and recognition for wetland management actions undertaken, while providing a means to satisfy mitigation requirements. An opportunity to sell or trade mitigation banking credits affords mitigation bankers an opportunity to recoup expenditures associated with habitat improvement and, accordingly, may serve as extra incentive to initiate or intensify wetlands management programs.

Substantial risks also are associated with mitigation banking. A major risk involves the possibility of neglecting good project planning and resorting to the use of banked credits before all means of avoiding or minimizing impacts have been exhausted. Moreover, developers may view mitigation banking as a mechanism for guaranteeing blanket approval of all future permit applications. On the contrary, mitigation banking should never be used as a substitute for adequate project planning to avoid or reduce impacts to fish and wildlife resources. Consequently, mitigation banks must be carefully planned and operated in a manner that will avoid such potential problems.

Literature Cited

Bean, M. J. 1978. The Federal role in wetland protection: an overview. Pages 103-107 *in* Proc. national wetland protection symposium. FWS/OBS-78/97. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. 103 pp.

Fehring, W. K. 1983. Ports, industry, and fisheries—can they coexist. Pages 30-38 *in* J. W. Reintjes, ed. Improving multiple use of coastal and marine resources. Amer. Fish. Soc., Bethesda, Md.

Gagliano, S. M., and J. L. van Beek. 1970. Hydrologic and geologic studies of coastal Louisiana. Geologic and geomorphic aspects of deltaic processes, Mississippi Delta System. Vol. 1. Coastal Studies Institute and Dept. of Marine Sciences, Louisiana State University, Baton Rouge, La.

Rappoport, A. 1979. The mitigation problem: a background review for the mitigation symposium. Pages 1-5 *in* G. A. Swanson, tech. coord. The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats. General Technical Report RM-65. Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, Fort Collins, Colorado.

Soileau, D. M. 1984. Final report on the Tenneco LaTerre Corporation mitigation banking proposal, Terrebonne Parish, Louisiana. U.S. Fish and Wildlife Service, Lafayette, La. 23 pp. plus appendices.

U.S. Fish and Wildlife Service. 1981. U.S.Fish and Wildlife Service mitigation policy; notice of final policy. Federal Register, 456(15): 7644-7663.

______. 1983. Interim guidance on mitigation banking. ES Instructional Memorandum No. 80. Division of Ecological Services, Washington D.C. 5 pp.

Wicker, K. M. 1980. Mississippi Deltaic Plain Region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. FWS/OBS-79/07. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. 45 pp.

Mitigation by "Banking" Credits: A Louisiana Pilot Project

Michael D. Zagata
Industrial Ecology Department
Tenneco Inc., Houston, Texas

Background

There are different criteria for measuring resource values. They may be measured in economics terms, in aesthetic terms, or in ecological terms. Generally, market place or commodity values are measured in economic terms and are set through the private sector. Other values are often set and/or protected by government through laws and regulations.

To date, the wildlife profession has focused mainly on government controls to broaden its impact in protecting non-commodity values. This often resulted in placing the private sector, with one criteria for measuring value, at odds with the public sector. All too frequently the results have been polarization and diminished resource protection.

If the public sector is going to be successful in attracting the participation of the private sector in the conservation of public values, it must be willing to incorporate economic considerations into its programs. One way to do this is to offer incentives that will save time and money while still affording protection to resources with public value, i.e., wetlands. This paper is about one attempt to accomplish that goal by demonstrating that industry and government can work together in designing a program that will afford increased habitat protection while simultaneously providing an incentive to a permit applicant.

Legislation

The Fish and Wildlife Coordination Act (FWCA) and the Clean Water Act (CWA) provide for the adverse ecological impact of a development project to be mitigated by the developing agency or individual. The Endangered Species Act (ESA), in certain cases, may also provide for impact mitigation. The "banking" concept offers a unique approach to satisfying those mitigation requirements.

As an example, Section 404 of the CWA provides protection for the Nation's navigable waters (the definition of navigable waters has been interpreted by the courts to include virtually all wetlands). That protection is provided by requiring a permit for dredge and fill operations in navigable waters, including most wetlands.

The Environmental Protection Agency (EPA) is charged with administering the program, and operational responsibility is vested with the U.S. Army Corps of Engineers (COE). The Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NMFS), and state wildlife and fish agencies, under the aegis of the Fish and Wildlife Coordination Act, have the responsibility to comment on the potential impact of a dredge and fill operation on wildlife habitat. They may recommend approval, denial, and/or certain measures to mitigate adverse impacts.

Mitigation

Mitigation is a term used to describe actions which are intended to offset adverse impacts of a project on the functional aspects of ecosystems, including wildlife habitat. It may involve requiring the permittee to set aside and/or enhance habitat of a similar type. This is often done by a fee title transfer of land from private to public owndership. The land is then managed by a state or federal wildlife agency for the benefit of wildlife.

The Council on Environmental Quality (1981) provided that the definition for mitigation include:

> (a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments. (40 CFR Part 1508.20(a-e)).

The FWS has adopted this definition of mitigation and considers the specific elements to represent the desirable sequence of steps in the mitigation planning process (40 CFR Part 1508.20(a-e)).

Because of the provision for mitigation, Section 404 of the CWA has been the source of controversy between the regulating agencies and permit applicants. This is due in part to the fact that the consideration of the need to mitigate comes at the end, rather than the beginning, of the permit process (mitigation is permitted only after other alternatives have been examined). Thus it is often perceived as an additional source of delay. Because time is money, this often places developers, generally with a desire to comply with the law, in the position of appearing to be callous toward the need to protect wetlands. Indeed, the following generic problems relate to the administration of the mitigation provision of Section 404, but do not discredit the need to mitigate:

1. mitigation is an add-on-cost, and comes after the proposed project's normal budgeting and planning process;
2. mitigation may cause a delay in obtaining permits and therefore is often perceived as blackmail;
3. mitigation is a discrete action and is not integrated into overall land management scheme and therefore may not be ecologically effective;
4. mitigation may be off-site and therefore of no direct benefit to the landowner (applicant) who pays for it; and
5. mitigation may result in loss of title to the property involved.

Historically, the amount of mitigation required to offset damage has been a qualitative judgment. However, the FWS and others have been developing more quantitative methodologies for making such decisions. One of those methodologies is the Habitat Evaluation Procedures (HEP) (Schamberger and Krohn 1982). It allows one to determine the *adverse* and *positive* impacts of a perturbation on a given habitat, be it for one or more species. The unit of measure of HEP is habitat units (HU), a number obtained by multiplying the number of affected acres times the habitat suitability index (HSI) (zero to 1.0) for the affected species.

For example, the HEP process can be used to determine the impact of two theoretical actions on a given wetland of *100 acres* (40 ha) with a habitat suitability index of *0.8* (0.0 is the poorest and 1.0 is the best). At time zero there are 80 habitat units present (100 x 0.8). If an action is taken that totally destroys 50 acres (20 ha) or reduces the HSI from 0.8 to 0.4 for all 100 acres then 40 HU's would be lost for some period of time.

The period of time is dependent upon the duration of the impact and the ecological factors which affect recovery time (moisture, length of growing season, etc.). To offset this loss of 40 HU's, some form of mitigation would be required which would either enhance, or maintain through management, the remaining habitat. It may be possible to substitute an area of equal habitat value. The intent of the mitigation is to restore the 40 HU's lost to the adverse impact.

The same principle can be applied where the goal is to maintain a habitat type that may be lost via succession or subsidence. Although there may appear to be no net loss or gain of HU's, the management objective was attained. For example, if the rate of wetland subsidence can be reduced from 6 percent to 4 percent per year the wetlands would benefit.

Thus, actions to maintain a given habitat would result in that habitat being kept at the level of productivity it was at time 0 (when the maintenance program was initiated). If the wetland has an HSI of 0.6 today, it would have an HSI of 0.6 as long as the maintenance program was in effect.

Actions to enhance a habitat would result in that habitat being made more productive than it was at time 0. If the wetland had an HSI of 0.6 today it would be raised to an HSI greater than 0.6 and then kept at the higher level through maintenance (management).

Enhancement actions could be used to return degraded areas to "normal" levels for a given ecosystem by accelerating the rate of restoration (e.g., via intensive management).

Banking of Habitat Units—An Opportunity for Industry and Wildlife

Because the HEP process can be used to measure gains as well as losses in habitat, it offers us a unique opportunity to expedite the mitigation process by crediting a permitee with HU's gained through a management program. This has the potential to save money for permittees while affording protection and often enhancement for wetland habitats.

The mitigation banking process is an opportunity for a potential developer to cooperate with state and federal regulatory agencies in implementing a management program on land the developer owns, or that is set aside for its wildlife values. As a result of this management program, the developer would be given credits in the forms of HU's. They would be deposited in a "mitigation bank" to be partially used at some later date to offset mitigation requirements. Credits could be given for maintenance and/or enhancement programs (Figure 1).

The "bank" would be established in advance of a permit application and thus would have the effect of placing mitigation up front in the permit process. Current practice places mitigation at the end of the process (Figure 2). Because the bank is established before a permit is applied for, such a program is not under the normal

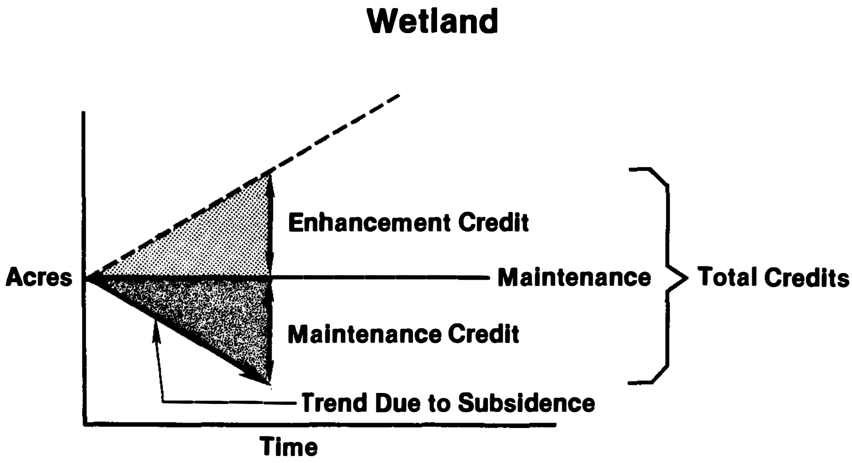


Figure 1. Basis for habitat units of credit for a mitigation bank in a coastal marsh undergoing subsidence.

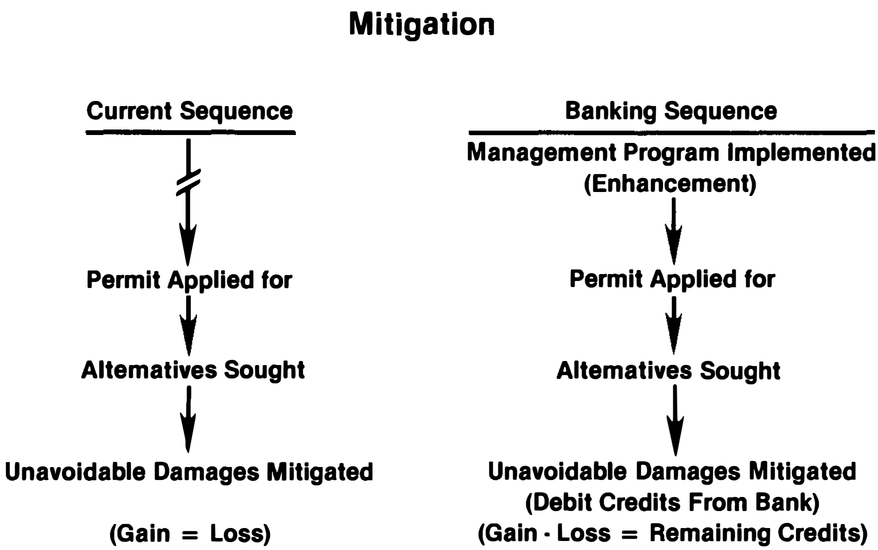


Figure 2. Comparison of the current mitigation sequence with the sequence that would occur under a banking program.

time pressure imposed on the applicant and the agencies. Thus, it would provide for an opportunity for the agencies and developer to work together in developing a project that is integrated into an overall land management program.

The ecological benefit per dollar of investment (management program) will be, in many cases, greater with the banking program versus normal mitigation. In general, permit applicants are seeking a permit for a small project (i.e., less than 10 acres [4ha]). It is very expensive, on a benefit-per-acre, per dollar-spent-basis, to mitigate for these projects. However, the cost per acre drops markedly when a large project is undertaken and thus the ecological benefit per dollar spent increases.

Incentives to Industry

The HU's that are credited and deposited in the "bank" can be used by a bankee in numerous ways. They can be used to expedite permits and therefore save money. An applicant with banked credits could use those credits as collateral or as a bond to insure good faith compliance with a permit stipulation. The details of mitigation will be worked out after a permit is granted rather than standing as a hurdle to the issuance of the permit. The applicant could later cash in part of his credits to meet the mitigation requirement or perform some other form of on-site mitigation.

The "bank" could allow a lessee to operate on the land of an entity that had a bank. That entity could sell (transfer) credits to the lessee, thus enabling the lessee to fulfill his mitigation requirements while permitting the holder of the credits to recover part of the cost of establishing those credits (HU's). Consider a case where a company owns land for energy production. It may allow a lessee to come in and drill. That lessee may not get a 404 permit unless he can purchase land off the site for mitigation . Drilling could be expedited and/or conducted if the lessee could obtain credits for work done in advance of the permit application which would satisfy the mitigation requirement stipulated in the permit.

Major land holders could exchange credits to facilitate operations in frontier areas where they have no holdings or credits. For example, Company X owns land and has credits in Alaska and Company Y owns land and has credits in Louisiana. Company Y decides to undertake a project in Alaska but is hampered by the mitigation requirement. Company Y could either buy Alaska credits from Company X, or exchange Louisiana credits for Company X's Alaska HU's. The credits could only be applied with concurrence of the appropriate agencies in the state where they were generated and could only be used to offset impacts in the same type of habitat where they were produced.

The mitigation banking process affords an opportunity to integrate mitigation actions into land management program and thus internalize mitigation as a cost of doing business. By putting mitigation up front in the mitigation process, it will allow one to plan expenditures and therefore be in a better position to budget money for wetland management. In the past, the level of funding for mitigation was determined by the number of permits applied for and the extent of mitigation per permit. This made it difficult for private land managers to obtain funds for large scale management projects other than those required for mitigation. The banking process will encourage the implementation of intensive management programs on lands needing to be managed because the funding level needed for a given year will be known in advance.

Intensive management can be in the landowner's best interest. For example, in coastal Louisiana, wetlands are being lost at a rate of 25,000 acres (10,120ha) per year (Fruge 1982). Indeed, landowners run the risk of losing title to subsurface minerals once the land becomes inundated.

Mitigation banking can foster cooperation between industry and state and federal agencies charged with protecting wetlands. Participants will gain mitigation credits while enhancing their land. For example, the COE is considering a program to create wetlands from their dredge spoil. If the spoil were place on wetlands to enhance the wetland, the owner could gain credits and delay subsidence thereby retaining title to the minerals and obtaining mitigation credits.

Mitigation banking works when it is in both parties' interest. Banking benefits the applicant by the management practices being applied to his land and from the banking credits.The public benefits from the increased level of management and protection being afforded the private sector wetlands.

Benefits to Wildlife Habitat

The incentives for industry to maintain and enhance wetlands for the purpose of obtaining credits will benefit wildlife habitat. The number of credits in the bank is a reflection of the benefit to habitat. Those credits are counted annually and, as long as they exceed 1, wildlife benefits. The interest on those credits results in a benefit to wildlife through habitat maintenance/enhancement. Because of the economies of scale, the large projects used to establish a bank will result in more benefit to wildlife per dollar spent than would the smaller, discrete projects done to satisfy a permit condition.

Mitigation banking is an approach that provides a carrot rather than a stick. By encouraging the landowner to undertake management programs well in advance of actions requiring a permit, the public values associated with wetland will be given increased protection.

Proposed Administrative Procedures

The mitigation "banking" program can be used to satisfy mitigation requirements under Section 404 of the CWA. Its administration is patterned after the banking program implemented by the EPA via the Clean Air Act. However, in the case of mitigation "banking" the FWS will serve as the banker. An agreement or a contract is needed to stipulate the terms of the "banking" arrangement and must be agreed to by the banker and bankee. Once the "banking" conditions are formalized, mitigation credits could be added to or deleted from the bankee's account.

The exchange commodity is an HU. The bankee will be given credit for the number of HU's developed, or debited for the number of HU's lost due to a project's impact. The credits or debits will be made via the HEP process as administered by the FWS or NMFS in consulation with the developer.

Tenneco LaTerre—A Pilot Project

In January of 1984 the final signature was applied to a Memorandum of Agreement (MOA) between Tenneco Oil Exploration and Production (TOE&P) and the

FWS, NMFS, Soil Conservation Service (SCS), Louisiana Department of Fish and Wildlife (LDFW), and the Coastal Management Section of the Louisiana Department of Natural Resources (CMS). It contains 18 provisions that spell out how the bank is to be administered and what the responsibilities of the signatories are.

According to the MOA, Tenneco will install and maintain for at least 25 years a system of weirs, dikes, and mud dams to maintain and enhance 7,200 acres (2,914 ha) of wetlands, 5,000 acres (2,023 ha) of which are within Tenneco's LaTerre property. There were no immediate plans for development of sub-surface minerals within the tract. The expected life of the area without the program is 77 years.

As a result, TOE&P will generate 11.9 million HU's on 7,200 acres (Soileau 1984). Of these, they will receive 8.4 million HU's for the 5,000 acres they own. Thus there will be an initial benefit to the public of 3.8 million HU's.

The total number of expected HU's (8.4 million) was divided by 77 (the expected life of the marsh without the project) resulting in 108,000 average annual habitat units (AAHU) in category 2 wetlands. Tenneco, based on the expected life of the management structures, agreed to maintain the project for 25 years. At year 25, the agencies and TOE&P will re-evaluate the project. Because of the agencies' need to protect the public's values in perpetuity, they reduced the number of available credits by the fraction 25 over 77. The result was that TOE&P would be allowed to use a total of 35,000 AAHU's over the first 25 years of the bank (Figure 3). If credits are not used in a given year they are lost (are not cumulative) and once credits are used they are deducted from each subsequent year (Figure 4).

There were about 73,500 credits withheld in each year of the first 25 years (108,733 produced—35,300 available). Thus 1.8 million AAHU's were withheld. If this, the worst case scenario, is assumed and calculations are based on the expectation that Tenneco will abandon the project after year 25, then this withholding can be justified as an effort to mitigate in years 26 through 77 (52 years) for impacts

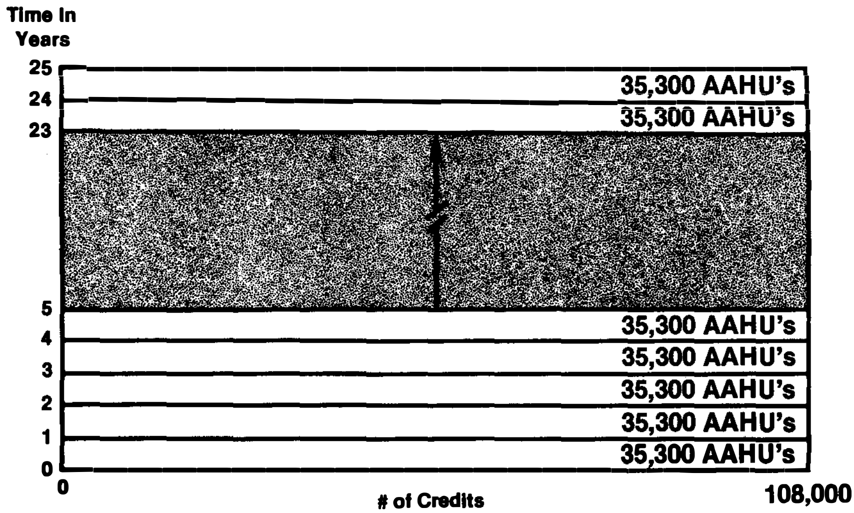


Figure 3. Available average annual habitat units.

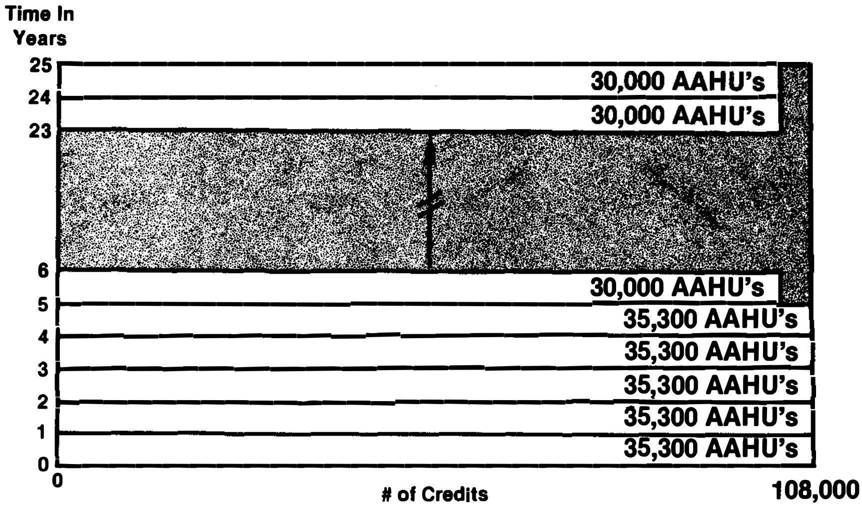


Figure 4. Impact on the bank of a project started after 5 years and requiring 5,300 habitat units for mitigation.

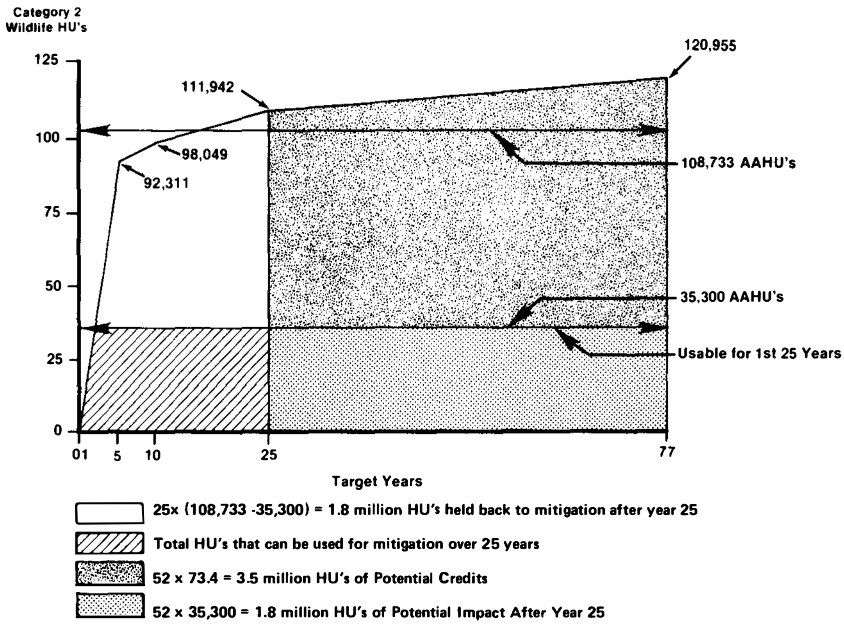


Figure 5. Mitigation banking allows for mitigation in perpetuity while meeting immediate mitigation needs via habitat units of credit.

caused in years 1 through 25. Indeed the calculations in Figure 5 show this to be true (52 x 35,300 = 1.8 million) (Soileau, 1984 pers. comm.). In fact, there will be about 3.5 million AAHU's available for use in years 26 through 77.

The typical oil and gas permit is stated as being for a canal 1,200 feet (366m) long and 70 feet (21m) wide with a drill slip at the end having 345 feet (105m) by 160 feet (49m) dimensions (Soileau 1984). Based on the conditions found in the LaTerre study, such a canal would require 435 wildlife and 452 fishery HU's for mitigation. Thus, based upon the typical permit, TOE&P would receive enough credits, in the most restrictive sense, to mitigate damage to fish and wildlife from about 100 canals in category 2 wetlands. Based on experience since acquiring the property, it is not likely that 100 canals will be permitted over 25 years. However, if they were and, assuming the worst case scenario that the project was abandoned after 25 years, the expected life of the wetlands would still be extended (Figure 6) (Soileau, 1984 pers. comm.).

According to the MOA,

> Mitigation by debiting available AAHU's from the mitigation bank is appropriate and will be used to offset only unavoidable impacts on fish and wildlife when the applicant can demonstrate to the satisfaction of all parties to the MOA that there are no on-site alternatives which are available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes.

Thus, it should appear evident that the program is in no way intended to circumvent the regulatory process. The application of credits was restricted to

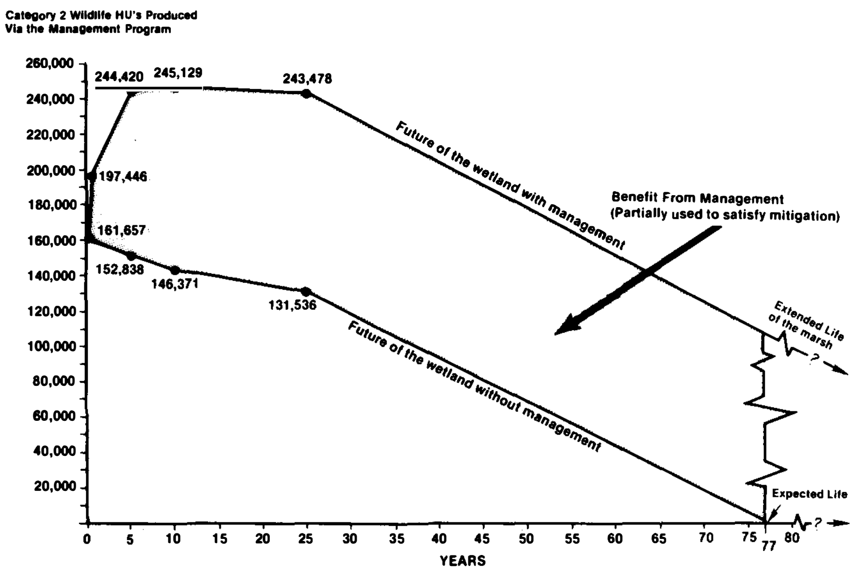


Figure 6. Impact of the mitigation banking project at LaTerre on the expected life of the wetland.

Louisiana wetlands in hydrologic unit 5 and a penalty is attached to projects in the 5,000 acre (2,023 ha) management area.

The banking approach to mitigation puts mitigation up front in the permit process and thereby reduces the delay historically associated with this facet of the Section 404 permit process.

Summary

We live in an economy influenced by both marketplace forces and government regulation. Because of the non-commodity values often associated with resources with commodity or economic value, the two influences often appear to be at odds. The minerals underlying Louisiana's wetlands have commodity value, while the wetlands themselves have both commodity and non-commodity values. To develop the mineral resources, a permit which attempts to protect the public values must be obtained. Mitigation may be a condition of that permit and, if it is, the applicant may be forced to experience costly delay and the mitigation agreed upon may not be cost effective. The banking program will reduce delay associated with obtaining a permit and allow the bankee to budget for and implement large-scale management programs in cooperation with state and federal fish and wildlife agencies. As a result of this pilot project, Tenneco expects to maintain its property and mineral rights by reducing the rate of subsidence, to bank enough credits to offset the mitigation requirements for more permits than we expect to apply for, and to expedite the permit process by reducing the delay associated with the mitigation process. Based upon the Tenneco pilot project, the process should maintain and/or enhance the wetland base and expedite the conduct of business in wetland areas.

The wildlife profession has the necessary expertise to identify innovative approaches to regulatory compliance from an ecological standpoint. The business community has the necessary economic skills. The two should work together to meld their mutual intrests and expertise into creative programs that will be of benefit to both the public and private sector. Only when this is done will we have truly effective regulation.

Literature Cited

Council on Environmental Quality. January 23, 1981. U.S. Fish and Wildlife Service Mitigation Policy. Federal Register 46:15:7644-7663.

Fruge, D. W. 1982. Effects of wetland deterioration on the fish and wildlife resources of coastal Louisiana. Pages 99-107 *in* D. F. Boesch, ed. Proceedings of the Conference on coastal erosion and wetland modification in Louisiana: causes, consequences, and options. FWS/OBS-82/59. U.S. Fish and Wildlife Service.

Schamberger, M., and W. B. Krohn. 1982. Status of the habitat evaluation procedures. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 47:154-164.

Soileau, D. M. 1984. Final report on the Tenneco LaTerre Corporation mitigation banking proposal, Terrebonne Parish, Louisiana. U.S. Fish and Wildlife Service, Lafayette, LA. 23pp.

U.S. Fish and Wildlife Service. January 23, 1981. U.S. Fish and Wildlife Service Mitigation Policy. Federal Register 46:15:7644-7663.

National Wetlands Functions and Values Study Plan

Ellis J. Clairain, Jr.
U.S. Army Engineer Waterways Experiment Station
P.O. Box 631, Vicksburg, Mississippi 39180-0631

Introduction

Wetlands have many valuable functions, including fish and wildlife habitat, flood storage and desynchronization, nutrient and heavy metal immobilization, groundwater recharge/discharge, sediment retention, shoreline anchoring, silviculture, and aesthetics. However, not all wetlands provide the same functions, and the importance of functions differs both within and among wetland types and geographic regions of the Nation. Some wetlands have well-documented and critical functions; others have poorly understood or less important functions.

The varying degree of understanding of how wetlands function is a major reason for the lack of comprehensive assessment techniques. Procedures have been developed to address specific regions of the Nation (Golet 1973, Gupta and Foster 1973, Larson 1976) or to assess particular functions (U.S. Fish and Wildlife Service 1980, U.S. Army Engineer Division, Lower Mississippi Valley 1980), but no single assessment procedure exists to quantify accurately all functions attributed to wetlands. A technique recently developed by the Federal Highway Administration (FHWA), however, provides an excellent framework for wetlands assessment (Adamus 1983).

The Corps of Engineers (CE) has recognized the need for a standard technique that can be used to reliably assess and quantify wetlands values throughout the Nation. Responsibility for developing an assessment technique has been assigned to the U.S. Army Engineer Waterways Experiment Station (WES). The FHWA technique has been tentatively adopted by WES as the basis for a wetlands functions and values assessment procedure.

The objective of this paper is to present a study plan for developing a national wetlands assessment technique. The study plan (Clairain et al. 1985) was developed after three years of problem identification and analysis and balances CE wetlands information needs with weaknesses in the technical literature to produce a systematic framework for development of the technique.

Study Plan Development

The general approach to developing the study plan was to select an existing assessment procedure to serve as a basic framework, modify the selected technique as necessary, identify research that would strengthen and refine the technical validity of the selected technique, and develop effective information transfer methods. Coordination with other agencies having similar interests and needs was sought throughout development of this approach to ensure broadest acceptance and application of the resulting technique. A series of interrelated steps were identified to accomplish the general approach. These steps are illustrated in Figure 1 and described below.

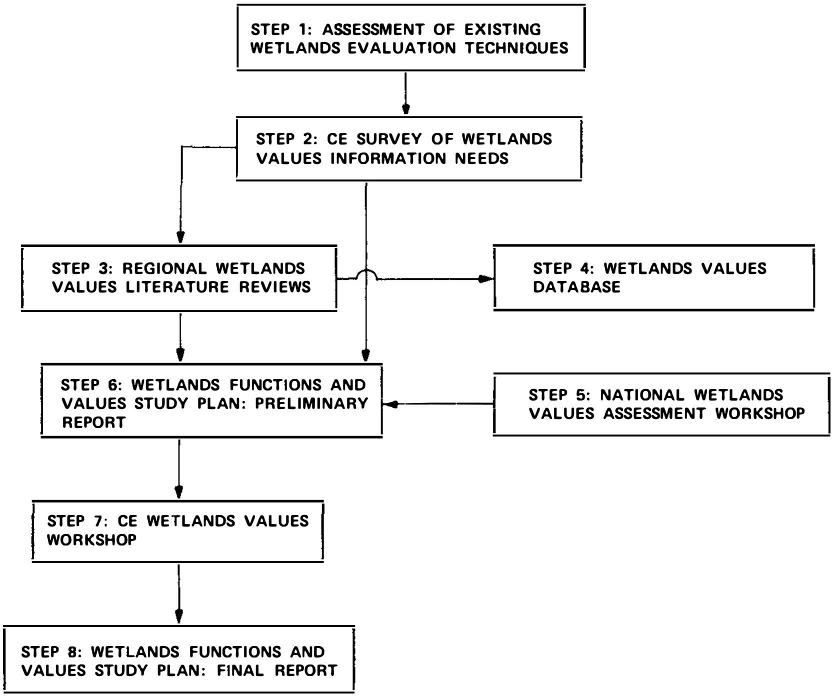


Figure 1. Development of wetlands functions and values study plan.

Step 1. Assessment of Existing Wetlands Evaluation Techniques

In 1981 forty wetlands evaluation techniques were examined to determine their advantages and disadvantages (Lonard et al. 1984). No single technique was found to provide an adequate framework upon which to develop a method responsive to CE needs. Therefore, a survey of CE Districts was conducted to determine the published or unpublished wetland evaluation techniques being used by CE personnel.

Step 2. CE Survey of Wetlands Values Information Needs

Thirty-seven CE Districts were surveyed to determine currently used assessment techniques. Information concerning wetland types receiving greatest developmental pressures, research priorities, and user needs was also sought (Forsythe et al. 1983). Results indicated that District personnel generally do not use formal wetlands assessment methods, but rely primarily on professional judgment. Wetland types receiving most intense developmental pressures nationally included bottomland hardwoods, freshwater marshes, swamps[1], and estuarine marshes. Wetland functions identified as highest national research priorities were food chain production,

[1]Colloquial wetland names were used in the survey and are therefore used in this report. The author, however, recognizes the similarity between bottomland hardwoods and swamps.

heavy metal immobilization, nutrient uptake, groundwater recharge/discharge, flood storage and desynchronization, reduction of suspended solids, aquatic habitat, and erosion abatement. CE District personnel identified flexibility, scientific validity, regional applicability, and acceptability by the CE and other agencies as desirable characteristics of a wetlands evaluation technique. Regionalized summaries of wetlands values information, together with a mechanism for rapid retrieval, were other important needs identified.

Step 3. Regional Wetlands Values Literature Reviews

Literature on wetlands functions was analyzed by region (Figure 2) according to four broad categories: water quality (Nixon and Lee 1985), fish and wildlife habitat (Bane et al. 1985), socioeconomics (Shabman and Batie 1985), and hydrology (Jones et al. In prep). The socioeconomic literature was not summarized by region due to limited region-specific information. Regional summaries of other wetlands literature were prepared. Each literature review examined the quantity and quality of available information, and the information was synthesized by wetland type and specific function or value for each region. Recommendations for additional research to address identified data gaps were also provided.

Step 4. Wetlands Values Database

A mechanism for rapid retrieval of published wetlands values information, as requested in the survey responses, has been developed. The U.S. Fish and Wildlife Service (FWS), CE, and U.S. Environmental Protection Agency are jointly developing a computerized literature retrieval system that can select articles by various categories (e.g., author, location, wetland type, CE District or Division, and

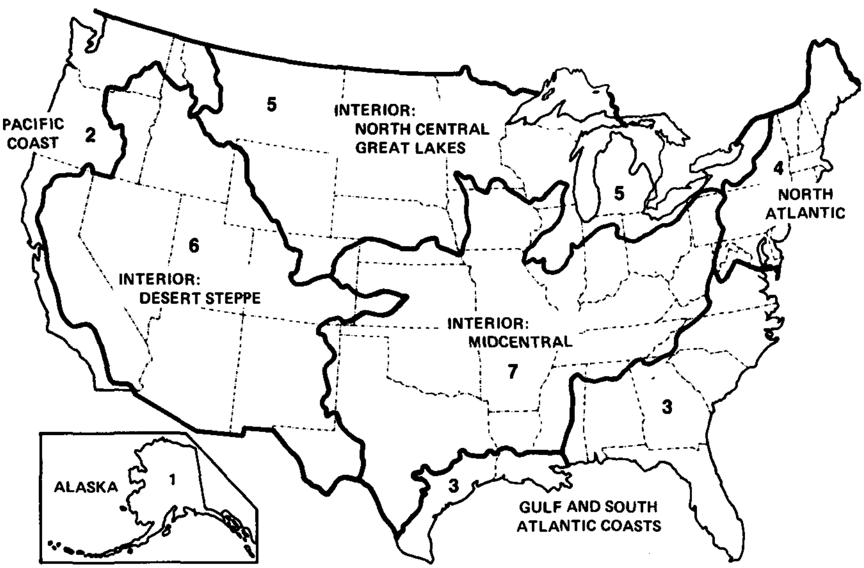


Figure 2. Regions for wetlands values research.

wetlands functions or value) and provide a complete citation and abstract of each article. The database, which presently contains about 4,000 articles, is being expanded toward a goal of more than 7,000 articles.

Step 5. National Wetlands Values Assessment Workshop

After the CE survey was completed, a new wetland assessment technique was published (Adamus 1983) by the Federal Highway Administration (FHWA). The technique was recognized by the CE and other federal and state agencies as having potential merit. A workshop, hosted by the FWS and cosponsored by 16 other agencies, was held in 1983 for critical review of the FHWA technique and to provide recommendations for revisions and needed research. The technique was thoroughly examined by panels of experts on wetlands hydrology, food chain production, water quality, fish and wildlife habitat, socioeconomics, and wetlands assessment methodologies (Sather and Stuber 1984). Workshop results indicated that the FHWA technique required structural modifications and was constrained by serious gaps in information known about certain functions. However, the conceptual basis of the technique was considered to be sound, and the technique was thought to be the most comprehensive and thorough assessment method presently available, particularly for habitat functions.

Step 6. Wetlands Functions and Values Study Plan: Preliminary Report

Subsequently the WES developed a draft study plan that identified regional research needs by integrating information derived from Steps 1-5 and other information sources (e.g., distribution of CE permitting activities and national or regional symposia and workshops). To provide the broadest research scope, research needs were identified for each of the seven regions (Figure 2), regardless of potential overlap between regions or wetland types or potential funding requirements.

Step 7. CE Wetland Values Workshop

A CE workshop was held in 1983 to review the preliminary study plan and address the following questions: "Are regional research priorities identified by the WES an accurate indication of research needs? If not, what should be the regional research priorities, and why?" The workshop was attended by representatives from 41 CE elements and several other federal agencies. Workshop participants were divided into regional working panels to provide an effective atmosphere for expression of ideas. Workshop panels developed specific recommendations for regional needs, which were used to establish national research priorities.

Step 8. Wetlands Functions and Values Study Plan: Final Report

Steps 1-7 provided background information for development of the final study plan. This plan (Clairain et al. 1985) presents recommendations for development of a technically sound wetland assessment technique. A national research approach is also provided to address priority needs. Emphasis will be placed on research that will strengthen and refine the FHWA technique.

Implementation of the Study Plan

The study plan is currently being implemented as part of the Wetlands Research Program at WES. Three separate but interrelated tasks necessary to develop the wetland assessment technique are being addressed. One task involves structural modification of the FHWA technique. A second task involves implementation of research to improve the scientific validity of the technique. The third task is to develop mechanisms for technology transfer and coordination of research efforts with other federal and state agencies. A summary of activities currently underway or planned in each task is presented in the following paragraphs.

Structural Modification of the FHWA Technique

A major weakness of the FHWA technique is its structural organization. Refinement, modification, and improvement are necessary before the technique is ready for field use. Principal among the requirements are the need for literature updating, computerization, addition of a mechanism for sensitivity analysis, regionalization, and field testing.

Literature updating. The FHWA technique presently incorporates data available through 1981 (Adamus and Stockwell 1983). Updating of the literature is underway to improve the validity of the technique within constraints imposed by the literature.

Computerization. The technique currently must be implemented manually, which is both cumbersome and time consuming. Development of computer software will essentially eliminate this undesirable characteristic; a program is being developed to reduce the time for data analysis from several hours to a few minutes. The program is designed for use on microcomputers and is written in dBase II.[2] An initial version of the computer program is being reviewed. The computer program should be available in 1986, and subsequent revisions are scheduled annually through 1990 as research results and user needs dictate.

Sensitivity analysis.. The FHWA technique provides the user with a high, moderate, or low probability that a wetland performs a particular function. However, it does not provide any level of confidence in the assigned values. The sensitivity analysis will provide information that, when incorporated into the computer program, will reflect a level of confidence in the conclusions. Development of the sensitivity analysis will begin in 1985.

Regionalization. Regionalization of the FHWA technique will simplify the procedure, improve reliability of conclusions, and incorporate red-flag features. A screening feature will be incorporated to eliminate inapplicable and unnecessary procedures (e.g., when analyzing a North Dakota wetland, questions related to tidal systems will be electronically excluded), thus reducing both the complexity of the system and the time required to perform an assessment. The red-flag feature will allow users to focus on wetlands values of critical significance such as the presence of endangered species. Regionalization of the technique will proceed as research results are obtained.

Field testing. Field tests will be conducted for a variety of wetland types and situations, and results will be used to revise the evaluation technique. Field testing and revision will be an iterative process to ensure a current, technically sound system.

[2]Use of trade names does not constitute an official endorsement of a product.

National Wetlands Research Priorities

The FHWA technique is based on available literature and, therefore, is constrained by the knowledge of how wetlands function. Research is necessary to ensure the technical validity of conclusions resulting from application of the technique.

*Criteria for establishing priorities.*Three criteria were used to identify national wetlands functions and values research priorities:

- Wetlands widely distributed in one or more regions (highest priority).
- Wetland types receiving intense developmental pressure.
- Wetland types and functions having critical data gaps.

Primary sources of information used for establishing the criteria included the CE survey, CE workshop, and literature reviews. Less, but significant, emphasis was placed on results of a national analysis of wetlands distribution (Frayer et al. 1983), the National Wetlands Values Assessment Workshop (Sather and Stuber 1984), and other national and regional workshops and symposia.

Priority research. The CE national research priorities are presented in Table 1 by wetland type and function, arranged in descending order of priority. Other region-specific research needs are presented in Table 2, but no attempt was made to prioritize regional needs. Region-specific research needs are listed for each region depicted in Figure 2.

Table 1. National wetlands functions and values research priorities.

Priority	Wetland type (region) and kind of study[a]
1.	Bottomland hardwoods (Gulf and South Atlantic Coasts and Interior: Mid-central regions). Special study: synthesis study of hydrologic functions.
2.	Bottomland hardwoods, including swamps (Gulf and South Atlantic Coasts and Interior: Midcentral regions). Holistic study.
3.	Freshwater marshes (Interior: North Central-Great Lakes Region). Holistic study.
4.	Estuarine marshes (North Atlantic Region). Special study: synthesis study of groundwater recharge/discharge.
5.	Swamps (North Atlantic Region). Special study: synthesis study of groundwater recharge/discharge.
6.	Estuarine marshes (Pacific Coast Region). Holistic study.
7.	Swamps (North Atlantic Region). Holistic study.
8.	Riparian forests (Interior: Desert Steppe Region). Function-specific study: assessment of winter habitat for big game species.
9.	Tundra (Alaska Region). Holistic study.
10.	Pocosins (Gulf and South Atlantic Coasts Region). Function-specific study: assessment of hydrology and water quality functions.
11.	Freshwater tidal marshes and swamps (Gulf and South Atlantic Coasts and North Atlantic Regions). Function-specific study: assessment of spawning and nursery habitat for aquatic biota.
12.	Prairie potholes (Interior: North Central-Great Lakes Region). Function-specific study: assessment of hydrology and water quality functions.
13.	Altered wetlands (Pacific Coast Region). Special study: assessment of altered hydrology, water quality, and fish and wildlife habitat functions.

[a]Socioeconomic studies will be conducted for all implemented research priorities as investigated functions are better understood. Both monetary and nonmonetary value assessments will be investigated.

Table 2. Regional research needs.

Region	Research area
1-Alaska	Bogs
	Habitat for migratory waterfowl
	Estuarine marshes
	Food chain production
	Spawning and nursery habitat for aquatic biota
2-Pacific Coast	Freshwater marshes
	Groundwater recharge/discharge
	Flood storage and desynchronization
	Sediment retention
	Nutrient uptake
	Heavy metal immobilization
	Food chain production
	Wildlife habitat
	Spawning and nursery habitat for aquatic biota
	Riparian forests
	Flood storage and desynchronization
	Sediment retention
3-Gulf and South Atlantic Coasts	Freshwater marshes
	Groundwater recharge/discharge
	Flood storage and desynchronization
	Nutrient uptake
	Heavy metal immobilization
	Food chain production
	Spawning and nursery habitat for aquatic biota
	Estuarine marshes
	Shoreline anchoring and erosion abatement
4-North Atlantic	Freshwater marshes
	Sediment retention
	Shoreline anchoring and erosion abatement
	Nutrient uptake
	Heavy metal immobilization
	Food chain production
	Spawning and nursury habitat for aquatic biota
5-Interior: North Central-Great Lakes	None
6-Interior: Desert Steppe	Freshwater marshes
	Groundwater recharge/discharge
	Flood storage and desynchronization
	Sediment retention
	Shoreline anchoring and erosion abatement
	Nutrient uptake
	Heavy metal immobilization
	Wintering waterfowl habitat
7-Interior: Midcentral	None

Types of research studies. In addition to identifying the wetland types and functions requiring additional research, four types of needed studies were identified: holistic studies, function-specific studies, special studies, and socioeconomic studies.

Holistic studies will consist of comprehensive long-term research efforts that examine several interrelated wetlands functions at representative sites in priority wetland types (Table 1). Such studies will be conducted by interdisciplinary teams for a sufficient period to (1) assess the ability of the wetland types to perform each priority function and identify diagnostic characteristics for each function and (2) quantify, where possible, the degree to which the wetland type performs each function. Holistic studies are necessary because wetlands functions are interrelated. Failure of most previous studies to examine such interrelationships has limited the usefulness of resulting data.

Selected holistic study sites will be identified in 1985 and will be monitored for a minimum of three years. Studies will be designed to assess the ability of each wetland type to perform the priority functions in each hydrologic regime (zone) present at the study sites. Laboratory and modeling studies may be included to complement field research.

The following functions will be examined in each priority wetland type: (1) groundwater recharge/discharge; (2) flood storage and desynchronization; (3) sediment trapping and retention; (4) shoreline anchoring and erosion abatement; (5) nutrient uptake; (6) heavy metal immobilization; (7) denitrification; (8) food chain production; (9) detrital export; (10) spawning and nursery habitat for aquatic biota; and (11) waterfowl habitat in bottomland hardwoods and tundra.

Function-specific studies are planned in certain regional wetland types receiving intense developmental pressures. These wetland types have been relatively well studied with respect to some critical wetlands functions, but knowledge of other functions is missing. The lack of information regarding critical functions limits the quality of overall assessments of values in these wetland types. Holistic studies are not needed in such cases; instead, function-specific studies are proposed by wetland type and function.

Special studies are proposed to address unique research needs. Two types of special studies have been identified: (1) synthesis studies of particular wetlands functions and values data and (2) studies of altered wetlands in the Pacific Coast Region.

Synthesis studies are needed where CE personnel identified research needs for particular functions in wetland types for which extensive literature was already available. This stated need suggests that the literature is not available in a form that can be readily utilized. For example, CE personnel in the North Atlantic Region identified a need for research on water quality functions in estuarine marshes. However, these functions have been extensively studied in this regional wetland type (Nixon and Lee 1985). Three subjects have been identified for synthesis study (Table 1), and these will be conducted through regional workshops and/or reviews by regional wetlands values experts.

Studies of altered wetlands in the Pacific Coast Region, another special study, will be designed to determine the ability of diked wetlands to perform various wetlands functions. Appropriate field studies and/or synthesis studies will be conducted.

The fourth type of proposed research study addresses socioeconomic functions and values of wetlands. This research effort will be initiated once the basic knowledge of wetlands functions has improved. However, an economist will be included in interdisciplinary teams conducting holistic studies to ensure that proposed research provides data compatible with future economic assessments. Once an adequate understanding of wetlands functions is achieved, monetary and nonmonetary techniques will be developed to assess these functions.

Technology Transfer

An area of research often overlooked in large studies, but one critical to the overall success of the research, is a mechanism for disseminating information to the eventual users of the end-products. Several information transfer methods are proposed in the study plan to ensure effective interaction between researchers and product users.

One method involves training courses. The WES has five wetland assessment training courses planned for Fiscal Year 1985 with three more planned for next year. These training courses provide instruction in the use of the assessment technique and promote valuable interchange between users and researchers.

Another critical mechanism for information transfer is an interagency committee to coordinate ongoing and planned studies by federal agencies. The coordinating committee, consisting of representatives from 17 federal agencies and private wetlands organizations, was formed prior to the National Wetlands Values Assessment Workshop and continues to function. This committee will perform a critical task in the overall success of any wetland assessment technique developed. The committee will review the technique as it is developed, promote field testing by different agencies, and coordinate research efforts of the member agencies to ensure that research funds are carefully expended without duplication of efforts.

Other approaches for information transfer include technical reports, information brochures, and regional workshops.

Summary and Conclusions

No easily implementable wetland assessment technique exists that can be used to assess all wetland functions in all wetland types. A study plan has been developed by the U.S. Army Engineer Waterways Experiment Station to serve as a framework for developing such a technique. A technique developed by the FHWA has been tentatively adopted as the basis for designing a CE wetland assessment technique. The study plan presents steps necessary to improve the structural organization and technical validity of the FHWA technique. Planned structural modifications include computerization and regionalization of the technique. The technical validity of the procedure will also be improved by conducting several types of research studies. The study plan presents national research priorities, with highest priorities to be addressed initially and subsequent priorities to be addressed as resources become available.

The study plan identifies several mechanisms for information transfer, including presentation of training courses and formation of a formal interagency coordinating committee. The work of the coordination committee is critical to the successful completion of the study plan objectives. Duplication of research efforts has occurred in the past and will continue to occur without such a committee.

Wetlands are extremely valuable natural resources. Decision makers responsible for determining whether or not to allow alterations in wetlands must be provided the most technically sound tools available to assist in making defensible determinations. Products resulting from research identified in the study plan will provide the tools necessary for sound decisions.

Literature Cited

Adamus, P. R. 1983. A method for wetland functional assessment: Volume II, FHWA assessment method. No. FHWA-IP-82-24. Federal Highway Administration, Washington, D.C.

_____, and L. T. Stockwell. 1983. A method for wetland functional assessment: Volume I, FHWA assessment method. No. FHWA-IP-82-23. Federal Highway Administration, Washington, D.C.

Bane, G. W., A. W. Bane, and S. Ellsworth. 1985. Literature review of wetland fish and wildlife habitat values in the United States, 1970-1983. Technical Report Y-85-. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Clairain, E. J., Jr., D. R. Sanders, Sr., H. K. Smith, and C. V. Klimas. 1985. Wetlands functions and values study plan. Technical Report Y-83-2. U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Forsythe, S. W., E. J. Clairain, Jr., and H. K. Smith. 1983. Wetlands functions and values study plan; appendix b: survey of U.S. Army Corps of Engineers wetlands values information needs. Technical Report Y-83-2. U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Frayer, W. E., T. J. Monahan, D. C. Bowden, and F. A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States , 1950's to 1970's. Department of Forest and Wood Sciences, Colorado State University, Fort Collins, Colo.

Golet, F. C. 1973. Classification and evaluation of freshwater wetlands as wildlife habitat in the glaciated northeast. Trans. Northeast Fish and Wildlife Conf. 30:257-279.

Gupta, T. R., and J. H. Foster. 1973. Valuation of visual-cultural benefits from freshwater wetlands in Massachusetts. Northeast. Agric. Econ. Council 2(2):267-273.

Jones, P., et al. In prep. Literature review of wetlands hydrologic functions and values in the conterminous United States and Alaska. Technical Report Y-86-. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Larson, J. S., ed. 1976. Models for assessment of freshwater wetlands. Publ. No. 32. Water Resources Research Center, University of Massachusetts, Amherst, Mass.

Lonard, R. I., E. J. Clairain, Jr., R. T. Huffman, J. W. Hardy, L. D. Brown, P. E. Ballard, and J. W. Watts. 1984. Wetlands functions and values study plan; appendix a: analysis of methodologies for assessing wetlands values. Technical Report Y-83-2. U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Nixon, S. W., and V. Lee. 1985. Wetlands and water quality: a regional review of recent research in the United States on the role of fresh and saltwater wetlands as sources, sinks, and transformers of nitrogen, phosphorus, and various heavy metals. Technical Report Y-85-. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Sather, J. H., and P. R. Stuber, tech-coord. 1984. Proceedings of the national wetland values assessment workshop, May 23-26, 1983, Alexandria, Va. FWS/OBS-84-12. U.S. Fish and Wildlife Service, Western Energy and Land Use Team.

Shabman, L. A., and S. S. Batie. 1985. Socioeconomic values of wetlands: a state-of-the-art review. Technical Report Y-85-. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

U.S. Army Engineer Division, Lower Mississippi Valley. 1980. A habitat evaluation system (HES) for water resources planning. Vicksburg, Miss.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP) manual. 102 ESM. Washington, D.C.

Chesapeake Bay: History and Management Needs

Robert L. Lippson
National Marine Fisheries Service
Oxford Laboratory
Oxford, Maryland 21654

Nearly 400 years have passed since Captain John Smith and members of the Virginia Company first rounded the southern headland (Cape Henry) at the mouth of Chesapeake Bay, where they anchored and put ashore on April 28, 1607. The landing company came upon a place where the indians had recently been roasting oysters, the natives fled and left the Englishmen to eat the oysters "which were very large and delicate in taste" (Chatterton 1927). Captain Christopher Newport, master of the *Susan Constant* wrote in 1607, that the James, then known as the Powhatan River, "abounds with sturgeon very large and excellent good, having also at the mouth of every brook and in every creek both store and exceedingly good fish of diver's kinds" (Wharton 1957).

The early colonists were ill-equipped for fishing and resorted to crude seines and weirs fashioned from stakes and brushwood. The indians also taught them how to spear large fish in the shallow waters. Though the people of Jamestown were surrounded by thousands of miles of inland sea and the nearby Atlantic,they never developed a productive fishing industry. Perhaps it was because their aims were set in different directions; chief among them was the search for gold and ultimately the development of a coastal trade in furs, corn, and fish. The Virginians favored tobacco growing above fishing and except for incidental fishing to forestall starvation there was little harvested from the Bay and its tributaries. In fact, Virginians relied heavily on fish from Canada and New England in trade for their tobacco.

Towards the end of the century, fishing equipment and techniques improved considerably. Apparently the settlers had obtained a better supply of good salt with which to preserve the catch for consumption in the winter months, when there were few fish available to harvest.

The fishing industry of Virginia grew, but at a glacial pace, and as the demand for salt herring and shad slowly grew, fishermen found that upstream access to the herring's spawning grounds and for the navigation of boats was blocked by the construction of mill dams and other structures. Some of the earliest legislation was enacted for purposes of allowing fish to pass through on their way upstream from February through May. The Revolutionary War, however, arrived and somewhat dampened the ardor of early conservationists; the dams were not modified, the fish were denied their upstream spawning grounds and one of Chesapeake Bay's first multiple-use conflicts was firmly established.

Fishing grew in intensity throughout the Bay and as demand grew so did conflicts. The Potomac River Compact between Maryland and Virginia was enacted in 1785 to allow Virginians to fish the Maryland-owned Potomac River in exchange for free entry of Maryland ships through the Virgina Capes. This agreement remains in force to this day and although free entrance to the Bay is not now threatened, Marylanders and Virginians still fish side by side in the Potomac where the fishery resources are managed by a bi-state commission; the Potomac River Fisheries Commission.

By the 1800s, fishing had become an important industry throughout the Bay. Baltimore became an important seafood center. Fish and oysters caught near Tangier and Smith islands and other areas in the Bay were transported to ports like Baltimore aboard large sailing craft. An account of the soft-crab fishery of Crisfield, Md. in 1889 paints a picture of a vigorous fishery along the Eastern Shore of Maryland. "Generally long before sunrise the harbor of Crisfield and the adjacent creeks and marshes are alive with the crabbing crafts. At 6 o'clock on the morning of August 14, 1888, 215 canoes and bateaux were counted between Crisfield and the mouth of the short river upon which it is located. —the sight was a striking one" (Smith 1889). Smith reported that 25 firms were engaged in buying, shedding, and shipping crabs in the Crisfield area in 1888.

Oysters were a favorite food of the colonists, they were abundant in the shallows, easily harvested and they kept reasonably well. Oysters have always been an important staple for citizens of the Chesapeake and a valuable commodity for the market place. Dr. William K. Brooks, a Maryland oyster commissioner in 1883-4, reported that 6,954,500 bushels of oysters were harvested in both Maryland and Virgina in 1865. Ten years later the annual production had increased to 17,000,000 bushels and production continued to grow for several years thereafter (Brooks 1891). Brooks stated quite emphatically in 1905 that "the demand for Chesapeake oysters has outgrown the natural supply. We have wasted our inheritance by improvidence and mismanagement and blind confidence . . ." Dr. Brooks wrote that the danger of the pollution of the open waters of the Bay is slight, but he called for the whole Bay to be treated as "drinking water" to protect our oysters from the slightest breath of suspicion.

Dr. Brooks advocated artificial propagation as the remedy for maintaining and increasing the supply of oysters to feed an insatiable market. He believed that the fishery, being a common property, was the responsibility of everybody to preserve and since no one individual or individuals attempted to do so, the resource was not preserved. Tongers blamed the oyster dredgers, owners of small boats blamed the operators of larger vessels, and packers found fault with exporters of oysters in the shell, but all parties united in placing the blame conveniently on the officers of the Fishery Force. So conflicts were common, then as now, between competitors for the same resource, generally to the detriment of the resource and the industry.

In the late 1800s fishery managers were enamored with the thought of rearing fish in hatcheries to enhance the stocks of various areas. A review of the Report of the Commissioner of Fish and Fisheries for 1883 clearly points out the interest and hopes that fishery managers had for hatchery-reared species. The U. S. Fish Commission cultivated and distributed 22 species of fish and shellfish in 1883. Some of those species which were cultured and destined for the Chesapeake Bay included the Spanish mackerel *(Scomberomorus maculatus)* and the rockfish or striped bass *(Morone saxatilis)*. There was concern about the rapid decrease in the abundance and size of striped bass and so holding pens were constructed at a station near Havre de Grace, Md., for the retention of ripe females for subsequent propagation; however the project failed for lack of mature-sized spawners. American shad *(Alosa sapidissima)* and herring eggs were collected and hatched at several stations along the Potomac River. In an attempt to ameliorate the scarcity of the American lobster *(Homarus americanus)* and to increase their geographical distribution, 100 lobsters, some with eggs, were transported aboard the U. S. Fish Commission steamer *Fish*

Hawk from Fort Pond Bay, Long Island to the Chesapeake with the hopes that further reports would record some success. Experiments in oyster culture were undertaken at St. Jeromes Creek in southern Maryland with some success. It is not clear if the interest in propagation was for the purpose of offsetting the depredation of overfishing, to overcome habitat destruction, or simply a fascination with fish culture. In any event, it appears that fishery managers were looking to fish propagation as an important tool for managing the stocks.

The early work of Brooks in the late 1800s on oysters has been followed by a large number of studies by various workers on the biology, systematics, abundance, and distribution of a number of species that occur in Chesapeake Bay. Early studies were devoted to various aspects of the life history stages of a number of organisms as well as some limited work on the sediments and the physical and chemical characteristics of the Bay.

In the 1940s some attention was directed toward the management of certain species which were in danger of being overfished. R. E. Tiller (1944) recognized that the shad stocks in Maryland were in decline and had been so since 1890. This despite hatchery operations which had been conducted since 1876 with 5 million to 150 million shad fry released each year in Maryland waters. Tiller wrote that "hatcheries have not effected restoration of this fishery nor, for that matter, have they noticeably stemmed depletion." He called for a management plan to reduce depletion by overfishing and to increase the brood stock. It was becoming clear to scientists and fisheries managers that the production of hatchery-reared stocks of shad, striped bass, and other species would not be successful in stemming declines or increasing natural reproduction as long as unrestrained harvesting continued. Up until this time there was little concern about pollution and habitat degradation. Tiller did mention, however, some interest in the prohibition of industrial pollution.

Scientists began to investigate problems of water quality around the 1950s. Galtsoff (1947) studied the effects of sulfate pulp mill wastes on oysters in the York River, and C. C. Davis (1948) reported on the effects of industrial pollution in the Patapsco River.

Researchers and resource managers were beginning to realize that the problem of declining stocks was a complex one. They recognized that along with the little understood phenomenon of natural fluctuation and the obvious impact of overfishing was a third component, environmental degradation, which was becoming increasingly apparent. Mansueti (1961) stated that the Cheaspeake Bay has been subjected to great influences of civilization, some catastrophic, others moderate but sustained. He pointed out that the carrying capacity of the Bay, especially the bottom, has been reduced. Beaven (1946) estimated that roughly half of the upper estuarine spawning areas for fish and shellfishery areas for oysters, *Crassostrea virginica* have been destroyed or shifted downstream by sedimentation in Chesapeake Bay. Massman et al. wrote in 1952 that chemical pollution produced biotic destruction on a local, temporary level with no long-range losses to economically important marine species in the whole of Chesapeake Bay.

In 1967, exactly 18 years ago, L. Eugene Cronin presented a paper on the condition of the Chesapeake Bay to this very forum. It is instructive to return to this paper to determine what changes have occurred in the Chesapeake since that time. Cronin wrote that scientists and resource managers do not have enough information on the ecological requirements of many forage and economically important species to guide effective protection and optimal management. Some of the species that he listed included, American shad and the herrings, the striped bass, and white perch. Currently, the American shad stocks in Maryland have declined to such low numbers that the fishery has been closed to harvesting. The herrings, alewife and branch herring, have also severely declined in abundance, but are still being landed. The plight of the striped bass stocks in Chesapeake Bay is well-known. The stock has declined to record lows and a mortatorium has been established to prohibit the taking of this species in Maryland waters. Stringent regulations are being imposed in state waters throughout its range in an attempt to ameliorate the decrease in numbers of this important commercial and recreational species. The white perch, a closely related species to the striped bass, has also shown a serious decline in the last several years.

Cronin predicted that multiple uses of the Bay will increase and exacerbate the condition of the Bay even further. He noted that there will be an increased demand for shipping with the concomitant needs for dredging deeper channels and the disposal of spoil. Presently, the ports of Baltimore and Norfolk are competing for scarce federal funds to deepen their harbors and approach channels. Concern is being raised over the possibility of overboard dumping of contaminated spoil in the Chesapeake Bay and in coastal Atlantic waters. The State of Maryland has nearly utilized the capacity of the controversial 1,100 acre (445 ha) Hart-Miller Islands spoil site in the upper Bay and may seek an additional site to contain polluted spoil resulting from the deepening and maintenance dredging of channels.

Cronin looked to the future and predicted that oysters will increase in yield unless additional losses from disease occur or pollution intensifies. In the 1983-84 oyster harvesting season approximalely 868,000 bushels of oysters were landed in Maryland; the lowest catch since the late 1800s.

Cronin discussed the possible effects of the burgeoning population growth around the Bay and was concerned about ensuing eutrophication as a result of increasing quantities of nitrogen and phosphorus pouring into the Bay and its tributaries from sewage treatment plants. Chemical pollution, except in localized harbors, was not known to be a general problem in 1967. However, Cronin wrote that subtle chemical pollution, or what is now known as non-point source pollution, may eventually be more destructive. Cronin was correct in his estimation that "subtle chemical pollution seems to have high potentials for serious and unexpected damage to the estuarine ecosystem."

In 1983, the United States Environmental Protection Agency (EPA) published the results of a five year study of the Bay and reported that:

- Blue-green algae and dinoflagellates have increased in the upper Chesapeake Bay.
- Submerged aquatic vegetation has declined in abundance and diversity.
- Landings of anadromous fish such as shad and alewife have decreased significantly. Striped bass stocks are at an all-time low. Marine spawners such as menhaden and bluefish have remained stable or have increased in abundance.
- The harvest of oysters has decreased throughout the Bay and spat set has substantially declined.
- The Bay is highly enriched with nutrients, particularly in the upper reaches of the tributaries.

- Nutrient enrichment and the subsequent stimulation of algal production has resulted in a significantly increased area of anoxia in the main stem of the Bay from approximately the latitude of Annapolis to the Rappahannock River.
- Toxic compounds in high concentrations are incorporated in the bottom sediments in areas of maximum turbidity and particularly in the general locale of Baltimore Harbor and Hampton Roads.
- Heavy metal concentrations are significantly above background levels in the water layers and sediments.

Williamson (1972), before a symposium entitled "The Fate of Chesapeake Bay," stated that gross changes have been detected in the Bay that include that virtual extinction of several subestuaries as biologically and esthetically useful resources. Williamson was prophetic when he wrote that excessive nutrient loading, addition of hazardous materials, erosion and sedimentation, the cumulative effects of engineering activities, the exploitation of living resources and the alteration and destruction of the wetlands are events that if allowed to continue unchecked will affect the entire Bay.

Lippson and Lippson (1983) wrote that the competition for the Bay's resources, whether it be for striped bass or a source of industrial cooling water is all too apparent. In the past the Chesapeake has absorbed the impacts of a burgeoning population which placed conflicting demands on a multiple-use resource. Scientists and managers alike have too long relied on the presumed resilence of this complicated estuary to maintain the diversity of its biota and productivity.

The subtle environmental degradations have been difficult to measure, we do not have a good understanding of wetland losses and their linkage to biotic production in the estuary and coastal waters. The presumed resilence of the system, our inability to relate cause and effect to any great extent, and the multiple demands of society on the Bay's resources has allowed it to seriously deteriorate.

Small decisions have insidious effects. Cultural eutrophication is not the result of intentional and rational choices. Rather, eutrophication occurs through the cumulative effects of many small decisions; the addition of domestic sewage and industrial outfalls; increased run-off from housing developments, highways, shopping malls, and agricultural fields. This reductionist perspective rather than a holistic approach has brought about the piece-meal destruction and degradation of wetlands and of our air and water quality (Odum 1982).

The State of Maryland has recently established a Critical Areas Commission for the purpose of establishing a holistic management perspective throughout the State. Critical shoreside development will be permitted only after certain criteria are met. Unfortunately, this attempt at managing man's activities within this vulnerable estuarine zone is already being rebuffed by special interest groups, land owners, and politicians. The process is not perfect, but is an attempt at large-scale management to help avoid the consequences of small decisions.

Cronin, in 1967, said that if appropriate Bay research continues, an enduring solution is found to the disposal of wastes and nutrients, and state and federal governments exert wise leadership, the Bay will serve even more people in the next century. Williamson called for the management agencies of Virginia and Maryland to join with the academic community and the federal government to obtain the information needed for decision making. The effort will require a major interdisciplinary approach based on sound methodology so that the complex and serious problems of the Chesapeake Bay can be treated in a constructive manner.

Lippson and Lippson stated that there are no simple answers or inexpensive remedies and there is no doubt that additional serious impacts on the Bay will be identified in the future. They are sanguine for the Bay's future, however, if society continues to support environmental research and presses for prudent Bay-wide management decisions.

Wiliam Ruckelshaus, former Administrator, U. S. Environmental Protection Agency, said that the clean up of Chesapeake Bay will "take time and dogged effort to reverse the effects of man's indifference. The tough thing will be to make certain that we are steadfast, that we do our part, year after year, decade after decade."

The condition of Chesapeake Bay can be reversed and improved. However, we must be wary of quick fixes such as massive hatchery efforts to restore striped bass stocks. It is important to learn from the history of Chesapeake Bay that artificial propagation alone did not fulfill its promise. We must use all the tools that are available to maintain stock strengths, which includes intelligent management of migratory species and improvement of estuarine habitat. The Bay has not been studied exhaustively; we know too little about its complex processes and interactions. We need to maintain quality research and to continually upgrade our comprehension of the Bay ecosystem.

The groundswell of concern to "save the Bay" and the financial support that has accompanied it is needed and welcome, but we must be careful that we spend our money wisely—the opportunity may never come again. Scientists must provide information on the dynamics of the Bay system as a verification of the progress being made to improve its condition. Managers require the most current and best information available in order to make difficult Bay-wide decisions. The effort must be coherent. Society expects answers from scientists and it demands proper decisions from resource managers; it should also require its elected officials to be resolute, if we wish to avoid the tyranny of small decisions and the further degradation of the Chesapeake Bay.

Literature Cited

Beaven, G. F. 1946. Effect of Susquehanna River stream flow on Chesapeake Bay salinities and history of past oyster mortalities on upper bay bars. Ann. Rept. Md. Bd. Nat. Res. 3:123-133.

Brooks, W. K. 1891. The oyster. Johns Hopkins Univ. Press, Baltimore.

Brooks, W. K. 1905. The oyster. A popular summary of a scientific study. Second and revised edition. The Johns Hopkins Press, Baltimore.

Chatterton, E. K. 1927. Captain John Smith. Harper and Brothers, New York and London.

Cronin, L. E. 1967. The condition of the Chesapeake Bay. Trans.N. Amer. Wildl. and Natur. Resour. Conf. 32:137-150.

Davis, C. C. 1948. Studies of the effects of industrial pollution in the lower Patapsco River area. 2. The effect of copperas pollution on plankton. Publ. No. 72. Md. Dep. of Res. and Ed., Ches. Biol. Lab.

Galtsoff, P. S. 1947. Ecological and physiological studies of the effects of sulfate pulp mill wastes on oysters in the York River, Virginia. U. S. Fish and Wildl. Serv. 51: 58-186.

Lippson, R. L. , and A. J. Lippson. 1983. The condition of Chesapeake Bay: assessment of its present state and its future. *In* J. B. Pearce, ed. Reviews of water quality and transport of materials in coastal and estuarine waters. Intern. Coun. Explor. Sea. Coop. Res. Rep. No. 118.

Mansueti, R. J. 1961. Effects of civilization on striped bass and other estuarine biota in Chesapeake Bay and tributaries. Proc. Gulf and Carib. Fish. Inst. 14th Ann. Sess.:110-136.

Massman, W. H., E. C. Ladd, and H. N. McCutcheon. 1952. A biological survey of the Rappahannock River, Virginia. Two volumes. Va. Fish. Lab.

Odum, W. E. 1982. Environmental degradation and the tyranny of small decisions. BioScience 32 (9) : 728-729.

Smith, H. M. 1889. Notes on the crab fishery of Crisfield, Md. Bulletin of the U. S. Fish Commission, Washington, D. C.

Tiller, R. E. 1944. The Maryland management plan and the shad fishery. Educational Ser., No. 5. Md. Dept. of Res. and Ed.

U.S. Commission of Fish and Fisheries. 1885. Report of the Commissioner for 1883. Govt. Printing Office, Washington, D. C.

U. S. EPA. 1983. Cheaspeake Bay Program: Findings and recommendations. U. S. EPA, Reg. 3, Phil., Pa.

Wharton, J. 1957. The bounty of the Chesapeake. Fishing in colonial Virginia. Jamestown 350th Ann. Historical Booklet No. 13. Williamsaburg, Va.

Williamson, F. S. L. 1972. Biology and the Chesapeake Bay. Symp. Science and the Environment (II): The fate of the Chesapeake Bay. J. Wash. Acad. of Sciences. 62(2): 88-102.

Migratory Wildlife: Status, Needs and Future Management Directions

Chariman:
LEIGH H. FREDRICKSON
Director
Gaylord Memorial Laboratory
School of Forestry, Fisheries and Wildlife
University of Missouri—Columbia
Puxico, Missouri

CoChairman:
DENNIS G. RAVELING
Professor
Wildlife and Fisheries Biology
University of California
Davis, California

Opening Statement

Dennis G. Raveling
Division of Wildlife and Fisheries Biology
University of California, Davis, CA 95616

Leigh H. Fredrickson
Gaylord Memorial Laboratory
School of Forestry, Fisheries and Wildlife
University of Missouri—Columbia, Puxico, MO 63960

Welcome to the migratory birds session of the Golden Anniversary of the North American Wildlife and Natural Resources Conference. Fifty years ago we needed to know how many birds we had, what those birds needed for survival, and how to provide for their needs. We face those same problems today. Although we have made large strides in solving some problems, others still require extensive investigation. In addition, ecological and management concepts have matured rapidly. Unfortunately, these ecological concepts and management strategies have usually advanced more rapidly than our ability as a society to apply them to migratory bird problems. In some cases, we have failed to provide the needs of populations or even be assured of the perpetuation of some species.

Concerns for habitat preservation and dwindling populations were paramount at this conference in the 1930s. Concerns for populations are still prevalent today as reflected by five of eight presentations in this year's session and numerous presentations in the intervening years since the 1930s. In the last 20 years the role of hunting as a factor controlling populations has become even more of an issue, and five of the papers today address this concern.

While requirements to sustain migratory bird populations have remained relatively similar over the years, our perspectives in understanding those requirements have changed rapidly, especially in the last 10-15 years. The integration of genetics and physiology with population biology has resulted in a more coherent conceptualization of how and why populations fluctuate in the real world. Now factors controlling behavior and survival can be tested. For example, behavior studies tended to ignore causative environmental factors, while emphasizing taxonomic description, instinct-learning theory, and the conception of relative fixity. Today, emphasis is on flexibility of social organization in relation to other variables, especially predation, food quality and quantity. As a result, behavior studies now relate more clearly to the key element of habitat—i.e., carrying capacity fluctuations. Early food habits and body weight studies were concentrated in autumn and were descriptive. Feeding ecology studies now partition body components (protein, lipids, and mineral stores) in relation to the birds' physiological demands of varying activities throughout the annual cycle, and describe these relationships among different years. These results have profound effects for developing our understanding of habitat requirements for migratory birds and how we should provide and manage these habitats. While much effort continues to be spent on basic inventories of migratory bird populations, increasing sophistication in statistical methodology coupled with evolutionary theory point to different questions about how and when harvest or other mortality factors affect population numbers and distributions.

The role of diseases and toxicants present additional levels of complexity into our analyses and concern. The number of these problems has expanded over the last 50 years. In some cases they may override all other controlling factors, and we have a poor understanding of their sublethal effects in changing the balance of the population equation.

We close these brief introductory comments with some examples of the changes in our perspectives and the value of a more integrated understanding while continuing to be frustrated by the magnitude of the problems. For example, initial purchases of wetlands emphasized only large, permanent marshes without protection of the surrounding uplands or full appreciation of the necessity for drought in nutrient cycling to maintain habitat productivity over a longer time span.

Wetland protection programs have evolved and are changing rapidly with an increasingly detailed understanding that the rich waterfowl fauna of North America resulted from the diversity of wetland habitats that cover the continent. The value of very temporary wetlands as well as the changing role of wetland types in meeting waterfowl needs throughout the annual cycle are becoming increasingly clear. Today, expertise in hydrology, nutrient cycling, plant ecology, microbiology, invertebrate ecology, and evolutionary biology provide the fundamental insights into what makes a marsh "good" for waterfowl. Interdisciplinary wetland ecology integrated with studies of waterfowl behavior, productivity, and survival have expanded our perceptions of waterfowl in a dynamic environment. Excellent examples of more integrated multidisciplinary studies include several recent contributions from the U. S. Fish and Wildlife Service Northern Prairie Research Center at Jamestown, North Dakota and the Marsh Ecology Research Program and allied studies at the Delta Waterfowl and Wetlands Research Station in Manitoba.

Although management strategies and philosophies are rapidly evolving, we lose 450,000 acres (182,100 ha) of wetlands in the United States each year. Over 90 percent of the wetlands of many large geographical areas of North America have been drained, filled, or degraded. Selenium now makes national news by causing deformities of wildlife on a National Wildlife Refuge in California. The Chesapeake Bay is considered by many to be a sump. Marshes along the coast of the Gulf of Mexico are eroding into the sea at the astonishing rate of 40 square miles/year ($103 km^2$/year). But we do not need waterfowl or other wildlife to justify conservation of wetlands or any habitat. Even though we know that natural wetland basins provide essential functions in reducing floods, recycling nutrients, and providing for atmospheric stability, we continue to build on floodplains, remove cover, alter waterflows, create floods at unprecedented frequencies, and subsidize surplus crops of every description.

There is no doubt that all of these subjects will continue to be reported on annually at the North American Wildlife and Natural Resources Conference. What will be the conclusions at the 100th anniversary?

Let us now turn to today's program and further enhance our understanding of factors governing distribution and numbers of several migratory birds and management programs that can benefit them.

Evaluation of Efforts to Redistribute Canada Geese

Donald H. Rusch
Wisconsin Cooperative Wildlife Research Unit, University of Wisconsin, Madison

Scott R. Craven, Robert E. Trost and John R. Cary
Department of Wildlife Ecology, Univeristy of Wisconsin, Madison

Robert L. Drieslein
U. S. Fish and Wildlife Service, Mayville, Wisconsin

John W. Ellis
U. S. Fish and Wildlife Service, Twin Cities, Minnesota

John Wetzel
Wisconsin Department of Natural Resources, Madison

Background

In 1936-67, declines in Canada goose *(Branta canadensis)* populations wintering in the southern portion of the Mississippi and Atlantic Flyways were accompanied by marked increases in some northern areas. In the Mississippi Flyway, some of these increases occurred on refuges in Illinois, Wisconsin, and Kentucky (Hankla and Rudolph 1967, Reeves et al. 1968) among Canada geese identified as the Mississippi Valley Population (MVP; Hanson and Smith 1950). Horicon National Wildlife Refuge, established in 1941 primarily as a breeding marsh for redhead ducks *(Aythya americana)*, had no history of use by Canada geese prior to the early 1950s. By the early 1960s, fall Canada goose counts at Horicon National Wildlife Refuge (NWR) reached 100,000 and were increasing annually. Many managers and sportsmen perceived that Horicon was ''short-stopping'' geese, or holding them north of other traditionally used areas. In addition, the large concentrations of geese were associated with crop depredations (Hunt and Bell 1973), large increases in harvest, and a perceived deterioration in the quality of goose hunting (Brakhage et al. 1971). In order to alleviate these problems, management agencies dumped 467.5 tons of shelled corn to hold the geese on the refuge in 1965, but crop depredations and harvest were high nevertheless. In 1966, an effort was made to disperse the geese with aircraft, but the program failed when state and federal agencies involved were unable to cooperate effectively. Reeves et al. (1968) described a high harvest rate and wide dispersion of color-marked geese in east-central Wisconsin (ECW), but did not detect any unusual movements of geese into Illinois.

After the abandonment of the redistribution efforts in 1966, goose counts at Horicon continued to increase. By the early 1970s fall goose counts exceeded 200,000, and the problems of crop depredation and harvest management intensified. Also, the hunting system had changed. Firing lines, land leasing, and competition among hunters had been reduced by changes in hunting regulations that mandated (1) one tag per hunter for those fortunate enough to draw a permit, and (2) strict controls on hunter density on lands near Horicon NWR (Brakhage et al. 1971). Farmers were upset about substantial loss of lease income and perceived federal and state insensitivity to their problems. New problems were identified, including potential for large scale loss to disease, pollution on roost lakes, and impairment of road traffic by goose viewers. Allegations of short stopping, primarily from southern states, again increased. The peak fall count at Horicon represented approximately 65 percent of the subsequent midwinter inventory of MVP geese in 1970-1975.

In response to demands by irate farmers and other concerned citizens, the Wisconsin congressional delegation asked the U. S. Fish and Wildlife Service (FWS) to reduce goose numbers and problems around Horicon NWR. The Wisconsin Legislature passed a resolution in 1975 asking the Wisconsin Department of Natural Resources (DNR) to take similar action. The problems in the Horicon area were well recognized by the agencies; in fact, a strategic plan for alleviating these problems had been developed earlier (Klepinger and Ellis 1975). In 1976, the Wisconsin DNR and the FWS implemented a management program that aspired to: (1) Reduce the peak numbers of Canada geese in fall from 200,000 to 100,000; (2) reduce goose-use days from 10-12 million to 5 million; and (3) promote an "orderly migration" so that 95 percent of the goose-use days occurred prior to 5 December.

The management program was designed to discourage geese by combinations of reductions in food, water, and sanctuary. Flock reduction by increased hunting mortality was not selected as a management strategy because it was unacceptable to other states and provinces sharing the harvest of the MVP geese.

The objectives of this paper are to:

1. Evaluate the efficacy of techniques used during the 5-year Horicon management program to discourage or directly disperse geese.

2. Evaluate the changes in distribution, numbers, survival, and movements of geese in relation to management.

Study Area

The main treatment area was Horicon Marsh in east-central Wisconsin; satellite goose management areas up to 80 km from the marsh (Figure 1) received less intensive treatment. The northern 8,367 ha portion of the 12,550 ha marsh is managed by the FWS as Horicon NWR and the remainder is managed by the DNR. Horicon NWR and about 20 percent of the state wildlife management area are closed to waterfowl hunting. Dairy and corn production dominated the extensively farmed uplands around the marsh. Detailed descriptions of these areas are available from other authors (Reeves et al. 1968, Green 1968, Craven 1978, Hunt et al. 1962).

Methods

Habitat Management

On Horicon NWR, 283 ha of peatland previously planted to corn and winter wheat were left fallow in 1976. An additional 137 ha of corn and 82 ha of oats planted under share-cropping agreements were harvested prior to the arrival of geese and 73 ha of alfalfa were left uncut. All farming agreements were terminated on 31 December 1976. Beginning in 1976, a total of 109 ha of retired cropland was seeded to a mixture of native grasses to provide dense nesting cover for ducks and to discourage use of upland fields by geese.

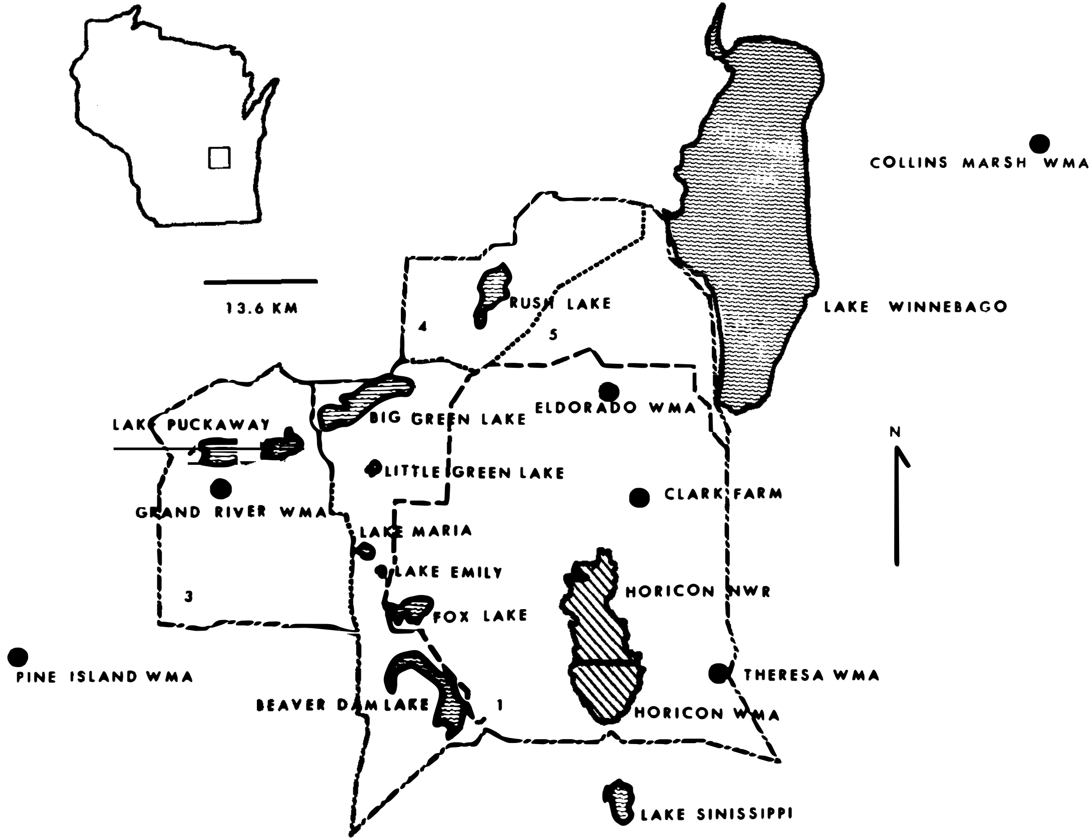


Figure 1. Location of Horicon National Wildlife Refuge (NWR), Wisconsin Wildlife Management Areas (WMAs) and lakes used by Canada geese in the east-central Wisconsin area.

By 1977 no crops were present at Horicon and only 309 ha of crops were planted for Canada geese on the five satellite areas. On these areas, an overall reduction in crops began in 1976 and reached 30-40 percent by the termination of the program. On the Grand River Wildlife Area crops were eliminated by 1979.

Water levels on Horicon NWR varied widely from 1976 through 1980. A dry summer and fall in 1976 compounded the impact of an intentional drawdown and resulted in extremely low water levels. No subsequent drawdowns were attempted and water levels approached normal in 1977-1980.

Disturbance

Hazing on Horicon NWR began as soon as geese arrived in September 1976. During late September and early October, a limited number of flights were made with fixed-wing aircraft to disturb geese, but flights were discontinued in mid-October for safety reasons. Between October 18-27, a helicopter conducted 57 hours of hazing during midday and evening when geese were returning to the refuge after feeding on private lands. The helicopter operated only over the refuge, but geese were observed flushing from adjacent private lands up to 2 km distant.

Between 19 September and 30 October four airboats logged 1,100 hours of hazing activity. Each carried a driver and an observer and was equipped with aircraft landing lights for night operation. Geese were hazed whenever they were encountered during two 8-hour shifts each day, except on days with scheduled aerial inventories. Effort was concentrated on midday, evening, and night periods when the geese depended on the refuge for loafing and roosting. No airboat operations were conducted after 30 October in order to minimize increased vulnerability to harvest outside the refuge; Reeves et al. (1968) suggested that this had occurred during the 1966 hazing program. Fixed-wing aircraft were also used on large lakes west of Horicon when 40-50,000 geese concentrated on these areas in late November and early December, 1976.

At the request of the Wisconsin Natural Resource Board, direct aerial and airboat hazing were not used in 1977. Board action was primarily in response to intense public sentiment against the use of mechanical disturbance and the drawdown on Horicon NWR. Instead, 365 propane exploders were deployed throughout the marsh between 14 September and 21 November, and airboats logged 2,000 hours "while servicing the exploders." Helicopters also spent 34.4 hours servicing exploders. Exploder and airboat operation continued during the goose hunting season and were discontinued on 21 November 1977.

Disturbance on Horicon NWR in 1978 was again accomplished with exploders serviced by airboats. Although the DNR and FWS had agreed to allow direct airboat hazing if the goose count for the refuge exceeded 50,000 birds, hazing activities were forestalled with the discovery of a type C botulism outbreak on the north end of the marsh on 29 September. Between 29 September and 26 October all airboats were diverted to salvage and sanitation activities in the area of the botulism outbreak and a helicopter was used for 76 hours from 2-17 October to assist the airboats in keeping waterfowl out of the affected area. From 26 October to 20 November, airboats were used to service exploders as in 1977.

Use of exploders was discontinued in 1979 and geese were directly hazed by airboats for a total of about 60 hours, 4 hours prior to sunrise and 4 hours after sunrise, 5 October to 11 October. In 1980, airboats were used for only 70 hours during a botulism outbreak in September and early October.

Less than 5 percent of the total hazing occurred on the DNR-managed portion of Horicon Marsh, Grand River, other satellite goose management areas and on public lakes.

Banding and Marking

During the period 1974-1980, 15,482 Canada geese were banded at Horicon NWR. Of these, 7,388 were marked with plastic neckbands. Each neckband bore a 4-character code which was legible at up to 500 m with a 15-60X telescope (Craven 1979). All geese were captured with rocket nets at sites distributed around the refuge. Near equal samples of banded geese were obtained from the east and west sides of Horicon NWR in 1976-1979. In 1980, about 50 percent of the banding was done on the State Prison Farm, 2 miles (3.2 km) northwest of the refuge. About 55 percent of all captured geese were males; proportions of immatures in the samples ranged from 20 percent in 1977 to 41 percent in 1975, and averaged about 29 percent.

Estimation of Numbers and Geese

Geese were surveyed from the air in Wisconsin, Illinois, and Kentucky by personnel of the FWS and the Illinois Department of Conservation. The pilots located concentrations of geese which were then tallied or estimated; the entire area was not ordinarily surveyed. In east-central Wisconsin, concentrations of geese at Horicon Marsh and on surrounding agricultural lands, state wildlife areas, and public lakes were routinely included in the counts. Counts were made as close to sunrise as possible, before large concentrations of roosting geese dispersed to feed. Aerial counts were conducted weekly throughout the fall in Wisconsin and biweekly in Illinois and on refuges further south.

A comparison of goose surveys during the 5-year program and the preceeding 6 years (1970-1975) provided the primary basis for evaluating changes in goose abundance and distribution. The bias of the surveys was unknown because the true size of the population was unknown. The sample variance was also unknown because surveys were not replicated. However, successive surveys gave generally similar population estimates. The mean coefficient of variation of these estimates, which include some variance due to movements, was about 60 percent.

Estimation of Goose Use

Goose use is the integration of numbers of geese present on an area with their length of stay. Goose use was estimated as the area under the curve delineated by plotting all the counts for an area against the date of counting.

Movement and Survival

Observations and recoveries of marked (neck-banded) and leg-banded geese were used to evaluate movement and estimate survival. Year-to-year changes in counts for various concentration areas also provided indirect evidence of movement. During the period 1974-1980, a field crew of up to 6 people per year observed marked individual geese on 21,568 occasions in Wisconsin (Table 1) and 95,526 occasions elsewhere in the flyway. Populations of marked geese were estimated from resighting

Table 1. Numbers of geese neckbanded and subsequently encountered near Horicon NWR, 1974-1980.

Banding	No. neck-	Number of neckbanded individuals encountered						
year	bands	1974	1975	1976	1977	1978	1979	1980
1974	431	28	164	106	33	22	10	13
1975	1499		1145	748	345	132	36	21
1976	1394			1101	503	177	72	49
1977	1197				732	317	131	107
1978	937					506	167	146
1979	999						578	383
1980	931							697

data; each year, 55 to 81 percent of the marked geese estimated to be present in Wisconsin were actually observed. Additional observations were made in southern Illinois and other MVP goose concentration areas outside of Wisconsin. Estimates of survival and recovery rates from legband recovery data were derived using Program Brownie (Brownie et al. 1978).

A survival index was also calculated from encounter data from marked geese (Jolly 1965, Seber 1973). Mean survival rates were weighted from age ratios in banded samples.

Results

Numbers and Distribution of Geese

The migratory pattern and the local distribution of geese in east-central Wisconsin were described by Green (1968), Raveling and Lumsden (1977), and Craven (1978). Typically, geese arrived at Horicon in late September and increased steadily to peak numbers by the end of October. Migration into the area ended in early November. Some southerly migration to wintering areas in Illinois and Kentucky occurred throughout October and November, but major movements did not occur until late November and early December (LaMarche 1972, Craven 1978) with the conclusion of the corn harvest and fall plowing, and the arrival of permanent snow cover and/or ice on Horicon Marsh. In late November, most of the remaining geese moved to lakes west and northwest of the marsh (Figure 1). Ice cover on these lakes and accumulation of snow cover of about 15-20 cm were associated with the final departure of geese to southern Illinois, Kentucky, and other small wintering areas in the south.

The mid-December count of MVP geese averaged about 300,000 between 1970 and 1975. The flock estimates almost doubled in the next 2 years with counts of 479,000 (+57 percent) in 1976 and 575,000 (+20 percent) in 1977. Then the mid-December count declined to 434,000 in 1978; 395,000 in 1979; and 367,000 in 1980. MVP increases in 1976 and 1977 were evident on wintering refuges in southern Illinois and Kentucky (Figure 2). Goose-use of southern Illinois averaged 60 percent above the 1970-75 means. The numbers of geese on the Illinois and Mississippi rivers in northern Illinois were also well above 1970-75 means, and goose-use of this area increased by an average of 232 percent (Figure 3). Numbers of geese counted in northern Illinois in 1977-1980 were 2-5 times the 1970-75 mean counts (Figure 3).

In east-central Wisconsin from 1976-79, goose numbers (Figure 4) and goose-use declined dramatically from 1970-75 means. Goose-use in 1980 was only 49 percent of the earlier means, but a mild fall and late winter held geese in Wisconsin well beyond the normal November departure date. The 1980 peak fall population of 100,875 was also slightly higher than the 94,300 peak of 1979. Prior to 1980, the peak count had fallen steadily from 195,870 in 1976 (Figure 4).

Estimates of numbers of geese in the Horicon area in 1976, 1977 and 1978 declined precipitously from earlier means and remained at relatively low levels in 1979-1981 (Figure 5). Use of the area by geese declined from 1970-75 means by 30, 55, and 80 percent in 1976-78, respectively and remained 64 percent and 57 percent below mean levels in 1979 and 1980.

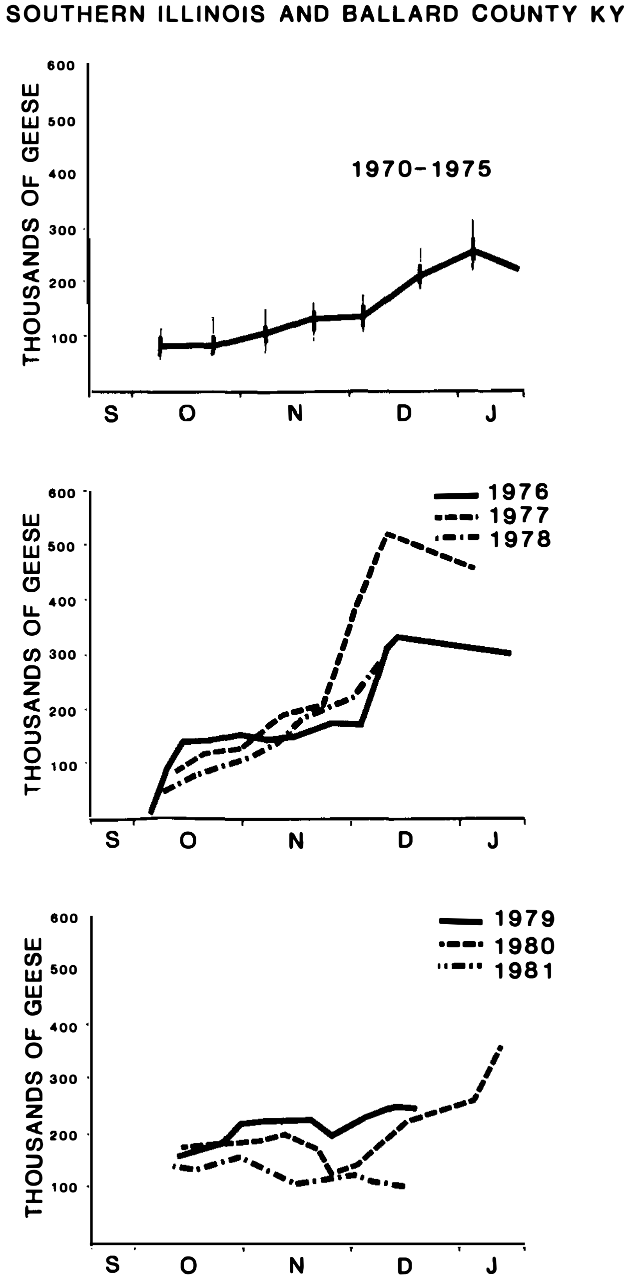


Figure 2. Estimated numbers of Canada geese in southern Illinois and Ballard County, Kentucky, 1970-1981.

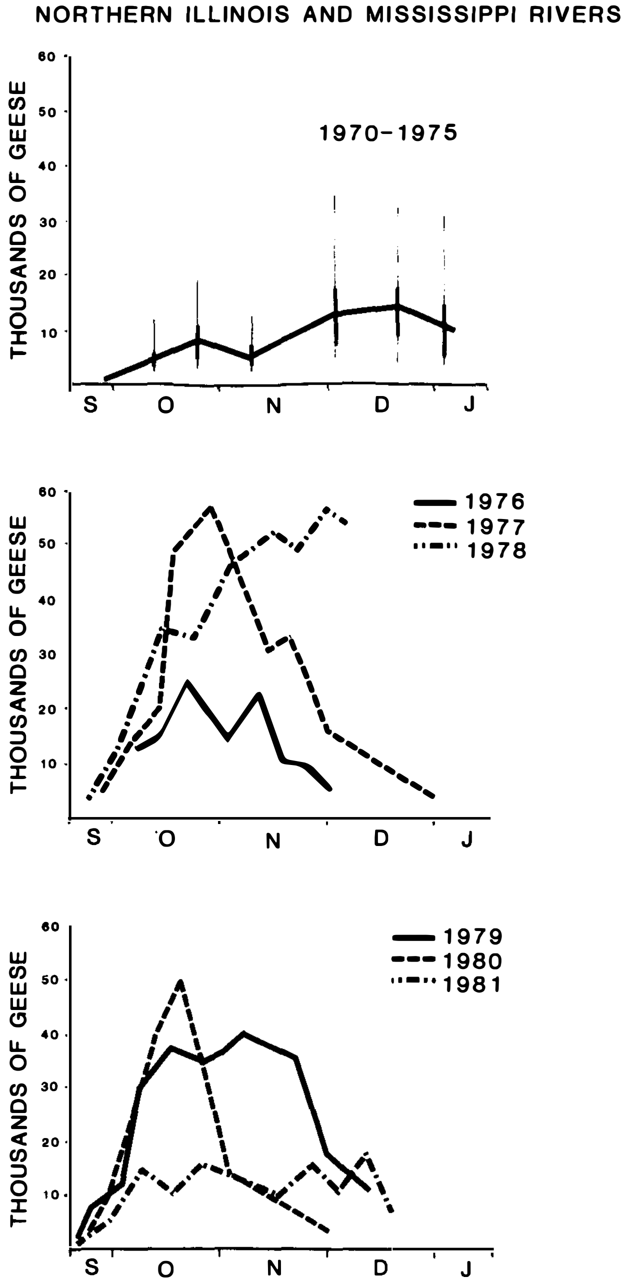


Figure 3. Estimated numbers of Canada geese in northern Illinois along the Illinois and Mississippi Rivers, 1970-1981.

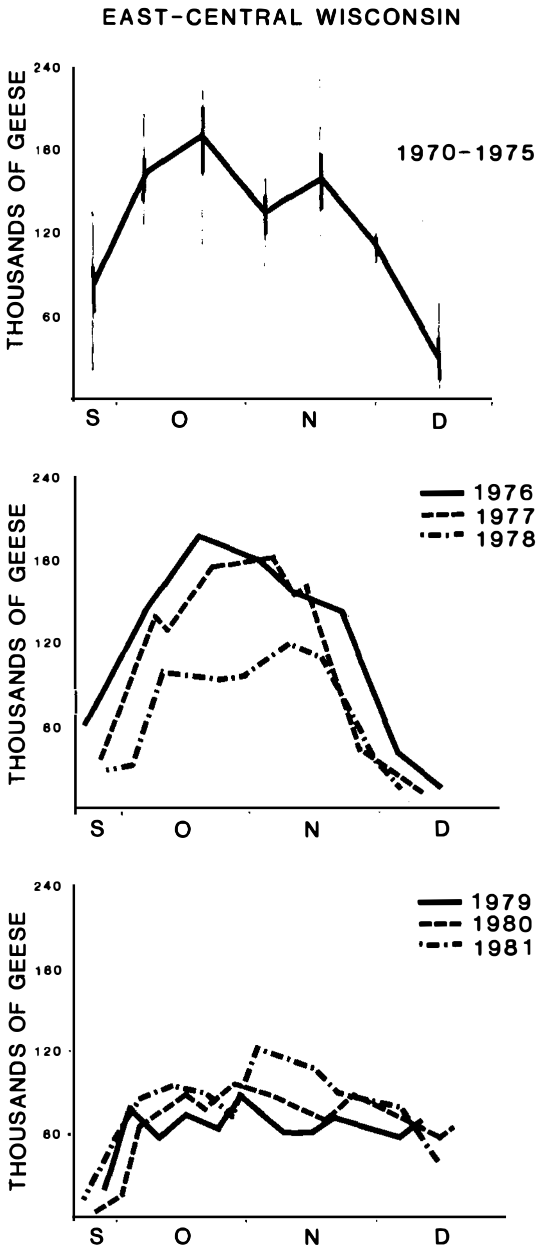


Figure 4. Estimated numbers of Canada geese in the east-central Wisconsin area, including Horicon Marsh, 1970-1981. Mean numbers of geese in 1970-1975 are plotted in the upper part of the figure. Wide and narrow vertical bars represent standard deviations and ranges, respectively.

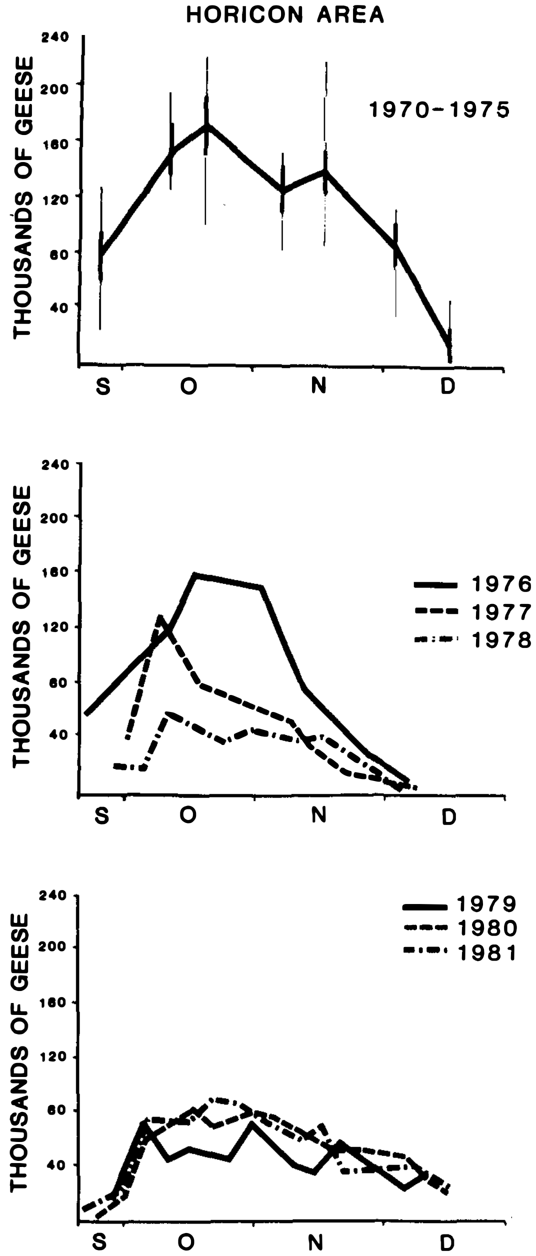


Figure 5. Estimated numbers of Canada geese on and within 10 kilometers of Horicon Marsh, Wisconsin, 1970-1981.

Thus following the initiation of the redistribution efforts at Horicon, increases in the parent MVP were not accompanied by proportional increases in geese using Wisconsin. In the first 2 years of the program, geese in ECW represented only 41 and 32 percent, respectively, of the total MVP count. In 1977-1980, the maximum Wisconsin count averaged about 25 percent of the subsequent MVP count. This share should be contrasted with the 1965-1975 period, when the maximum fall counts in east-central Wisconsin were consistently between 60 and 75 percent of the subsequent MVP mid-December count (Figure 6).

In addition to Horicon, several areas in east-central Wisconsin were also developed and managed for geese by the Wisconsin DNR during the 1950s and 1960s (Figure 1). By 1970-75, five of the DNR "satellite" goose projects attracted and held significant numbers of geese. Maximum counts for the 1970-1975 period averaged 3,950 at Collins Marsh, 5,150 at Eldorado, 8,500 at Grand River Marsh, 9,400 at Pine Island, and 1,350 at Theresa Marsh.

Estimates of numbers of geese on other areas in east-central Wisconsin, especially Grand River Marsh, increased dramatically (Figure 7) during the years geese were hazed on Horicon NWR. Total use by geese of Eldorado Marsh, Grand River Marsh, and other smaller areas increased by 140 percent, 180 percent and 91 percent in 1976-78, respectively, over 1970-1975 totals. These areas showed minor decreases over before-hazing levels (−8 percent and −3 percent) as numbers of geese in the MVP declined in 1979 and 1980.

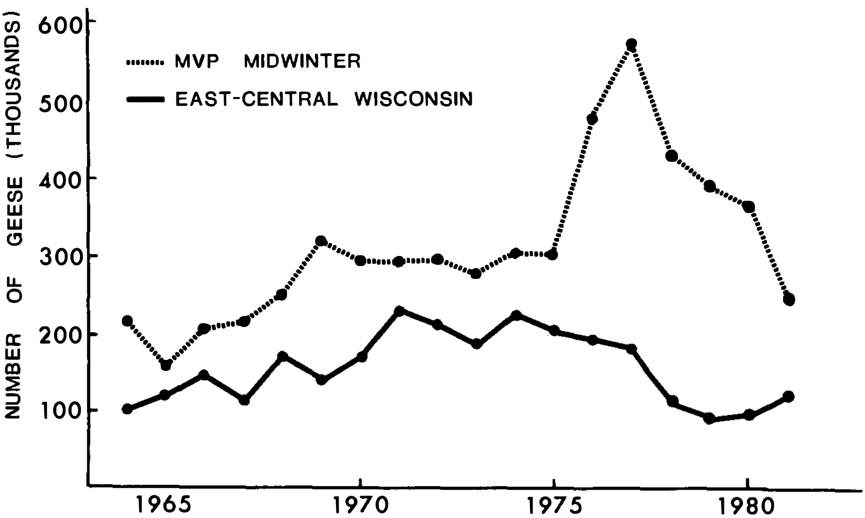


Figure 6. Numbers of Canada geese estimated present in the Mississippi Valley Population in mid-December compared to peak estimates in fall in east-central Wisconsin, 1964-1981.

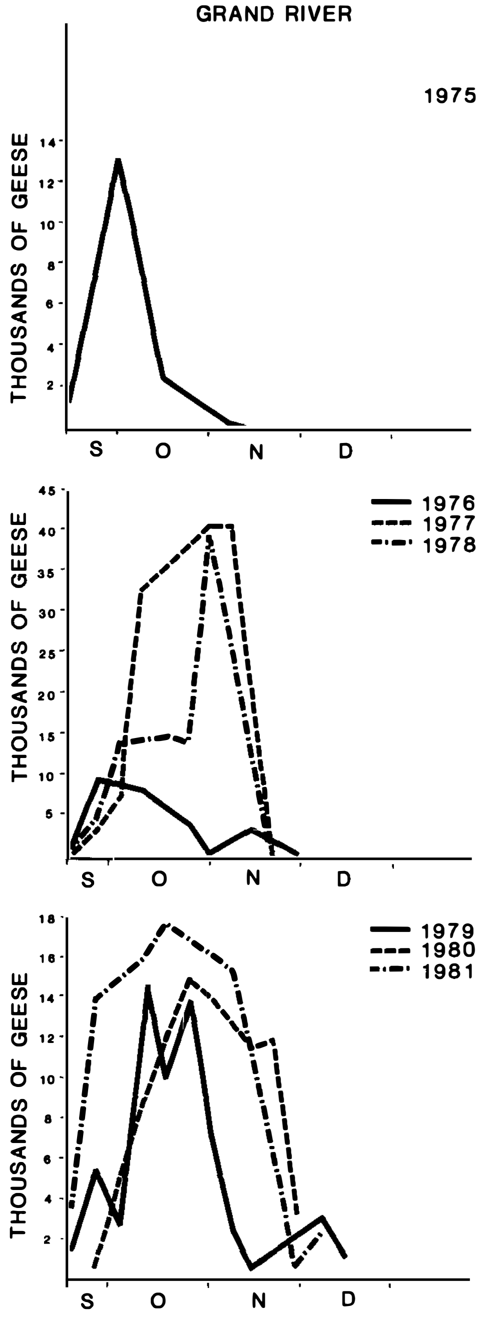


Figure 7. Estimated numbers of Canada geese on Grand River Marsh, Wisconsin, 1975-1981

Survival and Mortality of Geese

Leg band recoveries of geese shot by hunters were analyzed using Program Brownie (Brownie et al. 1978) to estimate survival and recovery rates. We combined the sexes after failure to reject the null hypothesis that recovery matrices for each sex were not different ($P = 0.30$). Model H2 was selected; we therefore assumed that recovery rates varied among years, that survival rates differed between 1st year and older birds, and that survival rates varied among years. Magnitude of and trends in survival indices calculated from encounters of marked geese (Jolly 1965, Seber 1973) were similar (Table 3) to those from legband recoveries (Brownie et al. 1978); the average of these 2 indices is hereafter referred to as survival rate. Survival rates for immatures decreased dramatically from a mean of about 0.63 in 1975-76 to about 0.48 in 1978-79, then increased in 1979-80 and 1980-81 to about 0.80 (Table 2). Survival rates for adults decreased from about 0.74 in 1975-76 to about 0.66 in 1978-79 and remained at about those levels in 1979-80 and 1980-81. The latter result was similar to estimates from band recoveries prior to the disturbance program.

Survival rates were associated ($r = -0.74$, $P = 0.09$) with goose harvests in Wisconsin which ranged from 46,000 in 1976 to 90,000 in 1977, then declined to 60,000 in 1980 (USFWS Administrative reports, unpublished).

Movements of Geese

Pronounced decreases in estimates of numbers of geese at Horicon NWR were associated with marked increases in estimates on Grand River Marsh and areas in northern Illinois (Figures 3, 5, and 7). Although large numbers of Canada geese were marked in the Horicon Area and subsequently encountered there (Table 1) and elsewhere throughout the flyway, there were insufficient encounters on satellite goose management areas in east-central Wisconsin and in northern Illinois to document changes in movements of neckbanded geese from Horicon.

Table 2. Estimates of survival rates[a] for Canada geese banded and/or marked near Horicon marsh, 1960-1980.

Year	Immatures		Adults	
	Jolly-Seber[b]	Brownie[c]	Jolly-Seber	Brownie
1960-65		0.810 ± 0.030		0.910 ± 0.030
1966-70		0.800 ± 0.030		0.820 ± 0.030
1970-75		0.690 ± 0.030		0.790 ± 0.030
1975-76	0.642 ± 0.035	0.613 ± 0.056	0.729 ± 0.023	0.761 ± 0.059
1976-77	0.634 ± 0.072	0.519 ± 0.069	0.650 ± 0.021	0.748 ± 0.059
1977-78	0.532 ± 0.072	0.666 ± 0.099	0.608 ± 0.024	0.707 ± 0.076
1978-79	0.478 ± 0.058	0.492 ± 0.116	0.538 ± 0.021	0.777 ± 0.099
1979-80	0.764 ± 0.109	0.829 ± 0.169	0.601 ± 0.021	0.808 ± 0.128
1980-81	0.612 ± 0.036	1.843 ± 0.592	0.646 ± 0.020	1.684 ± 0.514

[a]Means ± SE

[b]Estimates derived from subsequent encounters of marked geese using methods of Jolly (1965) and Seber (1973).

[c]Estimates derived from recoveries of legbands using methods of Brownie et al. (1978) and hypothesis H2 (year and age specific survival and recovery rates; unique first-year recovery rates for adults).

Table 3. Summary of management efforts to disturb Canada geese on and near Horicon National Wildlife Refuge, 1975-80[a].

	Year					
Management activities	1975	1976	1977	1978	1979	1980
Hunting of deer(d) and upland game(ug)	d[b]	d,ug[c]	d,ug	d,ug	d,ug	d,ug
Drawdown of water (difference from 1970-75 means)	0	−75%	−20%	0	0	0
Crops (hectares)	575	73	0	0	0	0
Hazing by airboat (hours)	0	1,100	2,000	60	70	0
Hazing via aircraft (hours)[d]	0	110	34	76	41	0
Disturbance via gas exploders (exploder-days)[e]	0	0	24,820	9,100	0	0

[a]Data from Anon, 1981. Goose watch, Final Report. Unpublished final report of the U.S. Fish and Wildlife Service and the Wisconsin Dept. of Natural Resources on the East Central-Wisconsin Canada goose project.
[b]No hunting of upland game or bow hunting of deer permitted in 1975.
[c]Refuge area opened to small game and bow and arrow deer hunting in order to create disturbance on upland sites.
[d]A helicopter was used to haze geese in 1976 (57 hrs) and for disease clean-up and surveillance in October, 1978 (76 hrs) and November 1979 and January 1980 (41 hrs).
[e]Airboats were used to service exploders; although geese were not directly pursued, the airboats did, nevertheless, disturb the geese and these hours are logged as "hazing by airboats."

The proportion of marked Canada geese that disappeared from Horicon was calculated from the numbers actually encountered (Table 1) and the year-specific probability of encounter (number encountered in year/number marked in year). Disappearance of neckbands was due to emigration, mortality, and neckband loss. Previous estimates of mortality (Table 2) and a mean neckband loss of 19 percent per annum (Craven 1979) thus enabled us to calculate rates of emigration. These crude estimates suggest that all geese marked or seen at Horicon the previous year returned in 1976; about 97 percent returned in 1977, 95 percent in 1978, and 100 percent in 1979, 1980 and 1981.

Crop Depredations

There was considerable concern on the part of managers and farmers near Horicon NWR that the dispersal program would aggravate crop depredation problems as displaced geese used private land for food and sanctuary. In 1975, 150 complaints of goose depredation were processed by both DNR and FWS staff at Horicon. In 1976, the first year of hazing, there were 266 complaints, an increase of 116 percent. In addition to dispersal of the geese, intensive publicity about how farmers should handle goose depredations may have contributed to that increase. There were 209 complaints of crop depredations processed in 1977, an increase over pre-program levels, but a decline from 1976. Complaints declined to historical levels, averaging about 130 in 1978-1980.

Efficacy of Management Activities

Managers encouraged geese to leave by reducing the availability of food on the refuges, by drawing down the water used for roosting and by disturbing the geese. To maximize impacts on geese, activities were usually carried on simultaneously, often without controls and adequate means of quantitative assessment. In addition, management activities varied within and among years and were often modified in response to behavior of the geese and the concerns of the public. We are thus unable to evaluate individual management activities specifically and quantitatively. Our subjective assessment of efficacy of management activities is that probably only hazing and crop reduction had an important impact on behavior of geese (Table 3).

Discussion and Management Implications

The numerical objectives of the Horicon goose redistribution program were reached by 1978; peak goose numbers were below 100,000 and use-days were less than 5 million. Continued use of east-central Wisconsin by geese after 5 December in 1980 and other years was probably mainly due to land use, weather, and their effects on goose food. Extensive fall plowing, a snow cover of 15-20 cm, a successful fall agricultural harvest and the freeze-up of roost lakes all reduce foods available to geese and probably all influenced the final departure of geese. Departure dates were probably not dramatically influenced by habitat management on public lands.

Numbers of geese in east-central Wisconsin tended to parallel numbers in the Mississippi Valley Population in 1965-75. With the advent of the redistribution efforts at Horicon in 1976, numbers of geese at Horicon decreased dramatically while the MVP apparently increased. Increases on Grand River Marsh and in northern Illinois were also noted, but could not be specifically related to goose movements; they may have resulted from the general increase in size of the MVP in 1976-1978.

Unusually large numbers of geese appeared in Tennessee, Mississippi, and Arkansas in the winters of 1976-77 and 1978-79. These movements were apparently related to food, weather, and perhaps goose densities on wintering areas (Trost el al. 1980); they were probably unrelated to the Horicon program. Analysis of visual encounters of neckbanded geese suggests that virtually all birds marked at Horicon return year after year provided they are still alive; changes in return rates were related mainly to changes in survival, not to emigration to other areas. In a detailed analysis of legband recoveries and neckband encounters in 1977-1980, Trost (1983) found adult geese from Illinois survived better than those from Wisconsin (71 percent versus 56 percent); immatures showed similar trends (56 percent versus 43 percent).

Airboats were the most effective and versatile means of hazing or disturbing geese. Their chief advantage was the ability to operate after dark. Canada geese also demonstrated high sensitivity to helicopters flying low over the marsh. The chief limitation of the helicopter was the restriction to daylight operation. Although geese loafed in upland areas during the daytime, they tended to return to water areas after dark. Airboat operators reported thousands of geese returning to the marsh during the 2-hour period after sunset. Reeves et al. (1968) concluded that inability to disrupt night roosting patterns was a key factor in failure to effectively haze geese from the refuge in 1966. Conversely, disruption of night roosting was achieved with airboats in 1976-78.

Propane exploders are widely used to alleviate crop depredation by geese in isolated agricultural fields, but they were largely ineffective in dispersing geese from Horicon marsh. On larger lakes and marsh areas (100ha), the amount of equipment needed to prevent geese from roosting between and among the exploders was prohibitive. Airboats provided the only practical means of servicing the exploders (adjustments in the firing mechanism and replacement of fuel tanks). The frequent use of airboats for exploder maintenance provided the major disturbance, not exploders.

Airboat operators and managers believed that airboat hazing quickly changed the local distribution of geese. However, airboat hazing was not without problems; it was expensive, labor intensive, and abhorred by some segments of the public. Salaries for airboat operators and airboat purchase/maintenance accounted for more than 65 percent of the $115,000 cost of the hazing program in 1976.

When subjected to intensive hazing, geese used mud flats for roosting and loafing and often loafed in upland fields and parking lots. There was some suspicion that night feeding activity may have increased in response to disturbance. Raveling et al. (1972) suggested an increase in night feeding when geese were disturbed by intensive hunting activity during the day.

Perhaps the major long-term impact of the change in habitat management on Horicon NWR was a shift in emphasis from a "single-species" approach for geese to a more diversified management for a variety of species, particularly ducks. Conversion of 283 ha of peatland from agricultural crops for geese to shallow marsh, and conversion of several hundred hectares of upland crops to dense grass cover illustrate this shift in management philosophy and potential benefits. Cropland is abundant in EC Wisconsin, but marshes and grasslands are relatively scarce.

Crissey (1968), Raveling (1978, 1979) and others have suggested that rather than habitat management on refuges, tradition, enforced by survival, may be the dominant factor influencing goose distribution. Consistent with this concept, geese at Horicon did not abandon migratory traditions when hazed or discouraged by habitat changes. Alteration of goose distribution in the Mississippi Flyway to benefit humans and geese will probably require innovative manipulation of harvest rates based on vastly improved knowledge of numbers, movements, and survival of individual goose flocks.

Summary

On continental or flyway scales, numbers of Canada geese have been successfully increased by wildlife managers for several decades. On a regional or local scale, however, problems related to abundance and scarcity of Canada geese have persisted and even intensified. In response to large concentrations of geese at Horicon Marsh and concerns about crop depredations, disease, and competition with other waterfowl, federal and state managers implemented a 5-year program to disperse these geese in 1976. Agricultural crops were eliminated on the Horicon NWR, the marsh was drawn down, and geese were disturbed with airboats and exploders. In 1974-1980, 7,380 geese were marked with plastic neckbands in order to detect and evaluate the roles of movement and survival in the planned redistribution of Horicon geese. About 2,813 recoveries and 117,094 encounters of geese banded or marked at Horicon indicated that most wintered in southern Illinois and Kentucky with the parent Mississippi Valley Population. Before the redistribution program commenced, rates of emigration from Horicon were low in October and early November, and most surviving geese marked at Horicon returned on subsequent falls. During the program, the numbers of geese which stopped at Horicon

decreased by 60 percent, even though the Mississippi Valley Population increased by about 50 percent in the same interval. The proportion of marked geese which were detected at Horicon decreased from 56 percent before the redistribution program began to 45 percent in 1976-79. Aerial counts, observations of marked geese, and band recoveries indicated that some geese from Horicon moved to nearby areas in Wisconsin and northern Illinois. A dramatic increase in harvest caused a decrease in survival from 70-80 percent per year prior to the program to 61-66 percent per year in 1976-79. Hazing was thought to have been the most effective tool in moving geese off Horicon NWR. Although the objective of a 50 percent reduction in numbers of geese at Horicon was met, most of the geese that disappeared from Horicon were probably shot; goose movement to other areas occurred but was less than had been hoped for.

Acknowledgments

The Horicon goose redistribution program involved hundreds of people; we appreciate their contributions. We specifically thank the entire staff at Horicon National Wildlife Refuge, especially J. E. Toll, and FWS personnel throughout Region 3. We also thank the staff at the Wisconsin Department of Natural Resources at Horicon, especially R. A. Hunt, and DNR managers throughout the state. Finally, we thank all the technicians and project assistants who conducted dispersal activities, counts, and observations of geese. We appreciate the analytical assistance of G. Swenson and M. Samuel.

Literature Cited

Brakhage, G. K., H. M. Reeves, and R. A. Hunt. 1971. The Canada goose tagging program in Wisconsin. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 36:275-295.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1978. Statistical inference from band recovery data—a handbook. Res. Publ. 131. U.S. Fish and Wildlife Serv. 212 pp.

Craven, S. R. 1978. Distribution and migration of Canada geese associated with Horicon Marsh, Wisconsin. Ph.D. Thesis. Univ. of Wisconsin, Madison. 135 pp.

______. 1979. Some problems with Canada goose neckbands. Wildl. Soc. Bull. 7:268-273.

Crissey, W. F. 1968. Informational needs for Canada goose management programs. Pages 141-146 *in* R. L. Hine and C. Schoenfeld, eds. Canada goose management. Denbar Educational Research Services, Madison, Wisc. 195pp.

Green, W. E. 1968-1973. The phenology of the fall migration of Canada geese in Dodge and Fond du Lac Counties, Wisconsin and its relationship to agricultural crops. Progress Reps. 6 vols. U.S. Fish and Wildl. Serv., Div. of Wildl. Refuges.

Hankla, D. J., and R. R. Rudolph. 1967. Changes in the migration and wintering habits of Canada geese in the lower portion of the Atlantic and Mississippi Flyways—with special reference to National Wildlife Refuges. Proc. Annu. Conf. Southeast Assoc. Game Fish Comm. 21:133-144.

Hanson, H. C., and R. H. Smith. 1950. Canada geese of the Mississippi Flyway, with special reference to an Illinois flock. Bull. Ill. Nat. Hist. Surv. 25(3):59-210.

Hunt, R. A., J. G. Bell, and L. R. Jahn. 1962. Managed goose hunting at Horicon Marsh. Trans. N. Amer. Wildl. Natur. Resour. Conf. 27:91-106.

Hunt, R. A., and J. G. Bell. 1973. Crop depredations by waterfowl in Wisconsin. Pages 85-101 *in* Proceedings of the 6th Bird Control Seminar, Bowling Green State Univ., Bowling Green, Ohio.

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. Biometrika 52:225-247.

Klepinger, K., and J. W. Ellis. 1975. Strategy paper—management of Canada geese in east-central Wisconsin. Federal Bldg. Fort Snelling, Twin Cities, MN. 93 pp.

LaMarche, E. D. 1972. Radar moritoring of the departures of *Branta canadensis* from the Horicon Refuge Area, 1970 fall migration. M.S. Thesis. St. Mary's College, Winona, Minnesota. 53 pp.

Raveling, D. G. 1978. Dynamics of distribution of Canada geese in winter. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:206-225.

______. 1979. Traditional use of migration and winter roost sites by Canada geese during winter. Wilson Bull. 84(3):278-295.

______, and H. G. Lumsden. 1977. Nesting ecology of Canada geese in the Hudson Bay Lowlands of Ontario: evolution and population regulation. Fish and Wildl. Res. Rept. No. 98. Ontario Ministry of Natur. Resour. 77 pp.

Raveling, D. G., W. E. Crews, and W. D. Klimstra. 1972. Activity patterns of Canada geese during winter. Wilson Bull. 84(3). 278-295.

Reeves, H. N., H. H. Dill, and A. S. Hawkins. 1968. A case study on Canada goose management. The Mississippi Valley Population. Pages 150-165 *in* R. L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educational Research Services. Madison, Wis. 195 pp.

Seber, G. A. F. 1973. The estimation of animal abundance. Hafner Press, New York. 506 pp.

Trost, R. E. 1983. Ecological aspects of Canada geese and other waterfowl in the Mississippi Flyway. Ph.D. Thesis. Univ. of Wisconsin, Madison. 88 pp.

______, D. H. Rusch,and D. H. Orr. 1980. Population affiliation of Canada geese from six southern refuges. Proc. Annu. Conf. Southeast Assoc. Game Fish Comm. 35:598-606.

Factors Affecting Autumn and Winter Distribution of Canada Geese

Dale D. Humburg and David A. Graber
Missouri Department of Conservation
Columbia, Missouri 65201

Kenneth M. Babcock
Missouri Department of Conservation
Jefferson City, Missouri 65102

Introduction

Cooperation among natural resource agencies is essential for successful management of North American waterfowl. Those involved with migratory bird management can, for the most part, take pride in the cooperative spirit with which these valuable resources have been managed. One principal management issue, however, that has repeatedly threatened to undermine the unified approach among political entities is changing distribution of certain species or populations of birds. Waterfowl distribution changes have often been perceived to be the result of management efforts by one state to increase populations at the expense of declining numbers in other areas.

Shifts in migration patterns no doubt have changed major waterfowl population centers or delayed arrivals on wintering grounds. A variety of species have been involved in controversy surrounding waterfowl distribution and subsequent alterations in recreational opportunities. Canada geese (*Branta canadensis*), however, have most often been the object of contention. Initial population increases and attendant changes in winter distribution of Canada geese occurred by the early 1950s (Hanson and Smith 1950, Vaught and Kirsch 1966, Crider 1967). By the mid-1970s Canada goose numbers in the United States almost doubled those in the mid-1950s (Bellrose 1978:142). Coincident with population growth and distribution changes were development of waterfowl refuge systems, changes in agriculture land use, and completion of major water resources projects. The most frequently implicated factors affecting long-term changes in Canada goose distribution include intensified refuge and food management on northern state and federal waterfowl areas (Hankla and Rudolf 1967) and differential survival/harvest of various population segments (Crissey 1968, Raveling 1978).

Regardless of reasons for distribution changes, waterfowl managers are now faced with migration and wintering patterns dramatically different from those 30 years ago. Canada geese continue to redistribute themselves among states, but major segments are primarily associated with managed state and federal lands that offer predictable refuge areas, or private lands such as the Delmarva Peninsula (Bellrose 1978:148). Managed public areas, particularly in the mid-latitudes, are usually associated with rich agricultural regions where an abundance of grain and browse are provided on nearby private lands. Short-term, seasonal distribution between public and private land is affected by refuge and hunting season, and the vagaries of weather, food abundance, and food availability. Knowledge of the factors that affect short-term Canada goose distribution can assist waterfowl managers with habitat and population planning efforts.

We believe the Eastern Prairie Population (EPP) is representative of growth and distribution changes of Canada goose populations. Our purpose here is to examine autumn and winter EPP Canada goose distribution in Missouri and to describe how managed agricultural crops, weather, and refuge/hunting season influence distribution.

Methods

Study Area and Population

The EPP is defined as the wintering concentration of Canada geese primarily associated with Swan Lake National Wildlife Refuge (NWR) and Fountain Grove Wildlife Area (WA) (Babcock et al. 1978:2). The EPP primarily migrates on through Manitoba, Minnesota, and Iowa from the major nesting region in northern Manitoba (Vaught and Kirsch 1966, Malecki et al. 1981). Periodic aerial surveys and ground counts of Canada geese in Missouri were conducted annually, 1955-1984, and were the bases for our examination of factors affecting seasonal changes in goose numbers and distribution. Populations associated with Swan Lake NWR and Fountain Grove WA are included in the Swan Lake Zone, a 1,400 square mile (3,626 km^2) goose management zone in North Central Missouri (Figure 1). Swan Lake NWR is a 10,670 acre (4,318 ha) area located approximately six miles (9.66 km)

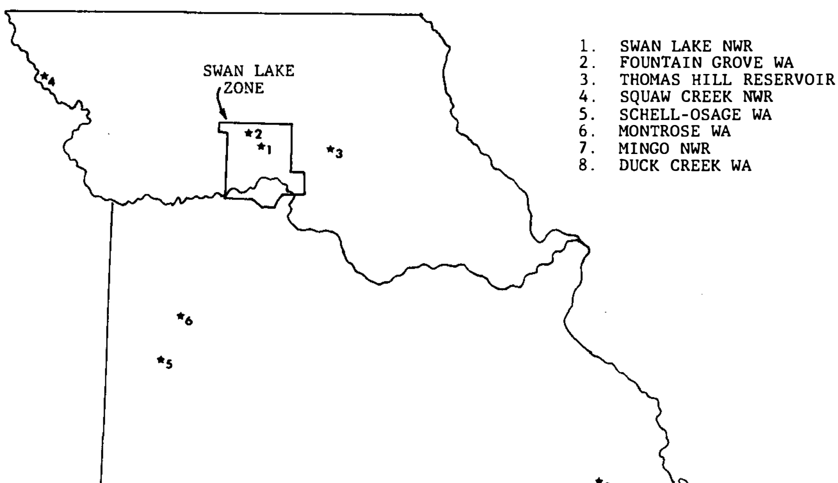


Figure 1. Missouri areas included in an index of Canada goose populations, 1955-1984.

southeast of the 6,318 acre (2,557 ha) state-owned Fountain Grove WA. North Missouri population indices included surveys of the Swan Lake Zone, the Missouri River outside the Zone, Squaw Creek NWR, and Thomas Hill Reservoir. Additional areas included in a statewide index to Canada goose populations were Montrose, Schell-Osage and Duck Creek WA, and Mingo NWR (Figure 1).

Temporal goose distribution among areas was recorded by weekly surveys beginning with initial migrations in September and continuing until January. We selected surveys nearest 15 October, 1 November, 1 December, 15 December, and 1 January. Mid-December and early January surveys coincided with the annual flyway-wide coordinated surveys of geese in December and all waterfowl in January.

Factors Affecting Distribution

We compared seasonal Canada goose surveys with indices to crop production, weather, and hunting season. The range of impacts and relationships among food, weather, and hunting are broad and complex. No single factor can be used to explain variable Canada goose distribution. We used a combination of simple relationships between Swan Lake NWR and Canada goose numbers and indices to refuge grain production, winter temperature and snowfall, and hunting season length to illustrate the impact and temporal influence of factors affecting distribution.

Annual production of grain crops—corn, milo, and soybeans—left standing on Swan Lake NWR is an index to managed Canada goose food. Vaught and Kirsch (1966) and Babcock et al. (1978) described the historical changes in Swan Lake NWR crop management. Briefly, this has involved a progression from permittee cropping of less than 1,000 acres (405 ha) prior to 1950, to shared agency/permittee farming of 1,300 grain crop acres (526 ha) after the early 1960s. Beginning in 1980, changes in Swan Lake NWR farming philosophy incorporated a crop rotation system and resulted in reduced grain crop acreage. Crop production on managed public land is one of several factors affecting food abundance and availability. On Swan Lake NWR, production of natural foods (150-2,200 acres [61-980 ha]) and wheat (70- 1,850 acres [28-749 ha]), 1968-1984 has been variable (Swan Lake NWR Annual Reports). Depending upon fall plowing and other factors affecting food availability, the supply of waste grain on private land in the Swan Lake Zone may be well in excess of wintering Canada goose requirements (Babcock et al. 1978:69-70). Foods other than managed grain crops may be important for migrant and wintering waterfowl. However, production and/or availability and the relationship to goose distribution is difficult to quantify. Therefore we used production of grain crops left standing on Swan Lake NWR to reflect the annual status of managed food on public land.

Weather directly affects Canada goose distribution through factors such as snowfall, ice cover, or fall/winter flooding. Indirectly, weather influences goose distribution through weather variables that affect crop production. Freezing temperatures and snowfall eliminate open water and reduce food availability. Such conditions directly influence goose distribution. Seasonal precipitation extremes affect crop production, food availability, and wetland conditions. The timing of excessive or deficient precipitation determines specific impacts. Records of daily temperature and flood and drought frequency from Fountain Grove WA, a reporting station for the National Climatic Data Center, (National Oceanic and Atmospheric Administration, Asheville, NC) were used to reflect weather variables. December and January average minimum temperature and snowfall characterized winter weather severity. Because of the relationships among precipitation extremes, food production, and food availability, effects of individual factors on goose distribution are difficult to quantify. Therefore we simply described the frequency and seasonal occurrence of floods and drought and discussed the impact of these events on food production and availability.

Swan Lake NWR was established in 1937. A hunting program has been operated by the Missouri Department of Conversation on a 2,500 acre (1,012 ha) perimeter of the refuge by cooperative agreement since 1955. Hunting seasons in the Swan Lake Zone have ranged from 14-70 days during the same period. Season length has been limited by 14,000-30,000 goose harvest quotas since 1960. Hunting season length was the variable compared with goose populations to reflect the influence of refuge and hunting season on Canada goose distribution.

Results

Population

Peak populations on Swan Lake NWR, 1941-1984 reflect EPP status and increased affiliation with North Central Missouri in the 1940s and early 1950s (Figure 2). Modest increases in Swan Lake peak populations occurred until 1946. Canada goose populations declined at Swan Lake NWR and throughout the Mississippi Flyway in 1946 and the hunting season was closed flyway-wide. Hunting

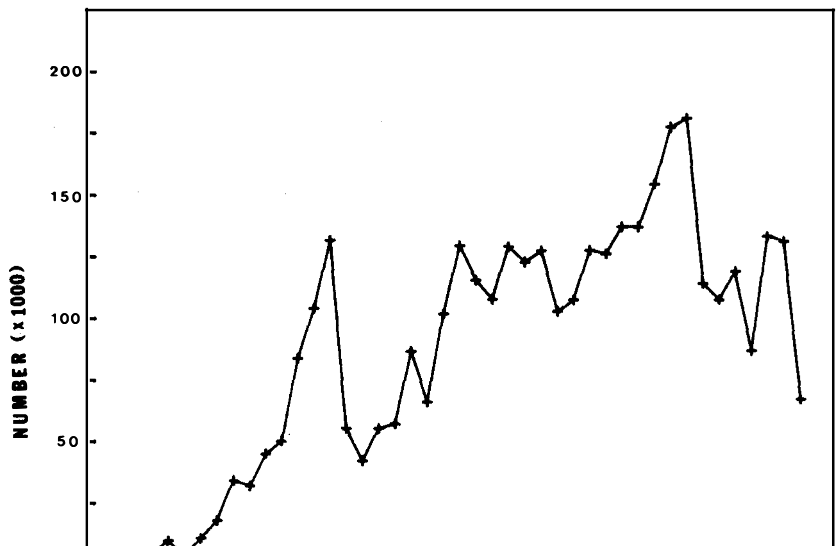


Figure 2. Peak Canada goose populations on Swan Lake National Wildlife Refuge, 1955-1984.

season restrictions in effect through the early 1950s corresponded to a period of dramatic EPP growth and increased affiliation with Swan Lake NWR. During this period, proportional population growth was not evident on wintering areas south of Missouri (Babcock et al. 1978:8). Excessive harvest and associated EPP decline in 1955 corresponded to establishment of a hunting program on Swan Lake NWR. Harvest controls were established by 1960, and gradual increases or stable peak populations occurred until 1969. During the 1969 nesting season a June snow storm resulted in a production failure. Subsequent population decline was due to poor production and a continued high harvest rate. Reduced quotas in the Swan Lake Zone and harvest restrictions in other areas, coupled with excellent production, were responsible for dramatic increases in the EPP through the mid-1970s. Generally poor EPP production, (Rusch 1984) continued harvest, and broader autumn/early winter distribution north of Missouri (W-13-R progress reports) accounts for lower Swan Lake peak numbers since 1978.

Changes in Canada goose distribution among areas in Missouri (statewide, North Missouri, public lands in the Swan Lake Zone, and Swan Lake NWR) during the period, 1955-1984 were examined. This 30-year period followed most dramatic EPP increases and includes the period of cooperative EPP management.

Seasonal population levels among Missouri areas indicate the relative importance of Swan Lake NWR and Fountain Grove WA (public land in the Swan Lake Zone) to Canada geese from mid-October to early January. Mid-October Canada goose populations have been relatively stable since 1960. During autumn, most geese have been associated with public lands in the Swan Lake Zone (Table 1). The most dramatic population increase on public lands occurred from the late 1950s (1955-1959) to the early 1960s (1960-1964). No major increase in early fall numbers occurred in the 25 years, 1960-1984. Similar population and distribution trends were apparent in early November, with inventories remaining relatively stable 1960-1984. Early November populations in the early 1960s, however, increased proportionately more than did mid-October numbers. These early fall trends were not consistent with an EPP increase of more than 200 percent, 1960-1975 (Babcock et al. 1978:9-13).

Early December Canada goose numbers in Missouri progressively increased, 1955-1979. During the late 1950s, December populations declined about 50 percent from October levels. During the early 1960s, the proportion of November goose numbers remaining on public lands in December was higher than in the late 1950s. The trend for Canada geese to remain in Missouri and utilize public areas in early December continued to increase from the mid-1960s through the 1970s. The early December increase in Missouri Canada goose numbers was comparable to EPP growth.

Mid-December Canada goose populations in North Missouri increased statewide 1955-1979; however, the flock associated with Swan Lake Zone public lands has been relatively stable since 1965. Similar to mid-December, numbers of geese in early January increased in Missouri during the late 1960s and 1970s. In early January even fewer geese were associated with public lands than in mid-December.

Winter goose distribution was limited primarily to North Missouri until the late 1970s. During the last ten years a declining proportion of statewide December and January populations have occurred in North Missouri and on Swan Lake NWR. Since the late 1970s, fewer Canada geese have been surveyed in December in

Table 1. Missouri Canada Goose Populations, 1955-1984. Expressed as five year averages of periodic surveys for statewide, North Missouri, public lands in the Swan Lake Zone[a], and Swan Lake National Wildlife Refuge.

	Survey period				
Years/Area	Mid-October	Early November	Early December	Mid-December	Early January
1955-1959					
Statewide	57,600	55,600	30,900	34,900	22,700
North Mo.	57,500	53,400	28,400	31,900	20,000
Public Land	52,800	44,800	23,700	25,800	16,800
Swan Lake	52,100	44,800	22,200	21,900	15,500
1960-1964					
Statewide	95,600	106,800	84,200	76,000	73,900
North Mo.	93,900	102,300	79,100	70,500	67,700
Public Land	89,400	96,100	67,200	63,700	58,300
Swan Lake	85,200	89,200	58,000	57,700	50,900
1965-1969					
Statewide	97,900	125,300	112,900	120,700	116,900
North Mo.	97,200	123,000	107,600	113,900	103,900
Public Land	94,790	117,700	100,700	99,200	49,700
Swan Lake	84,400	109,200	91,000	82,400	42,200
1970-1974					
Statewide	100,200	148,300	166,200	165,900	164,900
North Mo.	99,000	141,200	152,400	149,500	138,800
Public Land	89,100	132,900	125,100	97,400	54,100
Swan Lake	78,200	117,600	94,300	62,800	39,100
1975-1979					
Statewide	107,900	148,000	196,200	213,000	204,500
North Mo.	102,200	138,600	174,000	183,800	166,400
Public Land	79,800	131,200	147,800	98,500	64,100
Swan Lake	73,300	119,600	131,400	69,500	45,400
1980-1984					
Statewide	78,500	133,700	148,500	147,200	121,500
North Mo.	76,100	115,500	117,800	112,700	64,600
Public Land	55,800	114,300	97,900	84,600	36,100
Swan Lake	53,500	94,800	78,800	69,900	15,900

[a]Swan Lake Zone Public Lands included Swan Lake NWR and Fountain Grove WA

Missouri. The EPP declined from a peak of 270,000 in 1977 to levels below 200,000 since 1979. In addition to lower population status, reduced Missouri populations in December have been the result of EPP numbers in Minnesota that increased from an average 11,800, 1975-1979 (range = 800-33,600) to 31,800, 1980-1984 (range = 14,000-16,000) (W-13-R progress reports).

Factors Affecting Distribution

Average numbers of Canada geese surveyed in Missouri indicate general changes in population levels and distribution. Individual year population levels have also been variable, however. Seasonal differences in Swan Lake NWR managed crop production, regional-weather conditions, and Swan Lake Zone hunting season length have also been substantial and were used to explain variable numbers of Canada geese utilizing Swan Lake NWR.

Crop Production

Swan Lake NWR grain crop production ranged from 4,920 to 118,000 bushels, 1955-1984. We compared annual Swan Lake NWR crop production with the Swan Lake NWR Canada goose population in early December and early January to determine when standing grain crops were important to Canada geese. Babcock et al. (1978) estimated that average grain yields 1971-1975 would have supplied one-third of the Swan Lake Zone Canada goose food needs, about the number of goose-use days reached in late November/early December. The Canada goose population on Swan Lake NWR, 1955-1984 in early December (range = 6,750 to 177,725), was significantly correlated (r = 0.075, P = 0.001) with refuge crop production (Figure 3). However, goose numbers in winter (early January) did not appear to be related to refuge crop conditions. The number of Canada geese on Swan Lake NWR in early January (range = 0 to 181,300) was not significantly correlated with refuge crop production (r = 0.705, p = 0.251).

Among years, the number of Canada geese and crop production varied considerably. Although correlated with goose numbers in early December, managed crops alone did not determine goose use of Swan Lake NWR. Impacts of variable hunting

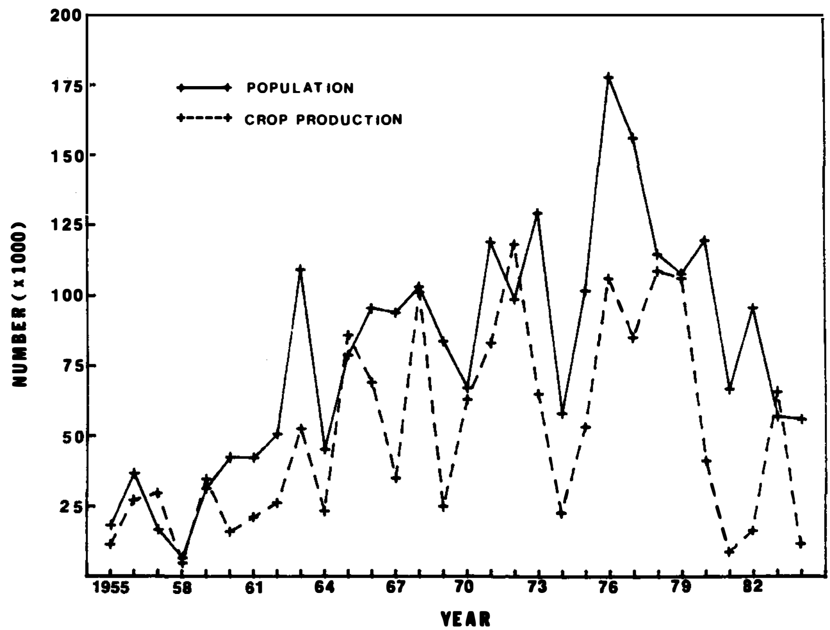


Figure 3. Swan Lake National Wildlife Refuge Canada goose populations surveyed nearest 1 December and bushels of standing grain crops (corn, soybeans, milo) produced on the Refuge, 1955-1984.

season length, private land crop conditions, and weather were undoubtedly important annual variables. For example, fall floods in 1967, 1969, and 1982 (Table 2) likely increased private land food availability and negated impacts of poor refuge crop production. Swan Lake NWR crop production appears to have been one factor influencing refuge goose numbers prior to mid-December, but less of a factor affecting later season goose use of the refuge.

Weather

Severe winter weather also affects December/January Canada goose distribution. During the 20 years 1965-1984, there was an increased tendency for geese to remain in the Swan Lake area during December and January. We compared the proportion of the mid-December Swan Lake Zone population remaining on the Swan Lake NWR in early January with December/January average minimum temperature and total snowfall. Ten inches (25.4 cm) of snowfall and average minimum temperatures less than 12°F (-11.1°C) appeared to correspond with predictable goose dispersal from Swan Lake NWR (Figure 4). Less snow and higher average temperatures corresponded to more variable Canada goose dispersal. Combinations of extreme low temperatures and heavy snowfall occurred in 4 of the last 20 years (1976, 1978, 1981, and 1983), accounting for a low proportion of geese remaining on Swan Lake NWR. In addition, greater snowfall alone corresponded with dispersal of geese in 4 of 20 years when relatively mild temperatures occurred (1972, 1973, 1974, and 1984). We did not account for snow melt during years of mild temperatures. Some of the inconsistency in goose distribution was probably due to combinations of snowfall and mild temperatures (e.g., 1966 and 1969). Despite the low average temperature in 1977, lack of snowfall, 4.5 inches (11.4 cm), accounted for a higher proportion (93.1 percent) of the December zone population that remained in early January.

Mid-latitude waterfowl management areas are usually associated with rivers and their flood plains. Drought has obvious impacts on crop production, but excess precipitation near flood prone areas may have even more dramatic effects on farming and wetland management. Combined, flood and drought frequency and timing determine crop production and wetland conditions. Swan Lake NWR is located near the Grand River and is intersected or bordered by three other streams. Major floods affect all but approximately 250 acres (101 ha) of refuge agricultural land (Babcock et al. 1978:68). Records of drought and flood occurrence and precipitation data from Fountain Grove WA show the frequency of drought and floods, 1955-1984 (Table 2).

Spring (March-May) flooding was most frequent (20 of 30 years). Depending upon timing and duration, spring floods may delay planting, negate planting efforts that occurred earlier, or affect drawdown management for moist soil plants (Fredrickson and Taylor 1982). Early summer floods (June-July), which occurred in about one-half the years examined, often occurred too late to allow replanting of the affected lowland areas. Late summer/early autumn (August-September) floods occurred in about one-third of the last 30 years. Cultivated and moist soil crops can be nearly eliminated in flood prone areas, and wheat planting can be significantly affected by late summer flooding. Hunting season (October-December) flooding, similar in frequency (12 of 30 years) to late summer flooding, has less effect on public area agricultural crops. Excessive autumn precipitation delays fall plowing which may improve food availability on private land and affect goose dispersal from

Table 2. Swan Lake National Wildlife Refuge grain crop production (bushels) and the frequency of seasonal drought and floods, 1955-1984.

	Seasonal flood (+)/Drought (−)												
Year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Crop production
1984-85	+	+	+	+	−	−			+				11,900
1983-84	+	+											65,650
1982-83	+	+	+	+		+	+	+	+	+			16,650
1981-82	−	−	+	+	+						+	+	8,960
1980-81				−	−	−				+			41,250
1979-80		+	+							+			105,850
1978-79		+				+	+						108,450
1977-78							+	+	+				85,000
1976-77	+	+			−	−							105,800
1975-76		+	+		−	−	−	−	−	−			53,250
1974-75			+	+/−	−								22,625
1973-74	+	+	+		+		+	+		+			65,000
1972-73		+	+						+			+	118,000
1971-72										+			83,000
1970-71		+	+	−	−		+	+		+		+	63,000
1969-70					+		+	+	+				25,000
1968-69		+											101,200
1967-68				+				+	+				35,250
1966-67				+	−	−	−	−	−	−			69,000
1965-66	+	+			+		+						86,000
1964-65				+	−	−	+				+		23,400
1963-64	+						−	−	−	−			52,600
1962-63	+												26,280
1961-62	+	+			+		+		+			+	21,180
1960-61		+		+	−	−		+					16,000
1959-60			+	+	+		+						34,750
1958-59					+					+			4,900
1957-58			+										29,800
1956-57	−	−	−			+							27,350
1955-56													11,450

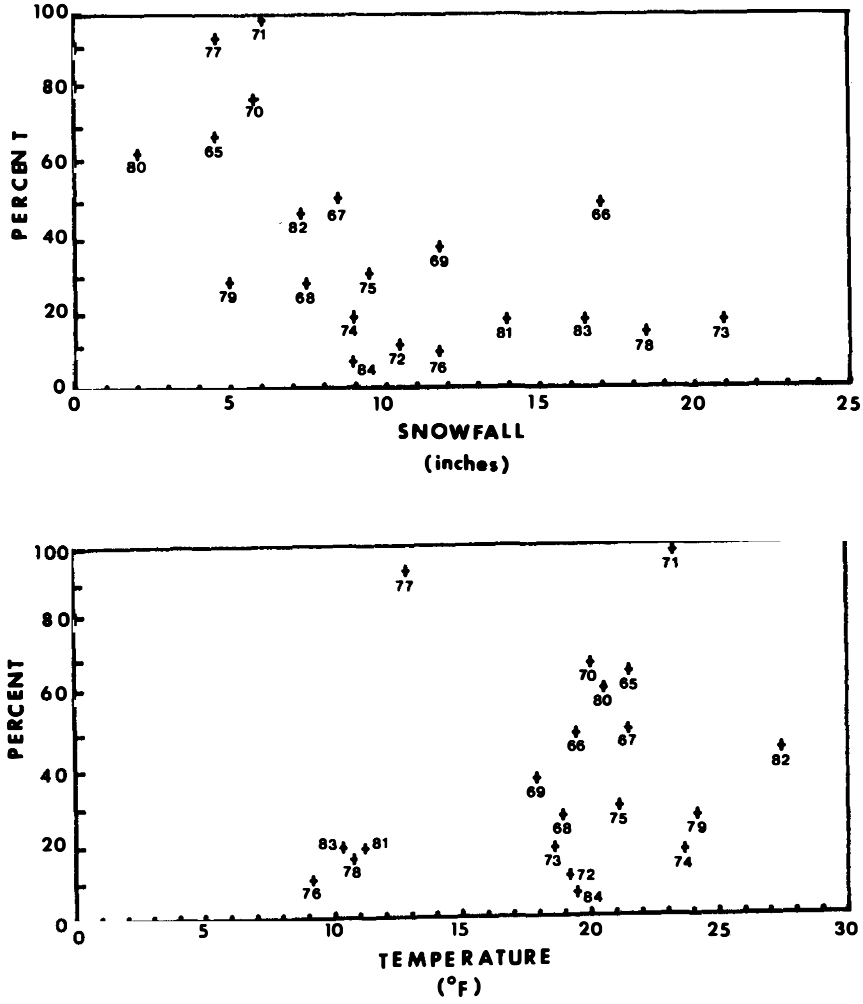


Figure 4. The proportion of mid-December Swan Lake Zone population remaining on Swan Lake National Wildlife Refuge during the Mid-Winter Survey as a function of total December and January snowfall (inches) and average minimum December/January temperatures (°F), 1965-1984.

managed public areas. These conditions also increase potential for crop depredations (Kahl 1980:41).

Drought occurred in about one-third of the summer and once in 10 autumn seasons, 1955-1984. Crop production is affected by growing season drought while reflooding of wetlands may be affected by deficient fall precipitation. Either flooding or drought have occurred most years since 1955. A wide range of impacts are associated with precipitation extremes; however, the general effect is to reduce the predictability of waterfowl area management.

Season Length and Refuge

Missouri Canada geese are most closely associated with managed public areas in November and early December (Table 1). This period corresponds to the time when hunting pressure is the greatest, weather is relatively mild and refuge food is most apt to be abundant. To relate the importance of managed refuges to Canada geese, we compared the length of the Swan Lake Zone Canada goose season with the proportion of the North Missouri peak population using Swan Lake NWR and the Fountain Grove WA refuges at the end of the Canada goose season (Figure 5). The timing of goose seasons was fairly consistent, opening between 20 October and 1 November in 25 of the 30 years, 1955-1984. The proportion of the peak population associated with refuges was the greatest during the shortest seasons. An average of 87 percent (range = 84 to 88 percent) of the peak population remained on refuges when seasons of 14-16 days occurred. Progressively, a smaller and more variable proportion of peak goose numbers were associated with Swan Lake zone refuges as the season length increased. During years with long hunting seasons, refuges appeared less effective and/or important. Declining hunting pressure, reduced refuge food abundance, and increased weather severity were likely contributing factors.

Discussion

Seasonal changes in Missouri Canada goose numbers offer insight into the influence of Swan Lake NWR and other mid-latitude refuges. Prior to 1965, increases in

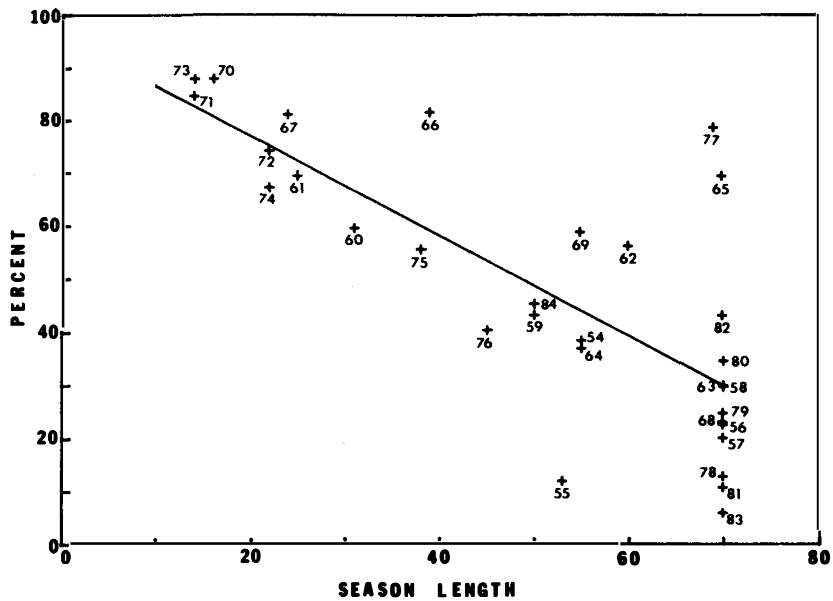


Figure 5. The proportion of the Swan Lake Zone peak population surveyed on Swan Lake National Wildlife Refuge and Fountain Grove Wildlife Area at the end of the Canada goose hunting season as a function of the hunting season length in the Swan Lake Zone, 1955-1984.

goose numbers occurred during all survey periods. The influence of managed areas appeared substantial, both for autumn migrant and wintering Canada geese. During the last 20 years, the number of geese associated with public areas in the Swan Lake Zone has not increased markedly during early autumn (October) nor early winter (mid-December to January). Despite continued population growth through 1977, no additional early autumn migrations into Missouri have occurred. This was primarily due to October populations in Manitoba and Minnesota that increased in levels in excess of 100,000 geese by the early 1980s (W-13-R progress reports).

Wintering Canada goose populations statewide and in north Missouri have increased without associated population growth on managed areas. In recent years, a period of EPP decline, fewer geese have been associated with Swan Lake Zone public areas. This has coincided with a period of generally poor EPP production (Rusch 1984), greater frequency of severe winter weather, relaxed EPP hunting seasons, and reduced Swan Lake NWR crop production. Most dramatic declines have occurred in mid-December and early January, which corresponds to the period when reduced refuge, food availability, and severe weather have the most pronounced effect.

Factors of food, weather, and refuge/hunting seasons differ in impact and timing of influence relative to Canada goose distribution. Canada goose managers have the greatest influence on hunting season regulations and refuge, and progressively less impact on food abundance, flood frequency, drought effects, and winter weather impacts. There is an increasing management intensity required and decreasing likelihood of management success along the same gradient.

Canada goose managers have been effective in controlling goose harvest (Vaught and Kirsch 1966, Reeves et al. 1968, Babcock et al. 1978:12-15). These efforts coincided with substantial Canada goose population increases in the Mississippi Flyway. Refuges are most effective when the highest proportion of the population is associated with them. When seasons exceeded 40-50 days in length, a smaller and more variable proportion of the EPP in Missouri was associated with Swan Lake Zone refuge areas. Raveling (1978) discussed the implications of goose dispersal and cumulative harvest impacts. Giant Canada geese (*B.c. maxima*) dispersing south from Minnesota were 4.7 to 5.5 times more likely to be shot as geese that remained at Rochester, Minnesota. When management objectives are to maintain or decrease harvest, hunting during periods of reduced refuge influence may be detrimental. Managers should determine the period when refuges are most effective and establish harvest management objectives and seasons accordingly.

Managed grain crops on northern refuges have been implicated as a cause of Canada goose distribution changes (Hankla and Rudolf 1967, Crider 1967). The amount of grain produced on Swan Lake NWR influences the number of geese utilizing the refuge prior to mid-December. However, by early winter (January), when weather severity was greater and refuge influence less, Canada goose numbers were not affected by Swan Lake crop production. General trends in Swan Lake Canada goose numbers corresponded to the timing of managed crop influence. Early December goose numbers increased 1955-1979, whereas later season populations stabilized or declined after 1965. Wintering Canada goose populations in Missouri, however, continued to increase without late season refuge crop influence. Despite Canada goose dispersal from Swan Lake Zone refuges, a high proportion remained in North Missouri. For example, 52,900 Canada geese (range = 7,125-

173,275) were surveyed on the Missouri River in early January, 1965-1984.

Managed grain crops appear to have been an unpredictable basis for goose management in north central Missouri. In light of the extreme variability in crop production, it is unlikely that managed food alone was responsible for increasing Canada goose use of Swan Lake NWR. The influence of weather events such as floods and drought has been substantial. Cropland acreage may be limited by the amount of flood-prone land. Goose managers can respond with levee systems or moist soil management. Irrigation may be utilized to negate drought impacts. Cropping limitations should be considered when objectives are established for refuge food management. Substantial capital outlay may be required to ensure predictable cropping systems in the long term.

Despite unpredictability of managed crops, refuge food resources play an important role in Canada goose management. Vaught and Kirsch (1966) reported increased hunter success and goose harvest when Swan Lake NWR crop production was low. When refuge crop production declines, a greater amount of feeding must occur on private land. During years of delayed crop harvest, depredation potential increases. Agencies managing goose resources are held responsible when overharvest or depredations occur. Predictable food resources are an integral component of Canada goose management. Goose population objectives should be established within the bounds of effective food management in addition to consideration of refuge and hunting season.

Managers have little control over the effects of winter weather. Canada goose use of Swan Lake Zone refuges declined and was more variable in late December and January. Cold temperatures and snowcover most predictably affected goose dispersal from refuge areas. An average minimum temperature of 12°F (-11.1°C) appeared to be the threshold at which goose dispersal occurred most frequently. This is within the range of long-term, minimum temperature tolerance predicted to result in migration by LeFebvre and Raveling (1967); predicted temperature ranges were 20°F to 32°F (−6.1°C to 0°C) for *B.c. parvipes* and -4°F to 5°F (-19°C to -15°C) for *B.c. maxima*. Snowfall in excess of 10 inches (25.4 cm) also corresponded with goose dispersal. During the extremely cold years—1976, 1978 , 1981, and 1983—a greater proportion of indirect band recoveries from Swan Lake banded geese occurred in areas south of Missouri than during the intermediate or mild years of the same era—1977, 1979, 1980, and 1982—(7.5 percent, range = 5.0 percent to 9.9 percent versus 4.1 percent, range = 3.1 percent to 4.8 percent, respectively) (W-13-R progress reports). Severe winter weather appears most predictably to disperse geese from North Missouri. The potential increase in hunting mortality must be anticipated from additional dispersal when harvest objectives are established.

Habitat management is less effective when severe winter weather influences Canada goose distribution. Management response through direct feeding or pumping to maintain open water have been controversial methods for managing wintering Canada geese. Although direct feeding was used at Swan Lake NWR in 1961-62 to alleviate depredation potential, this practice has not been utilized since. Such intensive habitat management for Canada geese should be critically examined prior to operational use.

Management of Canada geese specifically, and waterfowl in general will require cooperative management of shared resources. The timing and influence of specific management actions or natural events should be considered during development of habitat and population management plans. Agencies responsible for managing migrating birds must be aware of the timing and relative influence of factors that actually impact distribution. Effects of redistribution should be determined and subsequently considered during management planning. Efforts to equitably distribute populations and recreational opportunities may be detrimental to certain waterfowl stocks.

In recent years, Canada goose managers have spent considerable time discussing the division of harvestable surplus and markedly less time trying to determine precisely why geese are distributed as they are. Continuation of such activity will result in a drain on valuable manpower and budgets with few positive benefits. Many factors generally attributed to population shifts are of little consequence while others that actually affect distribution are beyond managers' control. Future plans for managing Canada geese will hopefully take this into account.

Acknowledgments

We would like to acknowledge the commitment of Missouri Canada goose managers to population and habitat management and conscientious collection of crop production, weather, and goose survey data. The following provided valuable critical review of the manuscript: R. Baskett, E. Dowd, K. Gamble, R. Jessen, D. Rusch, K. Sadler, N. Seek, S. Sheriff, D. Thornburg, and O. Torgerson. E. Seon assisted with preparation of figures. S. Sapp typed drafts and the final manuscript. Financial assistance was provided through P-R project W-13-R.

Literature Cited

Babcock, K., R. Malecki, J. Salyer, D. Caswell, K. Brace, R. Jessen, and R. Bishop. 1978. A management plan for the Eastern Prairie Population of Canada geese. Mississippi Flyway Council. 87 pp.

Bellrose, F.C. 1978. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA. 540 pp.

Crider, E.D. 1967. Canada goose interceptions in the southwestern United States with special reference to the Florida flock. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comms. 21:145-155.

Crissey, W.F. 1968. Informational needs for Canada goose management programs. Pages 141-147 *in* R.L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educational Research Services, Madison, WI. 195 pp.

Fredrickson, L.H., and T.S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. USFWS Resour. Publ. 148:1-29.

Hankla, D.J., and R.R. Rudolph. 1967. Changes in migration and wintering habits of Canada geese in the lower part of the Atlantic and Mississippi Flyway—with special reference to national wildlife refuges. Proc. Ann. Conf. SE Assoc. Game and Fish Comms. 21:133-144.

Hanson, H.C., and R.H. Smith. 1950. Canada geese of the Mississippi Flyway, with special reference to an Illinois flock. Bull. Ill. Nat. Hist. Surv. 25(3):59-210.

Kahl, R.B. 1980. Crop depredation by Canada geese in north central Missouri. M.S. Thesis. Univ. of Missouri, Columbia. 142 pp.

LeFebvre, E.A., and D.G. Raveling. 1967. Distribution of Canada geese in winter as related to heat loss of varying environmental temperatures. J. Wildl. Manage. 31(3):538-546.

Malecki, R.A., F.D. Caswell, R.A. Bishop, K.M. Babcock, and M.M. Gillespie. 1981. A breeding ground survey of EPP Canada geese in northern Manitoba. J. Wild. Manage. 45(1):46-53.

Raveling, D.G. 1978. Dynamics of distribution of Canada geese in winter. Trans. North Amer. Wildl. and Natur. Resour. Conf. 43:206-225.

Reeves, H.M., H.H. Dill, and A.S. Hawkins. 1968. A case study in Canada goose management: The Mississippi Valley Population. Pages 150-165 *in* R.L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educational Research Services., Madison, WI. 195 pp.

Rusch, D.H. 1984. Progress report: a forecast of EPP Canada goose production in 1984. Unpublished mimeo. 6 pp.

Vaught, R.W., and L.M. Kirsch. 1966. Canada geese of the Eastern Prairie Population, with special reference to the Swan Lake flock. Tech. Bull. 3. Missouri Dep. Conserv., Jefferson City. 91 pp.

Productivity, Mortality and Population Status of Dusky Canada Geese

John E. Cornely
Western Oregon Refuges
Route 2, Box 208
Corvallis, Oregon 97333

Bruce H. Campbell
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99502

Robert L. Jarvis
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon 97331

Dusky Canada geese *(Branta canadensis occidentalis)* nest only on the Copper River Delta, Alaska, and winter primarily in western Oregon and southwestern Washington (Figure 1). They are one of the smallest populations of Canada geese currently hunted. In 1973 the Pacific Flyway Council (Pacific Flyway Council 1973) adopted and published a management plan for this population. The principal objective identified in that plan was to achieve and maintain an annual post-hunting season population of 20,000-25,000 dusky Canada geese. The 1975 mid-winter estimate was 26,500 and subsequent annual estimates exceeded 20,000 through 1981. The development and implementation of the management plan was lauded as an outstanding example of interagency cooperation (Timm et al. 1979) and labeled an unqualified success (Bartonek 1984). However, by 1984 dusky goose numbers had declined to such an extent that the goose season in western Oregon and southwestern Washington was halted early by an emergency closure. Prior to the closure, the season had been shortened by two months and the daily limit reduced to one goose. The decline of the population was anticipated, but the rapidity of decline was not expected. The events that contributed to the decline occurred both on the nesting grounds and on the wintering areas.

In this paper we review the history of the dusky goose and report on the current status of the geese in light of dynamic conditions of both the nesting and wintering grounds.

Historical Perspective

The dusky Canada goose was described by Baird (1858) from a specimen collected at Port Townsend, Washington Territory, in 1857. Although the type locality was in Washington and specimens were collected in western Oregon in 1914 and in the 1920s (Jewett 1932), for many years dusky geese were considered to be non-migratory and largely confined to the nesting grounds in Alaska (Taverner 1931, Gabrielson and Jewett 1940, Delacour 1954). Gabrielson and Jewett (1940) noted, however, that small flocks of dusky geese wintered along the Oregon coast and

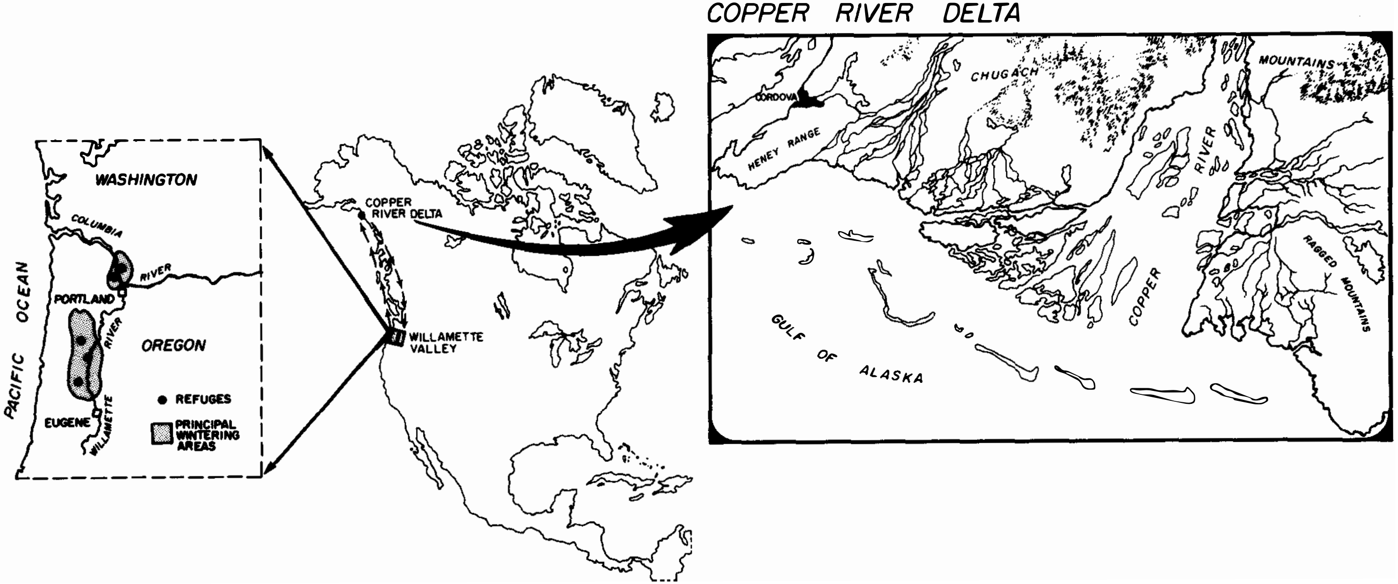


Figure 1. Map of the nesting and wintering areas of dusky Canada geese.

occasionally straggled inland to the Willamette Valley. Based on reports that discussed Canada geese wintering in the valley, dusky geese were uncommon until the late 1940s (Johnson 1880, Anthony 1886, Prill 1895, Woodcock 1902, Jewett 1932, Gabrielson and Jewett 1940). Banding studies initiated in Alaska in the late 1940s (Hansen 1962, Timm et al. 1979) established that the Willamette Valley of Oregon was the most significant wintering area for dusky geese. The first nesting studies on the Copper River Delta were completed in 1954 (Olson 1954) and 1959 (Trainer 1959). From 1951 to 1962, the estimated mid-winter population ranged from 10,000 to 17,000 geese (Hansen 1968).

Two events in the mid-1960s had significant impacts on the dusky goose population. In 1964, the nesting area was uplifted about 6 feet (2m) during the powerful "Good Friday" earthquake. The resultant drying of the substrate initiated vegetative changes. In 1964 and 1965 three National Wildlife Refuges were established in the Willamette Valley to provide sanctuary, food, and water for dusky Canada geese during the winter.

Methods

Much of the information in this paper was derived from published reports and unpublished theses concerning various aspects of the ecology and management of dusky Canada geese. That information was supplemented with unpublished reports and data from the files of the Alaska Department of Fish and Game, Anchorage; Western Oregon Refuges, Corvallis; and the Pacific Flyway Representative, Portland, Oregon.

Nest surveys after 1980 were completed by the Alaska Department of Fish and Game on plots established by Bromley (1976) in 1974. These surveys yielded estimates of nest density, nest success, and an indication of the type and frequency of nest predation. In 1982, an analysis of nesting habitat was conducted on the survey plots using the methods of Bromley (1976). Alaska Department of Fish and Game has conducted annual brood surveys since 1971 to estimate recruitment and calculate the size of the fall dusky goose population.

Total aerial counts of Canada geese were made after the hunting season, and subspecies composition was determined from photographs of goose flocks. Estimates of the size of the winter population of dusky geese were calculated by applying ratios from the aerial photographs to the total count. Estimates of the spring population were calculated by subtracting the mortality assumed to occur between the end of the hunting season and arrival of geese on the nesting grounds (Chapman et al. 1969). Fall population was the spring population plus recruitment, and the winter mortality was the difference between the fall population and the next year's winter population.

Results and Discussion

Nesting Grounds-Productivity

The Copper River Delta is a 260 mi^2 (650 km^2) coastal wetland on the Gulf of Alaska in southcentral Alaska (Figure 1). Most dusky geese nest within a few miles of the coast in supra-tidal habitat characterized by wet sedge (*Carex* spp.) meadows that are dissected by an extensive network of rivers, sloughs, and smaller drainage channels lined by alder *(Alnus crispa)* and willow (*Salix* spp.).

Results of early nesting studies indicated that dusky geese nested at high densities with high nest success relative to other subspecies of geese (Olson 1954, Trainer 1959, Hansen 1961). Trainer reported a density of 108 nests per square mile, and Bromley (1976, pers. comm.) found even higher densities, with the highest being 183 nests per square mile in 1978. In 1959, nest success was 89.2 percent (Trainer 1959), and sporadic nest surveys between 1959 and 1974 indicated that success ranged between 62.9 percent and 97 percent with an average of 81.6 percent (Trainer 1959, Bromley 1976, Alaska Dept. Fish and Game unpubl. data).

More recently, nest success and nest densities have been considerably lower. Investigations by Bromley (1976, pers. comm.) and Alaska Department of Fish and Game (unpubl. data) from 1975 through 1984 resulted in nest success estimates that ranged from 18.8 percent (1979) to 79 percent (1977) and averaged 48.1 percent. Recruitment averaged 20.5 percent for the same period (Jarvis and Cornely in press).

Prior to the earthquake, periodic tidal flooding apparently maintained salt tolerant vegetation on the outer delta and influenced habitat use by nesting geese (Trainer 1959). Virtually all nesting occurred on elevated slough banks in grass-mixed forb-low shrub vegetation; a cover type that covered less than 30 percent of the Delta (Table 1). The absence of tidal flooding after the earthquake promoted developement of fresh water marshes and expansion of shrub cover onto much of the preferred goose nesting habitat. Some of this area now supports stands of 10-15 foot (3-4.6m) willow and alder. The geese have apparently responded to the changes by nesting more frequently in meadow and in tall shrub cover than in the past (Table 1). Tall shrub habitat is predominantly along the channels and sloughs, but before the earthquake those areas were grass-mixed forb-low shrub. Therefore, geese may be nesting in the same locations, but are now in a different habitat type as plant succession proceeds. Although meadow habitat predominated in 1959, it was not extensively used for nesting by geese because of tidal flooding.

Changes in vegetation have apparently influenced predation on nests and geese. As demonstrated by high nest success, nest predation was low prior to 1975, and most unsuccessful nests were lost due to tidal flooding (Hansen 1961, 1962). There

Table 1. Pre-earthquake and post-earthquake distributions of dusky Canada goose nests with respect to cover type on the coastal portion of the Copper River Delta, Alaska.

	1959		1975[c]		1982[d]	
Cover type	% of Area[a]	% of Nests[b]	% of Area	% of Nests	% of Area	% of Nests
Grass-mixed forb-low shrub	10-15	97	46	76.4	25	35
Tall shrub	0	0	0	0	21	19
Meadow	85-90	3	54	23.6	54	46

[a]Calculated from data in Potyondy et al. 1975
[b]Trainer 1959
[c]Bromley 1976
[d]Alaska Dep. Fish and Game unpubl. data

was limited evidence of predation on eggs, but Trainer (1959) reported that brown bears *(Ursus arctos)* and coyotes *(Canis latrans)* occasionally ate eggs, goslings, and adult geese. The incidence of predation has increased dramatically in the past 10 years. Identification of nest predators, after the fact, is difficult, but predation by mammals is obviously more common than in the past. The incidence of avian predation appears to vary widely from year to year.

In the past two years (1983 and 1984) there were indications that low production was not solely due to predation on eggs. Nest success was 51.9 percent in 1983 and 75.8 percent in 1984, but recruitment was only 15 percent and 18.3 percent respectively, indicating poor survival of goslings between hatching and fledging.

Bromley (1976) reported that recruitment of dusky geese was controlled by the timing of spring thaw and the occurrence of storms during the nesting period. Low recruitment in years of unfavorable weather conditions was offset by high recruitment in favorable years. Even though weather appeared to be favorable in at least three of the last six years and average or better in the other three, recruitment was less than 24 percent during each of the last six years (Jarvis and Cornely in press). We believe that low production is symptomatic of current conditions on the Copper River Delta. It appears that post-earthquake vegetation changes have created conditions more favorable for mammalian predators, resulting in higher predation rates on eggs and possibly on goslings and adults.

Problems on the nesting grounds have not been unexpected. As early as 1953, Olson (1953) speculated that if conditions became more favorable for predators, or if the predators changed their foraging patterns, nest predation on the Copper River Delta could become a serious limiting factor. Following the earthquake, Shepherd (1965), Crow (1968, 1972), and Bromley (1976) predicted that changes in goose nesting habitat would occur. They speculated that production might increase at first as the amount of grass-mixed forb-low shrub cover type increased, but that, as plant succession continued toward tall shrub and then forest, the amount of favorable nesting habitat would decrease.

Wintering Grounds-Hunting Mortality

Most of the dusky Canada goose population winters in the Willamette Valley of western Oregon and along the lower Columbia River below Portland, Oregon. The mild, wet winter climate combined with extensive agricultural land make this area very attractive to wintering Canada geese. According to Youngberg (1975), the ryegrass seed industry alone accounts for 80,000 ha of grass fields in western Oregon. The grass remains green throughout the winter providing forage for the geese.

Results of the initial banding studies indicated that a heavy harvest of dusky geese occurred annually in the Willamette Valley. Expanded studies supported that contention (Chapman et at. 1969). Hansen (1962) believed that the nesting habitat in Alaska was capable of supporting a much larger population of dusky geese than nested there in the 1950s. Chapman et al. (1969) concluded that hunting mortality was the primary factor limiting the size of the dusky population. They estimated that the annual population mortality for the period 1952-1963 was 45.6 percent. Henny (1967) estimated that 94.4 percent of the annual mortality was due to hunting.

Beginning in 1959, large numbers of dusky Canada geese started to use an area of private land east of Corvallis, Oregon that was managed for waterfowl hunting

(Chapman et al. 1969). By 1963 the majority of geese wintering in the Willamette Valley was concentrated in that area. Hansen (1968) stated that dusky Canada goose numbers were controlled by hunting pressure in one small river valley. Establishment of the Willamette Valley National Wildlife Refuges significantly changed the distribution of geese in the valley (Timm et al. 1979), but hunting remained the most significant source of mortality to the dusky population. Timm et al. (1979) reported an increase in the post-season dusky goose population from about 14,000 birds to over 20,000 between 1963 and 1969. They attributed the increase to the effectiveness of the refuge system.

From 1971 through 1984, the winter mortality index for dusky Canada geese averaged 26.3 percent (Jarvis and Cornely in press). We do not believe that the mortality estimates calculated by Chapman et al. (1969) from band returns and our mortality indices for 1971-1984 are directly comparable. Whether goose mortality has changed or not, it is clear that mortality has exceeded recruitment for several years (Table 2).

Hanson (1968) pointed out that, even though the dusky goose population had remained relatively stable numerically, it had acquired an unfavorable age ratio. Current age structure data are limited to an examination of age ratios of geese harvested on state and federal management areas. Data from the Willamette Valley NWRs indicate a consistently heavy harvest of adult geese (Jarvis and Cornely in press). The percentage of adults in the bag between 1975-1983 ranged from 46.7 to 64.1 (average 55.8). Chapman et al. (1969) reported that the adult component of the harvest from 1964-1966 ranged from 22.3 percent to 38.5 percent.

From the 1950s through the early 1970s, most of the geese that wintered in the Willamette Valley were duskys (Hansen 1962, Chapman et al. 1969, Simpson and Jarvis 1979). Sometime in the early 1970s the numbers of Taverner's Canada geese (*B. C. taverneri*) wintering in the valley began to increase (Figure 2). By 1975, the Taverner's geese comprised about 25 percent of the wintering geese, and by 1977 they had increased to about 50 percent. Now they are approximately 80 percent of the wintering geese (Jarvis and Cornely in press). Initially, managers and biologists

Table 2. Summary of population data for dusky Canada geese, 1971-1984.

Year	Mid-winter	Spring population	Young produced	Fall flight	Winter mortality
1971	19,800	19,060	3,690	22,750	4,850
1972	17,900	17,230	2,045	19,275	3,475
1973	15,800	15,210	8,560	23,770	5,170
1974	18,600	17,900	18,935	36,835	10,335
1975	26,500	25,510	5,565	31,075	8,075
1976	23,000	22,140	6,975	29,115	5,015
1977	24,100	23,200	18,460	41,660	17,660
1978	24,000	23,100	7,635	30,735	5,235
1979	25,500	24,545	4,680	29,225	7,225
1980	22,000	21,175	6,575	27,750	4,750
1981	23,000	22,140	4,830	26,970	9,230
1982	17,740	17,075	5,310	22,385	5,385
1983	17,000	16,360	2,890	19,250	9,150
1984	10,100	9,720	2,180	11,900	

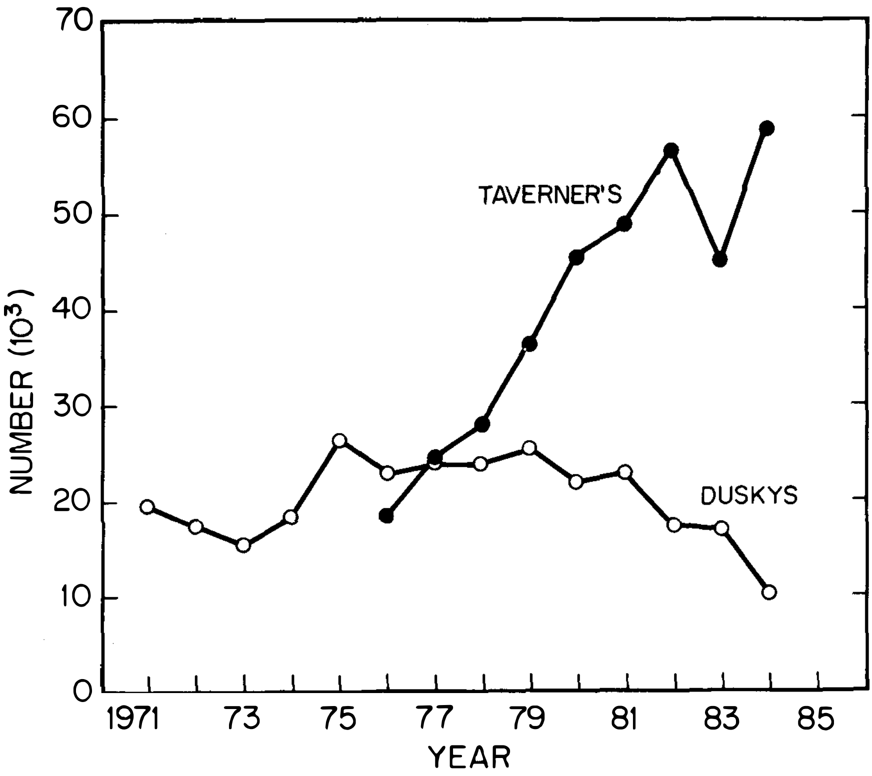


Figure 2. Trends of the post-hunting season populations of dusky Canada geese and Taverner's Canada geese.

hoped that the increase in Taverner's geese would take some of the hunting pressure off the dusky geese, but Taverner's geese have proven to be less vulnerable to hunting (Simpson and Jarvis 1979, Jarvis and Cornely in press.) Based on harvest and population statistics collected from 1975 to 1983, Taverner's geese were 2.4 times less vulnerable than dusky geese (Jarvis and Cornely in press). The differential vulnerability is apparently due to differences in behavior and activity patterns of the two races of geese (Havel and Jarvis in press).

In response to the dusky goose population decline, the goose season in western Oregon and southwestern Washington was shortened in 1983, but the harvest was still heavy. In 1984, the season length was reduced to one month, and the limit was reduced to one dusky goose on the state and federal management areas and one Canada goose of any subspecies outside of those areas. Even with those restrictions, the dusky harvest on the management areas was high enough to prompt an emergency closure of the already shortened season.

Management and Research Priorities

In light of continued low recruitment, the small size of the dusky goose population, and the ineffectiveness of recent attempts to manipulate the goose harvest, we believe that the only short term alternative is a restriction on goose hunting on the dusky goose wintering grounds. We have no reason to expect recruitment to improve significantly. Even with no hunting it would take five to seven years at the prevailing rate of production to reach the population objective level of 20,000.

Efforts to monitor the dusky population have been intensified in recent years, but refinements are needed. Current projects on the Copper River Delta are designed to identify the relationships between predators and nesting geese and to collect production and recruitment data. One of the immediate needs is to develop a reliable method of censusing the dusky goose population on the nesting grounds. That would result in a population estimate independent of the winter counts and could solve some of the problems associated with the current methods (Jarvis and Cornely in press). Other projects planned for the delta include updating habitat maps to determine the current composition, extent, and distribution of different habitats. A related project would be to determine how geese are using those habitats. These projects will provide information to help managers and biologists to evaluate the efficacy of augmenting dusky goose production. Increased goose recruitment might be achieved by manipulation of habitats or predator populations or by establishing nesting populations in suitable habitat in new areas.

On the wintering area, more accurate methods of assessing the goose harvest that occurs outside of state and federal management areas are needed. In addition, the aerial photographic technique used to determine subspecific composition of goose flocks needs refinement. A project is underway to investigate field use patterns and nutrition of wintering geese. We hope to use the results of that study to improve goose management on the federal refuges. Until a hunting system or another management scheme is devised that will result in the maintenance of desirable numbers of dusky Canada geese while allowing an appropriate level of harvest of Taverner's Canada geese, the status of the dusky goose will dictate hunting regulations. Further restrictions on Canada goose hunting in southwestern Washington and western Oregon could occur, despite record numbers of geese.

Acknowledgments

We gratefully acknowledge the contributions of the following people who provided support and information for this paper or made helpful comments on an early draft: T. Rothe and D. Timm (Alaska Department of Fish and Game); J. Bartonek, D. Boone, R. Rodgers, P. Sekora, C. Smith, S. Wilbur, and R. B. Wiseman (U. S. Fish and Wildlife Service); R. Denny and R. Johnson (Oregon Department of Fish and Wildlife).

Literature Cited

Anthony, A. W. 1886. Field notes on the birds of Washington County, Oregon. Auk 3:161-172.

Baird, S. F. 1858. Birds. Reports of explorations and surveys for a railroad route from the Mississippi River to the Pacific Ocean. Vol. 9, p.766.

Bartonek, J. C. 1984. Pacific Flyway. Pages 395-403 *in* A. S. Hawkins et al., eds. Flyways. USDI, Fish and Wildlife Service, Washington, D.C. 517 pp.

Bromley, R. G. H. 1976. Nesting and habitat studies of the dusky Canada goose (*Branta canadensis occidentalis*) on the Copper River Delta, Alaska. M. S. Thesis. Univ. Alaska, Fairbanks. 81 pp.

Chapman, J. A., C. J. Henny, and H. M. Wight. 1969. The status, population dynamics and harvest of the dusky Canada goose. Wildl. Monogr. 18:1-48.

Crow, J. D. 1968. Plant ecology of the Copper River Delta, Alaska. Ph.D. Thesis. Washington St. Univ., Pullman. 120 pp.

______. 1972. Earthquake-initiated changes in the nesting habitat of the dusky Canada goose. Pages 130-136 *in* The great Alaska earthquake of 1964: biology. Publ. 1609. Natl. Acad. Sci., Washington, D.C.

Delacour, J. 1954. The waterfowl of the world. Vol. 1. Country Life Lmtd., London. 284 pp.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon St. College, Corvallis. 650 pp.

Hansen, H. A. 1961. Loss of waterfowl production to tide floods. J. Wildl. Manage. 25:242-248.

______. 1962. Canada geese of coastal Alaska. Trans. N. Amer. Wildl. Conf. 27:301-329.

______. 1968. Pacific Flyway Canada goose management—Federal and state cooperation, Pages 43-49 *in* R. L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educ. Res. Serv., Madison, Wisconsin. 195 pp.

Havel, L. H., and R. L. Jarvis. In press. Formation of mixed feeding flocks of two subspecies of Canada geese in Oregon. *In* M. W. Weller, ed. Waterfowl in winter.

Henny, C. J. 1967. Estimating band-reporting rates from banding and crippling loss data. J. Wildl. Manage. 31:533-538.

Jarvis, R. L., and J. E. Cornely. In press. Recent changes in wintering populations of Canada geese in western Oregon/southwestern Washington *In* M. W. Weller, ed. Waterfowl in winter.

Jewett, S. G. 1932. The white-cheeked goose in Oregon. Condor 34:136.

Johnson, O. B. 1880. List of the birds of the Willamette Valley, Oregon. Amer. Nat. 14:485-491, 635-641.

Olson, S. T. 1953. Copper River Delta banding operations. U. S. F. W. S. Fed. Aid Wildl. Rest. Quart. Prog. Rept., Proj. W-3-R-8, Work Plan C. Juneau, Alaska. Pp. 34-40.

______. 1954. Migratory waterfowl studies: Copper River Delta banding and production studies. U. S. F. W. S. Fed. Aid Wildl. Rest. Quart. Rept. Proj. W-3-R-9, Work Plan C. Append. B. Juneau, Alaska. 9 pp.

Pacific Flyway Council. 1973. Guidelines for management of the dusky Canada goose. 12 pp.

Potyondy, J. P., M. P. Meyer, and A. C. Mace, Jr. 1975. An analysis of 1964 earthquake effects upon the vegetation and hydrology of the Copper River Delta, Alaska. Inst. Agric., Forest. Home Econ., Remote Sens. Lab. Rep. 75-6. 84 pp.

Prill, A. G. 1895. Winter birds of Linn County, Oregon. Oologist 12:47-49.

Shepherd, P. E. K. 1965. A preliminary evaluation of earthquake damage to waterfowl habitat in southcentral Alaska. Ann. Conf. West. Assoc. State Game and Fish Comm. 9 pp.

Simpson, S. G., and R. L. Jarvis. 1979. Comparative ecology of several subspecies of Canada geese during winter in western Oregon. Pages 223-241 *in* R. L. Jarvis and J. C. Bartonek, eds. Management and biology of Pacific Flyway geese. OSU Book Stores, Inc., Corvallis, Oregon. 346 pp.

Taverner, P. A. 1931. A study of Branta canadensis (Linnaeus) The Canada goose. Ann. Rep. Nat. Mus. Canada, 1929. Pp. 28-40.

Timm, D. E., R. G. Gromley, D. E. McKnight, and R. S. Rodgers. 1979. Management evolution of dusky Canada geese. Pages 322-330 *in* R. L. Jarvis and J. C. Bartonek, eds. Management and biology of Pacific Flyway geese. OSU Book Stores, Inc., Corvallis, Oregon. 346 pp.

Trainer, C. E. 1959. The 1959 western Canada goose *(Branta canadensis occidentalis)* study on the Copper River Delta, Alaska. 9pp. *in* Ann. Waterfowl Rep., Alaska. U. S. F. W. S., Juneau.

Woodcock, A. R. 1902. An annotated list of the birds of Oregon. Oregon Agric. Exper. Sta. Bull. 68:1-119.

Youngberg, H. 1975. Oregon grass and legume seed industry. Oregon St. Univ. Extension Serv. Rep. EXT/ACS 14:1-7.

The Effect of Restrictive Regional Hunting Regulations on Survival Rates and Local Harvests of Southern Manitoba Mallards

F. Dale Caswell[1]
Wildlife Branch, Manitoba Department of Natural Resources
1495 St. James St.
Winnipeg, Manitoba R3H 0W9

George S. Hochbaum
Canadian Wildlife Service
501 University Dr.
Winnipeg, Manitoba R3T 2N6

R. Kent Brace
Canadian Wildlife Service
115 Perimeter Rd.
Saskatoon, Saskatchewan S7N 0X4

Introduction

The annual spring mallard (*Anas platyrhynchos*) population in southern Manitoba averaged over 450,000 birds between 1955 and 1960. In the drought of 1962, numbers declined to about 200,000 and the population has never recovered with the exception of an influx of immigrants in 1976 (Hochbaum et al. 1984).

In 1973, federal and provincial waterfowl biologists were concerned about the persistent long-term decline in mallards in portions of Manitoba. They thought this trend was due to intensification of agricultural activity reducing production, coupled with lowered survival rates resulting from increased hunting pressure (see also Trauger and Stoudt 1978). These concerns led to the implementation of "restrictive" hunting regulations that year in Manitoba with the objective of reducing the harvest and slowly building the local breeding population back to about 500,000 birds.

The "restrictive" regulations were invoked to protect breeding stock as suggested by Hochbaum (1947) since about 35 percent of local young and adult mallards are harvested annually within Manitoba (Hochbaum and Caswell 1978). It was hoped that this measure would be supplemented with long-term habitat acquisition/management programs designed to enhance recruitment.

Recently, there have been studies generating much controversy as to whether restrictive hunting regulations can affect survival rates in mallards (see Anderson and Burnham 1976, Anderson and Burnham 1978, Rogers et al. 1979, Burnham and Anderson 1984, and Nichols et al. 1984). Nichols et al. (1984) suggest that experimental methods be designed to test whether or not such a relationship exists.

Mallard regulations in southern Manitoba between 1969 and 1983 have varied from "liberal" to "restrictive" and provide a means of testing this relationship between hunting regulations and survival. In this paper we document changes in

[1]Present Address: *Canadian Wildlife Service, 501 University Dr., Winnipeg, Manitoba R3T 2N6*

mallard survival and band recovery rates relative to harvest during "restrictive" and "liberal" regulatory periods and discuss the management implications of patterns we observed.

History of Mallard Regulations in Southern Manitoba

Traditionally, the duck hunting season in southern Manitoba has opened during the second or third week of September in migratory game bird hunting zones W3 and W4, respectively (southern Manitoba) (Figure 1). The traditional daily mallard bag limit has been four or five birds with eight or ten in possession. Such regulations were in effect in 1969 through 1972 and in 1979 through 1983. Between 1979 and 1983, there was further liberalization as there was no special limitation on mallards after about October 19 of each year; the daily mallard bag being eight for Canadian residents. In this paper these years are considered to be years of "liberal" regulations.

During the "restrictive" period (1973 to 1978), mallard bag limits in southern Manitoba were reduced to three birds daily with the exception of 1974, when only two could be taken. The possession limit remained at twice the daily bag. The design of the regulatory restraint was to not only reduce bag limits but to shorten season lengths by delayed openings. It was believed that shortening season lengths by early closures would have little impact since "freeze-up" in southern Manitoba occurs before the end of the legal season closure. Therefore, season openings during restrictive years were delayed one week in 1976 through 1978 and two weeks in 1973 through 1975. Although freeze-up does not occur at the same time annually and synchronously throughout zones W3 and W4, these delays effectively reduced the realized hunting season length from about 47 days during "liberal" years to about 35 days during "restrictive" years. This 12 day difference is significant since traditionally the major portion of the mallard harvest in southern Manitoba occurs during the last week of September and first week of October (Anon. 1974).

Data Sources and Analytical Methods

The results of this study are based on pre-season bandings of 85,576 mallards trapped at seven staging areas in southern Manitoba (Figure 1, Zones W3 and W4) and 10,191 within-season recoveries. Mallards were caught in bait traps between the third week of July and September 10 and only those birds with comparable status to previous mallard survival studies were utilized (see Anderson 1975). Within-season recoveries are birds shot or found dead during the period September 1 through January 31 anywhere in North America.

Band recovery data were analyzed using models for ducks banded as young and adults as described in Brownie et al. (1978:56-112). Survival and recovery rates were used from the models of best fit which were Model H1 for females and Model H2 for males. Comparisons of survival and recovery rates between "restrictive" and "liberal" years were tested using the Z statistic as described by Brownie et al. (1978:180-182).

Estimates of mallard harvest by age and sex were obtained from the Canadian Wildlife Service (CWS) National Harvest Survey (NHS) and the Species Composition Survey (SCS) (see Boyd and Finney 1978).

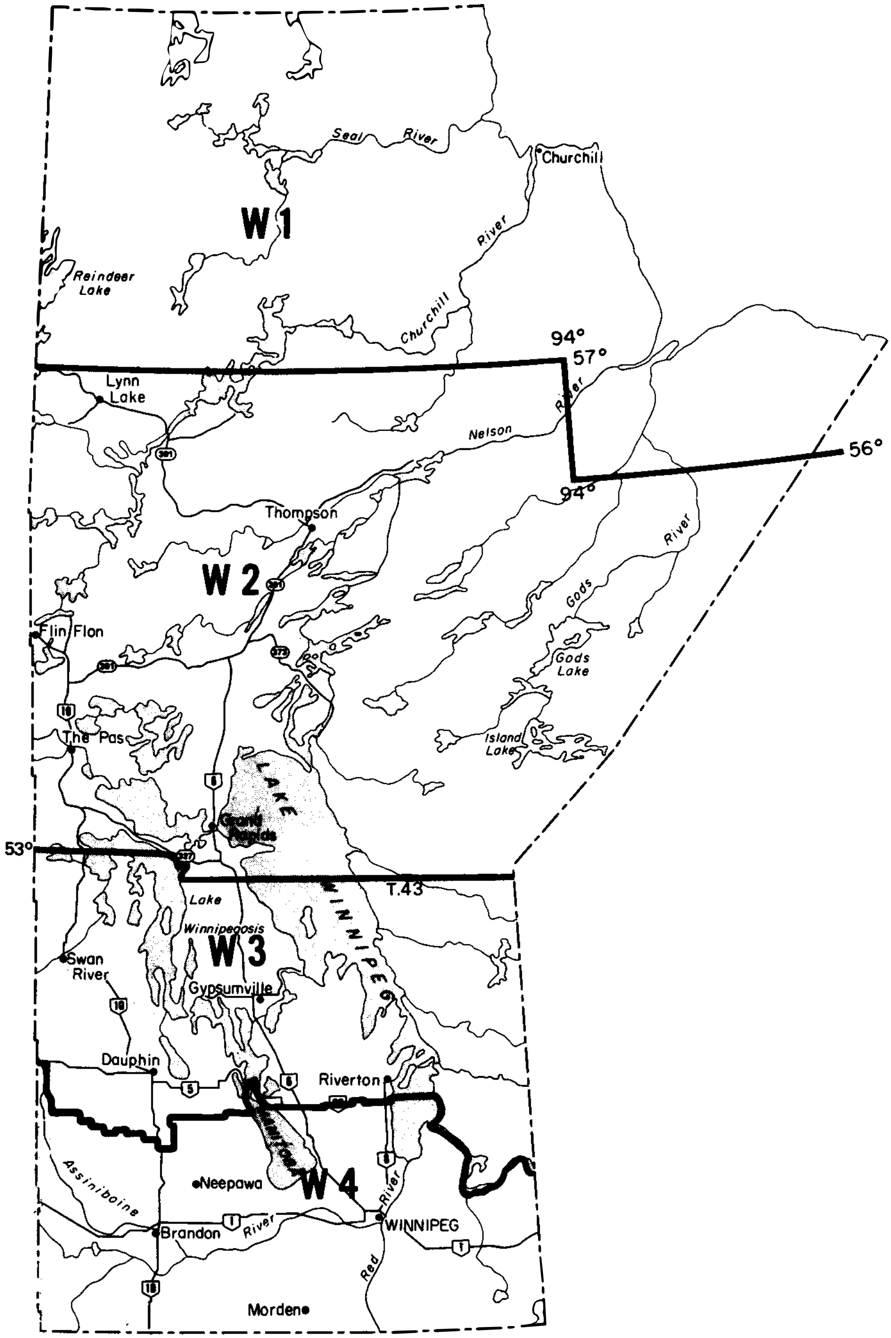


Figure 1. Migratory game bird hunting zones in Manitoba.

Results

Adult male mallards had higher survival rates than adult females. Juveniles survived at lower rates than adults, but there was no sexual difference within this age group (Table 1). Survival rates during "liberal" years averaged 63.91 percent for adult males and 51.32 percent for adult females. During the "restrictive" years survival rates of adults increased significantly ($Z>3$, $P<0.01$). Adult male rates were 71.87 percent, representing a 12.5 percent change from the "liberal" years. Adult female survival was 63.67 percent representing 24.1 percent change from the "liberal" years (Table 1). Survival rates of juveniles of both sexes remained relatively constant throughout the study (Table 1).

Annual band recovery rates were lower for all ages and sex classes during the 1973-1978 "restrictive" period compared to the "liberal" period—evidence of lowered kill rates. The decline in recovery rates during this period was highly significant for adult females and both juvenile sexes ($Z>2$, $P<0.05$) with a downward trend occurring for adult males ($Z=1.75$, $P<0.1$) (Table 2).

Direct band recoveries within Manitoba (birds banded in Manitoba, and shot or found dead in Manitoba during first hunting season after banding) showed a downward trend during the "restrictive" period versus the "liberal" period, suggesting a reduced mallard kill rate within the province (Table 3). This was highly significant ($Z > 2$, $P < 0.05$) for both adult and juvenile females. This trend is supported by CWS NHS, and SCS data which show that the mean mallard harvest during the "restrictive" period was 141,600 compared to 196,250 during "liberal" years. This represents a 27.8 percent reduction in mallard harvest.

Direct band recovery rates were regressed against harvests in southern Manitoba for each age and sex class. There was a positive relationship between band recovery

Table 1. Estimates of average annual survival rates and test results comparing years of "restrictive" hunting regulations (1973 to 1978) to years of "liberal" hunting regulations (1969 to 1972 and 1979 to 1983) in southern Manitoba.

	Restrictive	Liberal	Difference (Liberal-Restrictive)	Test statistic Z
Adult				
Female	63.67	51.32	—12.35 (—24.1)	3.4106***
Male	71.87	63.91	— 7.96 (—12.5)	3.0314***
Juvenile				
Female	59.48	57.02	— 2.46 (— 4.3)	0.3686
Male	58.46	58.93	+ 0.47 (+ 0.8)	—0.1068

() = percent change
**** = probability <0.01

rate and harvest in Manitoba. Since survival rates and band recovery rates are not independent samples, survival rates were regressed against harvests in southern Manitoba for adult females and adult males. Adult female survival was negatively correlated with harvest ($r = -0.61$; $P < 0.05$), whereas a downward trend occurred with adult males which was not significant ($r = -0.31$; $P > 0.05$). These findings suggest that "restrictive" mallard regulations in southern Manitoba increased survival rates for adult cohorts, especially females, by reducing the local kill as postulated (Hochbaum 1947).

Table 2. Estimates of average annual band recovery rates and test results comparing "restrictive" years to "liberal" years.

	Restrictive	Liberal	Difference (Liberal-Restrictive)	Test statistic Z
Adult				
Female	3.15	3.73	+0.58 (+15.5)	+2.4005**
Male	5.59	6.11	+0.52 (+8.5)	−1.75228*
Juvenile				
Female	5.08	6.16	+1.08 (+17.5)	−2.4082**
Male	7.34	8.37	+1.03 (+12.3)	−2.2175**

() = percent change
* = probability <0.1
** = probability <0.05

Table 3. Estimates of average direct band recovery rates in Manitoba and test results comparing "restrictive" years to "liberal" years.

	Restrictive	Liberal	Difference (Liberal-Restrictive)	Test Statistic Z
Adult				
Female	0.89	1.31	0.42 (+32.1)	−2.434**
Male	1.26	1.38	0.12 (+8.7)	−0.723
Juvenile				
Female	2.01	2.90	0.89 (+30.7)	−3.063***
Male	3.16	3.34	0.18 (+5.4)	−0.6016

() = percent change
** probability <0.05
*** = probability <0.01

Discussion

Anderson and Burnham (1976) examined two alternative hypotheses concerning the effect of hunting on annual survival rates in mallards: (1) non-hunting mortality is compensatory to hunting mortality below a threshold point, and (2) hunting mortality is totally additive to other forms of mortality.

Several studies support the compensatory hypothesis that hunting mortality is compensated for by variations in natural mortality and that hunting and non-hunting mortality appear inversely related below a threshold level (Anderson and Burnham 1978, Rogers et al. 1979, Burnham et al. 1984, Burnham and Anderson 1984). Anderson and Burnham (1976) concluded in their initial study that mallards could not be "stockpiled" since "restrictive" hunting seasons did not increase annual survival rates and the size of the breeding population the following year. Burnham et al. (1984) and Burnham and Anderson (1984) later concluded that the results of empirical studies were less conclusive for female mallards. Using formal hypothesis tests they could reject neither complete compensatory nor total additive models (Burnham et al. 1984).

Burnham et al. (1984) suggest three possible reasons for the inconclusive results obtained for females: (1) inadequate data for females relative to males, (2) the death process in females involves compensatory and additive components, and (3) the harvest process is compensatory in females but harvest rates have exceeded the threshold value.

Nichols et al. (1984) emphasized the need for large-scale field experimentation of a priori design where hunting regulations are deliberately modified in an effort to effect changes in mortality rates in examining death processes in mallards.

While our study was a posteriori, we feel the necessary contrasts in regulations existed to support our contention that survival rates of adult mallards, especially females, can be improved by delayed openings and reduced bag limits at the regional level on the breeding grounds. We attribute these findings of increased survival primarily to the absence of hunting pressure due to delayed openings which gives adult females time: (1) to leave natal ranges and intersperse with birds from other populations thereby buffering local kill, and/or (2) to become better nutritionally/physiologically prepared for migration and the hazards associated with hunting after the rearing of broods and the completion of moult. Implicated here is the idea that birds in better physiological condition survive at higher rates and that disturbance from hunters leads to reduced body condition.

Changes in the size of subpopulations due to increased survival may be difficult to detect since mallards are highly mobile and their response to spring habitat conditions is elastic. Counting unmarked birds in May with only partial coverage of the breeding grounds may also hamper enumeration of changes.

It is noteworthy that Burnham et al. (1984) and Burnham and Anderson (1984) could not reject the additive hypothesis for banding reference area 061 in Manitoba which encompasses the region of this study. This evidence supports our findings and suggests that harvest rates for adults in southern Manitoba were either above the threshold level or that death process involves both compensatory and additive components since banding samples were deemed adequate.

We suggest that death mechanisms such as predation and competition may be compensatory on the breeding grounds whereas hunting may be additive to deaths occurring as a result of mechanisms such as accidents. Our contention is that both density dependent and independent mortality affect mallards on the breeding grounds and that deaths involve both compensatory and additive components.

We conclude that:

1. "restrictive" regulations increased survival rates for the most important breeding unit (adult females),
2. the mallard population, represented by the banded sample, increased during "restrictive" years and that adults were "stockpiled,"
3. unilateral "restrictive" regulations on the breeding grounds can be used to adjust harvest and harvest rates as suggested by Kirby et al. (1983), and these changes affect survival rates, and
4. differences observed in comparing results from the "restrictive" and "liberal" regulatory periods in Manitoba may have been substantially greater if conservative measures had been matched throughout the Flyway.

Acknowledgments

We wish to thank the many duck banders in Manitoba who met the challenge of providing an adequate data base to carry out this analysis. We are indebted to R. Goulden, M. Gillespie, D. Davies, and L. Bidlake of the Wildlife Branch, Manitoba Department of Natural Resources. We appreciate the assistance of the United States Fish and Wildlife Service personnel out of Patuxent. We are especially grateful to R. Pospahala, R. Blohm, and A. Davenport for providing the data on short notice, and J. Nichols for assistance in selection of models and computation of Z statistics. We appreciate the help of A. H. Kooyman and D. Wilson in meeting our conference deadlines.

Literature Cited

Anderson, D. R. 1975. Population ecology of the mallard: V. Temporal and geographic estimates of survival, recovery and harvest rates. Resour. Publ. 125. U.S. Fish and Wildl. Serv., Washington, D.C. 110 pp.

______, and K. D. Burnham. 1976. Population ecology of the mallard. VI. The effect of exploitation on survival. Resour. Publ. 128. U.S. Fish and Wildl. Serv., Washington, D.C. 66 pp.

Anderson, D. R., and K. D. Burnham. 1978. Effect of restrictive and liberal hunting regulations on annual survival rates of mallards in North America. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:181-186.

Anonymous. 1974. Manitoba Waterfowl Status Report, 1974. A report by Manitoba Waterfowl Technical Committee. Unpubl. 26 pp.

Boyd, H., and G. H. Finney, eds. 1978. Migratory game bird hunters and hunting in Canada. Rep. Series 43. Can. Wildl. Serv., Ottawa, 127 pp.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1978. Statistical inference from band recovery data: A handbook. Resour. Publ. 131. U.S. Fish and Wildl. Serv. Washington, D.C. 212 pp.

Burnham, K. P., and D. R. Anderson. 1984. Tests of compensatory vs. additive hypotheses of mortality in mallards. Ecology 65:105-112.

Burnham, K. P., G. C. White, and D. R. Anderson. 1984. Estimating the effect of hunting on annual survival rates of adult mallards. J. Wildl. Manage. 48:350-361.

Hochbaum, G. S., R. K. Brace, and F. D. Caswell. 1984. Do displaced mallards breed? Can. J. Zool. In Prep.

Hochbaum, G. S., and F. D. Caswell. 1978. A forecast of long-term trends in breeding mallard populations on the Canadian Prairies. Prog. Note No. 90. Can. Wildl. Serv., Ottawa. 8 pp.

Hochbaum, H. A. 1947. The effect of concentrated hunting pressure on waterfowl breeding stock. Trans. N. Amer. Wildl. Conf. 12:53-64.

Kirby, R. E., J. E. Hines, and J. D. Nichols. 1983. Afternoon closure of hunting and recovery rates of mallards banded in Minnesota. J. Wildl. Manage. 47:209-213.

Nichols, J. D., M. J. Conroy, D. R. Anderson, and K. P. Burnham. 1984. Compensatory mortality in waterfowl populations: a review of the evidence and implications for research and management. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 49:535-554.

Rogers, J. P., J. D. Nichols, F. W. Martin, C. F. Kimball, and R. S. Pospahala. 1979. An examination of harvest and survival rates of ducks in relation to hunting. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 44:114-126.

Trauger, D. L., and J. H. Stoudt. 1978. Trends in waterfowl populations and habitats on study areas in Canadian parklands. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 43:187-205.

Metabolizable Energy of Seeds Consumed by Ducks in Lake Erie Marshes

Robert D. Hoffman
Ducks Unlimited, Inc.
New Paltz, New York

Theodore A. Bookhout
Ohio Cooperative Wildlife Research Unit
Columbus

Habitat quality for autumn waterfowl populations is often measured in terms of the quantity of food plants produced. This gives a relative measure of productive quality within a specific marsh, but the number of ducks a marsh can support is also a function of the quality of plants produced. Few analyses have been conducted to determine the energy content of autumn and winter waterfowl foods. Sugden (1971, 1973, 1974, 1979) studied the metabolizable energy of cultivated grains with mallards *(Anas platyrhynchos)* and some natural foods of blue-winged teals *(A. discors)*. Junca et al. (1962) and Bardwell et al. (1963) analyzed the nutrient content of winter foods in Louisiana from crops collected from teals *(A. discors, A. crecca carolinensis)*, pintails *(A. acuta)*, and mallards.

Studies to date have not combined the consumption, gross energy, and metabolizable energy of natural foods for autumn waterfowl populations. The apparent lack of information about the metabolizable energy (M.E.) of natural foods in waterfowl can be attributed to a two fold problem. First is the difficulty of obtaining large amounts of natural foods to feed captive waterfowl, and second is the lack of a concise analytical procedure. Sibbald (1977a) developed a new assay method for M.E. for domestic fowl which he termed "true" metabolizable energy (T.M.E.). The major advantage of this method is that it reduces the variation in feed intake between experimental birds. Other advantages are that the assay can be completed in 60 hours, birds can be reused for many assays, assays can be initiated on short notice, and the test foods and labor requirements are small (Sibald 1977a).

The objectives of this study were to measure the gross energy of natural foods that occur in the diets of autumn migrating ducks in the southwestern Lake Erie region and determine the "true" metabolizable energy mallards and pintails derive from these foods.

Study Area

The study was conducted on the 1,700 ha Winous Point Shooting Club, located 55 km east of Toledo, Ohio. For the past two decades, except between 1973 and 1976 when high water levels and severe storms destroyed existing dikes, water levels on the club's marshes have been manipulated to promote the growth of prime waterfowl food plants. Over 2,000 ha of marshes adjacent to Winous Point were also managed for moist-soils vegetation.

Materials and Methods

Duck gullets (esophagus[crop] and proventriculus) of mallards and pintails were collected from hunter-killed birds at the Winous Point Shooting Club during the 1981 waterfowl hunting season (16 October-28 November). Seeds were weighed to the nearest 0.01 g and results were presented in 3 ways: (1) average percent dry weight; (2) percent occurrence of food items; (3) percent occurrence (Prevett et al. 1979). Dry weight measurements were used to facilitate comparisons with data generated in T.M.E. trials. Seeds were identified to genus and species with the aid of Fassett (1957), Martin and Barkley (1961), and Hotchkiss (1970).

Mature seeds of emergent plants were collected from at least three locations, dried on racks, separated from the chaff, and stored in muslin bags until analyzed for gross energy. Prior to gross energy analysis in a Parr adiabatic oxygen bomb calorimeter, seeds were ground in a Wiley mill fine enough to pass through a 1-mm mesh screen.

Feeding trials were conducted in an unheated laboratory with natural photoperiods. Ducks were held in individual metabolism cages, 41 by 34 by 41 cm, with plastic trays placed under each cage to collect excreta. Between trials birds were held in a 2.5 by 5.0 by 2.5 m outdoor pen. Ducks were fed Purina Duck Chow as a maintenance diet during the summer and between feeding trials.

Feeding trials were conducted in November 1980 with immature pintails. Twelve experimental birds were fed 8.0 g of large-seeded smartweed *(Polygonum pensylvanicum)* and rice cut-grass *(Leersia oryzoides)*, and 2 birds were used as controls. In 1981 the maximum number of pintails available for each trial was 6 experimental and 2 controls. Mallards were force-fed 11.5 g of foodstuff in feeding trials with 12 experimental and 3 control birds. Large-seeded smartweed, rice cut-grass, softstem bulrush *(Scirpus validus)*, and Walter's millet *(Echinochloa walteri)* were force-fed to both species and arrowhead *(Sagittaria latifolia)* to mallards through a stainless steel tube 1.25 by 37 cm with attached funnel.

Four pintails and 12 mallards were fed a mixture of 50 percent large-seeded smartweed, 25 percent rice cut-grass, and 25 percent softstem bulrush (mix diet #1), and 12 mallards were fed a mixed diet of 50 percent rice cut-grass, 25 percent large-seeded smartweed, and 25 percent softstem bulrush (mix diet #2), to study the effects of mixed diets on energy metabolism. Two additional feeding trials were conducted in which mallards were fed large-seeded smartweed, and later rice cut-grass for five consecutive days to study the effect of individual birds on energy metabolism. Fifteen birds were used in each trial (12 experimental, 3 controls). In all feeding trials, if a bird regurgitated prior to the end of the fifth day it was excluded from the entire trial.

Statistical tests applied to the data included simple analysis of variance, Duncan's multiple range test, t-test, and Chi-square test. Differences were considered statistically significant at $\alpha = 0.05$.

Excreta were collected after a 24-hour period, rinsed into 500-ml plastic bottles, and frozen. Samples were later oven-dried at 80°C and feathers were removed. Dried excreta were allowed to come to equilibrium with the atmospheric moisture, weighed, and ground in a Wiley mill finely enough to pass through a 1-mm mesh screen. Samples were oven-dried at 80°C overnight and allowed to reach equilbrium with atmospheric moisture (at least 2 hours) prior to analysis on a Parr adiabatic oxygen bomb calorimeter.

The calculation of T.M.E. as described by Sibbald (1977a) was as follows:

T.M.E.(kcal/g) = GE_i – $(GE_f$ – $GE_c)$ / Weight of food (g)

where GE_i is the gross energy of the foodstuff (kcal/g dry matter) multiplied by the weight of the food, GE_f is the energy excreted by the fed bird (kcal/g), and GE_c is the energy excreted by the control bird (i.e., $FE_m + UE_e$).

Results

Seed Consumption

Mallard crops contained 34 categories of food items (Hoffman 1983:18-19). Food items were ranked by percent occurrence, percent occurrence of food items, and average percent dry weight. Rice cut-grass was highest in all three categories of the eight top ranked foods. Next were nodding *(Polygnum lapathifolium)* and large-seeded smartweeds. *Cyperus* (spp.) ranked 4 in the percent occurrence categories but did not rank in average percent dry weight. The agricultural grains, corn *(Zea mays)* and buckwheat *(Fagopyrum sagittatum)*, did not rank in the percent occurrence categories but ranked 4 and 5 in average percent dry weight, respectively. Other foods ranked included Walter's millet, softstem bulrush, panic-grass (*Panicum* sp.) and pigweed (*Amaranthus* spp.).

Only 24 categories of food items occurred in pintail crops (Hoffman 1983:21). Generally, pintails consumed the same foods as mallards, but the ranking differed. Rice cut-grass and nodding smartweed were the top-ranked foods. Large-seeded smartweed ranked 4 in percent occurrence categories and 3 in average percent dry weight. Similar to mallards, pintails fed frequently on *Cyperus* but in low quantities. Other foods important to pintails included softstem bulrush, Walter's millet, panic-grass, and pigweed. Corn, as in mallards, ranked only in the average percent dry weight.

Gross Energy in Seeds

Gross energy (kcal/g dry matter) of seeds collected on the study area showed little intraspecific variability among collection sites (Table 1). The highest standard error occurred in *Bidens* (0.07). Gross energy ranged from 4.40 in rice cut-grass to 5.37 in *Cyperus*. The values for *Cyperus* were significantly higher than for all other seeds except panic-grass and arrowhead.

"True" Metabolizable Energy Trails

Mallards and pintails showed similar trends in energy metabolism. Mallards metabolized the greatest amount of energy from rice cut-grass (3.00 kcal/g dry matter) and pintails the least from softstem bulrush (0.85) (Table 2). Generally, T.M.E. was represented from highest to lowest in arrowhead, rice cut-grass, Walter's millet, mixed diet #2, mixed diet #1, large-seeded smartweed, and softstem bulrush. No significant difference in T.M.E. was found between mallards and pintails for any of the food types.

Table 1. Gross energy (kcal/g dry matter) of seeds collected at different sites in marshes at the Winous Point Shooting Club, Port Clinton, Ohio, September-November, 1979-81.

Species	*N*	Mean	SE	Range
Cyperus spp.	3	5.30	0.05	5.20-5.37
Panicum sp.	3	5.21	0.05	5.11-5.29
Sagittaria latifolia	3	5.15	0.03	5.11-5.20
Bidens spp.	3	5.14	0.07	5.01-5.27
Scirpus validus	3	4.91	0.04	4.85-4.97
Polygonum lapathifolium	4	4.74	0.02	4.69-4.79
Sparganium eurycarpum	3	4.71	0.06	4.61-4.81
Zea mays[a]	3	4.70	0.06	4.58-4.80
P. pensylvanicum	3	4.61	0.01	4.59-4.63
Pontederia cordata	3	4.58	0.03	4.53-4.61
Echinochloa walteri	3	4.56	0.03	4.50-4.58
Leersia oryzoides	3	4.47	0.06	4.40-4.60

[a]Seeds collected from field adjacent to the marshes.

Table 2. "True" metabolizable energy (kcal/g dry matter) of ducks force-fed seeds collected from marshes at the Winous Point Shooting Club, Port Clinton, Ohio, September-December, 1980-81.

Seed type	*N*	$\bar{X}$	SE	Range
Polygonum pensylvanicum				
Mallard	70	1.08	0.04	0.34-2.06
Pintail	20	1.25	0.12	0.54-2.39
Leersia oryzoides				
Mallard	52	3.00	0.04	2.43-4.18
Pintail	11	2.82	0.15	2.27-3.88
Scirpus validus				
Mallard	24	0.99	0.08	0.38-1.73
Pintail	10	0.85	0.15	0.15-1.61
Echinochloa walteri				
Mallard	9	2.86	0.15	2.29-3.44
Pintail	8	2.82	0.14	2.54-3.53
Sagittaria latifolia				
Mallard	4	3.06	0.23	2.52-3.53
Mix diet #1[a]				
Mallard	12	1.74	0.07	1.09-2.13
Pintail	4	1.60	0.03	1.54-1.68
Mix diet #2[b]				
Mallard	12	2.28	0.07	1.76-2.57

[a]Mix diet composed of 50% *P. pensylvanicum*, 25% *L. oryzoides*, 25% *S. validus* by weight.
[b]Mix diet composed of 50% *L. oryzoides*, 25% *P. pensylvanicum*, 25% *S. validus* by weight.

Mallards metabolized significantly more energy from arrowhead, rice cut-grass, and Walter's millet than from either mixed diet, large-seeded smartweed, or softstem bulrush. In addition, they metabolized significantly more energy from mixed diet #2 than from mixed diet #1, large-seeded smartweed and softstem bulrush, and significantly more from large-seeded smartweed than from softstem bulrush. T.M.E. levels of arrowhead, rice cut-grass, and Walter's millet were not significantly different from each other in mallards. Levels of energy metabolism for pintails of rice cut-grass and Walter's millet were also not significantly different but were significantly higher than levels of energy metabolized from mixed diet #1, large-seeded smartweed, and softstem bulrush. Mixed diet #1 and large-seeded smartweed were not significantly different in pintails, but T.M.E. levels were significantly greater than levels from softstem bulrush.

Composite diets were analyzed for T.M.E. to test for additivity effects. The mean T.M.E. values were compared to expected mean values derived from trials of single species. The mean T.M.E. value of mix diet #1 for pintails (1.60 kcal/g dry matter) was not significantly different from the expected value of 1.54. For mallards, the observed T.M.E. value (1.74) was not significant from the expected value (1.54). The expected mean value (2.02 kcal/g dry matter) of mixed diet #2 fed to mallards was not significantly different from the observed value of 2.28.

In T.M.E. trials of a single food type over a 5-day period, mallards metabolized significantly more energy from rice cut-grass than from large-seeded smartweed on all 5 days. In both 5-day trails, day 1 was relatively higher in comparison to the other days, followed by a decrease in T.M.E. to day 4, and a slight increase in day 5. There was no significant difference in T.M.E. among the 5 days of the rice cut-grass trials. Large-seeded smartweed was significantly higher on day 1 than on any other day, but there were no significant differences among the remaining 4 days.

An analysis of variance for individaul birds between days was conducted to determine if individual birds significantly affected T.M.E. calculations. In the rice cut-grass trials there were no significant differences among individual birds over the 5-day period, but in large-seeded smartweed, variation among individual birds was significant.

Discussion

The primary importance of marshes in northern Ohio to autumn migrating waterfowl is replenishment of energy expended during migration. The decline in natural wetlands along migration corridors has resulted in greater concentrations of waterfowl on many stopover areas and has created a need to better understand and provide for the nutritional requirements of migratory waterfowl (Fredrickson and Drobney 1979).

Selection of food items by waterfowl we examined apparently was not based solely on energy content. Rice cut-grass, the most important food item in the diets of mallards and pintails, had the lowest energy level of the seeds analyzed. Large-seeded smartweed, nodding smartweed, and Walter's millet were also important in the diet but occurred in the mid-range level of energy.

Among the natural foods tested, the order of magnitude of T.M.E. values was the same for both species of ducks. This suggests that the chemical and physical characteristics of the food might have a greater effect on T.M.E. than any adaptive physiological advantage between these two species. The high fiber, low fat content of natural waterfowl foods might have a major influence on M.E. for ducks. High fiber foods create morphological changes in the gut of ducks that affect digestion and subsequently energy metabolism, and fat is a major source of energy in seeds. Bardwell et al. (1963) reported the fat/fiber ratios (proximate analysis) of arrowhead, Walter's millet, smartweed, and bulrush to be 0.66, 0.25, 0.12, and 0.14, respectively. The order of magnitude of these ratios is similar to our T.M.E. values for these foods.

The metabolic efficiency (T.M.E./G.E. x 100) was lower for the hard-coated large-seeded smartweed and softstem bulrush seeds primarily because these seeds were not digested as well as soft-coated seeds. Excreta examination showed that nearly one-half of the smartweed and bulrush seeds passed through the birds intact. Drobney (1977) and Sugden (1973) reported similar findings.

Interspecific differences in M.E. might limit the use of these T.M.E. values for predicting M.E. for other species. Significant differences in M.E. values have been measured between domestic birds (Slinger et al. 1964, Muztar et al. 1977, Siregar and Farrell 1980), between blue-winged teals and chickens (Sugden 1974), and between American coots (*Fulica americana*) and black ducks (*Anas rubripes*) (Penney and Bailey 1970). Metabolizable energy levels of closely related species of waterfowl do not differ significantly (Miller 1974).

During autumn migration the physiological condition of waterfowl changes to accumulate fat, and food intake probably is governed by total energy requirements rather than specific nutrient needs (Sugden and Harris 1972). Mallards and pintails feeding on natural foods in the Winous Point marsh seldom fed on a single seed resource. In the mixed diets we fed, the observed T.M.E. was statistically the same as the expected T.M.E. estimated from species trials. This agrees with Sibbald's (1977b) study on additivity on T.M.E. in feedingstuffs of domestic fowl.

Our 5-day bioassays revealed that T.M.E. was significantly higher in the low fiber food (rice cut-grass) (no significant differences detected among the 5 days). In the high fiber diet (large-seeded smartweed), less energy was metabolized, significant variation occurred among individual birds, and T.M.E. was significantly higher on day 1 than on the remaining 4 days. These results demonstrate a greater variability in T.M.E. bioassay with high fiber foods. Sibbald (pers. comm.) found that more than 24 hours are required to clear fibrous and high-ash foods from alimentary canal of chickens, and he currently extends the excreta collection period to 48 hours. In our study, if only part of the high fiber diet was excreted after 24 hours, the T.M.E. level for day 1 would be raised. On day 2 the portion remaining from day 1 and part of day 2 seeds would be excreted, giving a more accurate T.M.E. value. Schang et al. (1982) force-fed domestic fowl 2 consecutive days, gathered excreta for 24 hours after the second feeding, and compared T.M.E. values to excreta collected for 48 hours from birds force-fed once. They reported a trend for higher T.M.E. values with the double feeding technique. This trend was more evident with high fiber foods. We recommend the excreta collection period be extended to 48 hours for all natural foods force-fed to waterfowl, because passage rates of these foods have not been adequately determined.

The expenditure of energy of free-living birds can be calculated directly by quantifying their activities in caloric terms or by indirect measures such as body weights or crop content analysis. These methods require untested assumptions regarding their relationship to the energetic costs of free-living birds (Prince 1979). Basal metabolic rates (BMR) must be estimated for each species before estimates of energy expenditures can be calculated. King (1974) concluded that BMR is weight-dependent and expressed by the equation, $M = aW^{b}$, where M is a metabolic parameter, a is a constant, and b is an exponent. Aschoff and Pohl (1970) demonstrated the existence of diurnal rhythm in metabolic rate for non-passerine birds. Calculating kilocalories needed per day and kilograms of body weight, they equated $M = 91.0\ W^{0.729}$ for daylight active periods and $M = 73.5\ W^{0.734}$ for periods of rest. Prince (1979) tested Aschoff and Pohl's (1970) equations for non-passerines and determined they were useful estimates for prebreeding mallards and possibly other species of dabbling ducks. Prince (1979) calculated the constant $a = 87.0 \pm 2.3$(SE). Consequently, BMR can be calculated for waterfowl at rest as $M = 87\ W^{0.734}$. Based on average weights of 1153 and 908 g for mallards and pintails, respectively (Bellrose 1980:229, 262), the BMRs for mallards and pintails are 96.6 and 81.1 kcal/day, respectively. Energy expenditure of mallards that are awake was estimated by Prince (1979), who determined that $a = 114.3 \pm 3.3$(SE). He felt this more nearly represented the minimum metabolic rate of free-living mallards. His estimates of minimum energy expenditures of awake mallards suggest that mallards and pintails require 126.9 and 103.8 kcal/day, respectively.

Prince (1979) estimated the cost of daily existence energy of free-living mallards at intermediate (0-20°C) temperatures to be roughly 3.0 x BMR. This included 1 hour of flight/day but not the cost of migration. Based on his estimates, the energy requirements of mallards and pintails arriving on the Winous Point marshes would be approximately 290 and 243 kcal/day, respectively. Sugden (1979) predicted that field-feeding mallards require 294 kcal/day. The maximum quantity of corn found in a mallard crop in our study was 50.3 g, which contains approximately 236 kcal. More energy would be required to accumulate fat reserves (productive energy) before migration resumes.

The T.M.E. of large-seeded smartweed, rice cut-grass, Walter's millet, and softstem bulrush in mallards and pintails can be used to estimate the quantity of seeds needed to maintain a bird/day (Table 3). Sincock (1963) concluded that as a "rough rule of thumb" the average consumption of food per bird day could be estimated as 10 percent of the body weight of each species of duck. The estimated daily consumption rates calculated for mallards and pintails were 115 and 91 g, respectively. These estimates show that mallards and pintails could exist on rice cut-grass and Walter's millet with a limited amount of energy left for fat storage, but not on large-seeded smartweed and softstem bulrush.

Table 3. Estimated quantity of seeds required to maintain one mallard or pintail per day without weight loss on the Winous Point marsh.

Species of seed	Weight (g)	
	Mallard	Pintail
Leersia oryzoides	96.7	86.2
Echinochloa walteri	101.4	86.2
Polygonum pensylvanicum	268.5	194.4
Scirpus validus	292.9	285.9

Conclusions

The advantage of using metabolizable energy values to measure the relative importance of natural foods to autumn migrating waterfowl was demonstrated in this study by the comparison of gross energy and T.M.E. values for rice cut-grass, Walter's millet, and bulrush. The GE of bulrush was significantly higher than that of cut-grass and millet, whereas the T.M.E. of bulrush was significantly lower than that of cut-grass and millet.

Limited information on metabolizable energy in natural foods consumed by ducks is available to compare to this study. Several authors have noted that the nutrient levels derived from their studies were not adequate estimates of the nutrient requirements needed for free-living birds. Values we derived from T.M.E. assays were consistently higher and probably represent more realistic values for free-living waterfowl.

Managers can use the results of this study to improve the quality of stopover marshes for autumn waterfowl populations by increasing the production of rice cut-grass and Walter's millet. In Missouri, Fredrickson and Taylor (1982) suggested maximum seed production of rice cut-grass could be obtained by a mid- to late-drawdown, and Meeks (1969) felt mid-May drawdown produced the best growth of rice cut-grass and Walter's millet in Ohio. In an effort to produce these species, managers should give consideration to other species of seed-producing plants. It was shown that T.M.E. values for different seeds were additive to waterfowl and contribute to the total energy budget of the bird. The less energy that is required for foraging, the greater significance even low evergy seeds will have on energy accumulation. Although rice cut-grass and Walter's millet yielded higher T.M.E. values, we do not recommend managing exclusively for these species. A diversity of vegetative types will support a more diverse waterfowl population .

Acknowledgements

Financial support was contributed by the Winous Point Research Committee, the Oak Harbor Conservation Club, the Wildlife Management Institute, and the American Petroleum Institute. We gratefully acknowledge the advisory assistance of Drs. T. J. Peterle, S. Lustick, R. Stuckey, F. J. Margraf, The Ohio State University; Dr. R. Meeks, II, and Mr. R. Kroll, Winous Point Shooting Club; and the technical assistance of T. Cullinan, S. Borgwald, C. Armbrust, G. Balogh, M. Bumbulis, D. Aleshire, B. Van Putten, and W. Dryor. Drs. G. Burger and R. Montgomery, Max MaGraw Wildlife Foundation, Dundee, Illinois, and Dr. H. Prince, Michigan State University, East Lansing, donated the pintails and mallards used in the feeding trails.

Literature Cited

Aschoff, J., and H. Pohl. 1970. Rhythmic variations in energy metabolism. Fed. Proc. 29:1541-1552.

Bardwell, J. L., L. L. Glasgow, and E. A. Epps, Jr. 1963. Nutritional analyses of foods eaten by pintail and teal in south Louisiana. Proc. S.E. Assoc. Game Fish Comm. 16:209-217.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, PA. 540 pp.

Drobney, R. 1977. The feeding ecology, nutrition, and reproductive bioenergetics of wood ducks. Ph.D. Thesis. Univ. of Missouri, Columbia. 170 pp.

Fassett, N. C. 1957. A manual of aquatic plants. With revision appendix by E. C. Ogden. Univ. Wisonsin Press, Madison. 405 pp.

Fredrickson, L. H., and R. D. Drobney. 1979. Habitat utilization by postbreeding waterfowl. Pages 119-131 *in* T.A. Bookhout, ed. Waterfowl and wetlands—an integrated review. Proc. 1977. Symp. Madison, WI, NC. Sect., The Wildl. Soc.
Fredickson, L. H., and T. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. Resour. Publ. No. 148. U.S. Fish and Wildl. Serv. 29 pp.
Hoffman, R. D. 1983. True metabolizable energy of seeds consumed by postbreeding ducks in Lake Erie marshes. Ph.D. Thesis. Ohio State Univ., Columbus. 86 pp.
Hotchkiss, N. 1970. Common marshplants of the United States and Canada. Resour. Publ. 93. Bur. Sport Fish. and Wildl. 99 pp.
Junca, H. A., E. A. Epps, Jr., and L. L. Glasgow. 1962. A quantitative study of the nutrient content of food removed from the crops of wild mallards in Louisiana. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 27:114-121.
King, J. 1974. Seasonal allocation of time and energy resources in birds. Pages 4-70 *in* R.A. Paynter, Jr., ed. Avian energetics. Nuttall Ornithol. Club Publ. 15.
Martin, A. C., and W. D. Barkley. 1961. Seed identification manual. Univ. California Press, Berkeley. 221 pp.
Meeks, R. L. 1969. The effect of drawdown date on wetland plant succession. J. Wildl. Manage. 33:817-821.
Miller, M. R. 1974. Digestive capabilities, gut morphology, and cecal fermentation in wild waterfowl (Genus *Anas*) fed various diets. M.S. Thesis. Univ. California, Davis.
Muztar, J. J., S. L. Slinger, and J. M. Burton. 1977. Metabolizable energy content of freshwater plants in chickens and ducks. Poult. Sci. 56:1893-1899.
Penney, J. G., and E. D. Bailey 1970. Comparison of energy requirements of fledgling black ducks and American coots. J. Wildl. Manage. 34:105-113.
Prevett, J. P., I. F. Marshall, and V. C. Thomas. 1979. Fall foods of lesser snow geese in the James Bay region. J. Wildl. Manage. 43:736-742.
Prince. H. H. 1979. Bioenergetics of postbreeding dabbling ducks. Pages 103-117 *in* T. A. Bookhout, ed. Waterfowl and wetlands—an integrated review. Proc. 1977 Symp. Madison WI, NC. Sect., The Wildl. Soc.
Schang, M., S. Leeson and J. Summers. 1982. Effect of double force feeding on true metabolizable energy. Can. J. Anim. Sci. 62:963-965.
Sibbald, I. R. 1977a. The true metabolizable energy system. Part 1. Advantages of T.M.E. in poultry feed formulation. Feedstuffs 49:21-22.
______. 1977b. A test of the additivity of true metabolizable energy values of feedingstuffs. Poult. Sci. 56:363-366.
Sincock, J. 1963. Estimating consumption of food by wintering waterfowl populations. Proc. S.E. Assoc. Game Fish Comm. 16:217-221.
Siregar, A. P., and D. J. Farrell. 1980. A comparison of the energy and nitrogen-metabolism of fed ducklings and chickens. Br. Poult. Sci. 21:213-227.
Slinger, S. J., I. R. Sibbald, and W. F. Pepper. 1964. The relative abilities of two breeds of chickens and two varieties of turkeys to metabolize dietary energy and dietary nitrogen. Poult. Sci. 43:329-333.
Sugden, L. G. 1971. Metabolizable energy of small grains for mallards. J. Wildl. Manage. 35:781-785.
______. 1973. Metabolizable energy of wild duck foods. Canadian Wildl. Serv. Progress Notes No. 35. 4 pp.
______. 1974. Energy metabolism by Bantam chickens and blue-winged teal. Poult. Sci. 53:2227-2228.
______. 1979. Grain consumption by mallards. Wildl. Soc. Bull. 7:35-39.
______, and L. E. Harris. 1972. Energy requirements and growth of captive lesser scaup. Poult. Sci. 51:625-633.

The Protection of Bottomland Hardwood Wetlands of the Lower Mississippi Valley

Stephen W. Forsythe
U.S. Fish and Wildlife Service
Vicksburg, Mississippi 39180

Introduction

Bottomland hardwood wetlands were discussed in a special session of the North American Wildlife and Natural Resources Conference in 1980, and later that year were the subject of a special workshop in Georgia (Clark and Benforado 1981). In both instances, various sources of knowledge were combined in an effort to bring attention to the importance and plight of bottomland hardwoods, both in the Lower Mississippi Valley (LMV) as well as other areas of the United States where they occur. A community profile of bottomland hardwoods of the southeastern United States provided detailed information regarding characteristics of plant and animal communities (Wharton et al. 1982). In 1984 the Department of the Army convened a Blue Ribbon Panel for Bottomland Hardwoods that primarily discussed the impacts of Section 404 of the Clean Water Act on the remaining bottomland hardwoods of the LMV. Currently, the U.S. Environmental Protection Agency (EPA) is sponsoring a series of workshops on bottomland hardwoods. As a result of all these efforts, the values and functions of the resource for floodwater retention, detrital production, fish and wildlife habitat, erosion control, and water quality maintenance are well understood. Yet, relatively little progress has been made towards protecting the resource! It is the purpose of this paper to (1) report on the current condition of the bottomland hardwood wetlands of the LMV, and (2) provide an agenda for conservation of the resource.

Description and Present Status

Bottomland hardwoods have been classified in various ways, but for simplicity they can be described as an assemblage of tree-dominated vegetative communities which occur on soils that are saturated or inundated either seasonally or temporarily. Bottomland hardwoods have historically been considered by the Fish and Wildlife Service to be wetlands and are classified as such by the National Wetlands Inventory (Cowardin et al. 1979). For purposes of this paper, the LMV refers to the Mississippi River alluvial floodplain of six states (Figure 1), and consists of nearly 25 million acres (10.4 million ha) extending about 500 miles (800 km) from southeast Missouri to southern Louisiana.

The original 24 million acres (10 million ha) of forest in the LMV were reduced to about 12 million acres (5 million ha) by 1937. About 6.6 million acres (2.7 million ha) of forest were cleared between 1937 and 1978, leaving about 5.18 million acres (2.1 million ha) remaining (MacDonald et al. 1979). Since 1978, the Department of the Interior estimates that about 120,000 acres (48,580 ha) have been cleared annually (Blue Ribbon Panel for Bottomland Hardwoods 1984), leaving an estimated 4.5 million acres (1.82 million ha) of bottomland hardwoods in the LMV.

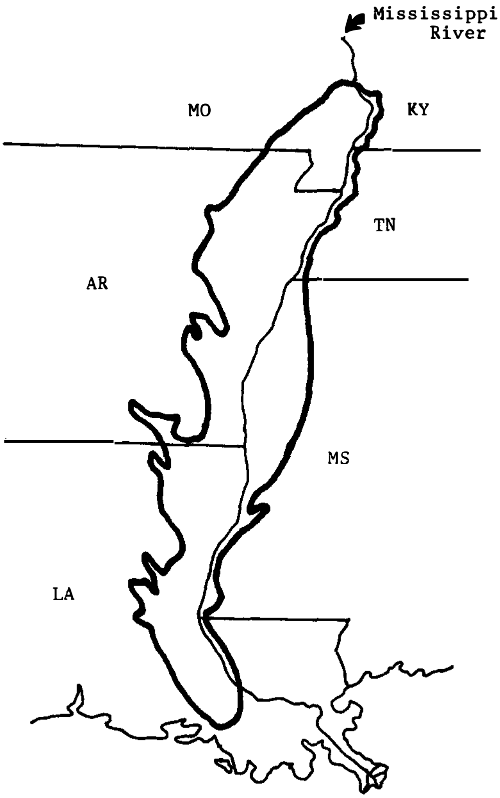


Figure 1. Lower Mississippi Valley

Current Conditions

The clearing and drainage of bottomland hardwoods in the LMV has progressed from the higher, well drained areas to lower, frequently flooded sites that are less suitable for agriculture. Although this point may seem obvious, it is necessary to emphasize it in order to understand the current condition of the resource.

As part of my research for the Blue Ribbon Panel for Bottomland Hardwoods, I looked at the general characteristics of the soils in the LMV that were vegetated by forests in 1984, and found that about 95 percent of those forests were situated on soil associations possessing hydric soil characteristics. I suggested in the panel report that those soils were sufficiently wet to be considered wetlands according to the Section 404 definition. Put another way, over 4 million acres (1.62 million ha) of the remaining bottomland hardwoods in the LMV are on wet soils that are basically unsuitable for agriculture in their present state, that is, without extensive flood control or drainage.

There are also large acreages of what can be referred to as "high risk" agricultural land. These are tracts of land that have had the bottomland hardwood forest vegetation removed in preparation for agricultural use. However, the hydrological regime has not been modified sufficiently to reduce the wetness characteristics of the soil. These areas are thus inundated or saturated for portions of the growing season sufficient to make agriculture endeavors difficult, if not impossible. I do not have a compilation of the acreages of these areas because of the difficulty of discerning them by remote imagery. However, in areas of the LMV that have been studied extensively, data show that landowners have cleared thousands of acres of such lands. For example in the Boeuf River Basin of Louisiana there are over 100,000 acres (40,485 ha) of cleared land within the one-year floodplain, which represents about 24 percent of the cleared land in the basin. Another example is the Upper Yazoo Basin of Mississippi where 19 percent of the cleared land (68,825 ha) is within the one-year floodplain.

The primary crop growth on these "high risk" lands is the soybean because of its ability to mature in the later portion of the growing season when moisture is not as much of an inhibiting factor. Yet, without drainage or flood control the suitability of these lands for soybean production is marginal, at best. At the present time, farming of these moist soils actually represents an economic disadvantage to the farmer because: (1) wetness adds to the cost of seed bed preparations and retards production; (2) soybeans have depressed market prices, due primarily to overproduction; and, (3) soil erosion is increased because the wetness and large-scale farming practice precludes soil conservation. Recent evidence in the form of newspaper articles and other national and local media illustrates that the impact of trying to farm these "high risk" lands is becoming a serious problem for the agricultural economy in the LMV. Furthermore, legislation, cited as the "Farm Debt Restructure and Conservation Set-Aside Act of 1985" (H.R. 1000), was recently introduced by Mississippi Congressman Franklin and would authorize the Secretary of Agriculture to acquire long-term easements on marginal farm land presently in the Farmers Home Administration inventory. Such land would be taken out of agricultural production and made available for public use purposes, such as conservation and recreation.

This body of evidence points to a growing awareness among both agricultural and conservation interests that, in all too many instances, the end result of much of the bottomland hardwood conversion has been an increase of poor agricultural land at the expense of excellent wildlife/wetland habitat.

These marginal agricultural lands provide valuable winter habitat for migratory waterfowl, primarily mallards. The key factor, of course, is the presence of water on the fields in winter when the ducks are in the LMV. The importance of this winter water, in forests as well as fields, is becoming better understood as a result of recent research (Reinecke et al. 1985). However, the availability of winter water becomes less likely as flood control projects provide increased drainage to lands in the LMV. In other words, as the agricultural suitability of the wet marginal lands is increased, the value for waterfowl is decreased.

Factors Influencing the Current Conditions

Flood Control

The history of flood control in the LMV has been aptly explained by Reinecke et al. (1985) who noted that the Mississippi River and Tributaries Project had spent

$5,384,179,271 through Fiscal Year 1982 to control flooding in the LMV. Furthermore, those authors described the development of flood control in the LMV as consisting of four fundamentally different phases (Table 1). In the present phase of flood control in the LMV, the major economic benefits for flood control projects come from increasing the suitability of wet areas, either cleared or forested, for agriculture. An example is the Yazoo Backwater Pump project in Mississippi where almost 79 percent of the anticipated benefits will come from pumping water off of frequently flooded forest and agricultural lands. Such projects practically guarantee continued clearing of bottomland forests and agricultural encroachment into wetlands.

Section 404 of the Clean Water Act

Section 404 of the Clean Water Act has been described as having the greatest potential for regulating private activities which contribute to the clearing and drainage of bottomland hardwood wetlands (Parenteau and Tripp 1980). However, for several reasons, this potential has not been realized in the LMV.

First, a significant portion of the bottomland hardwood wetlands have not been considered wetlands within the meaning of the Section 404 wetland definition and have been excluded from regulatory jurisdiction. The U.S. Army, Corps of Engineers (COE), which administers the Section 404 regulatory program, has consistently determined that only the wettest bottomland hardwood communities are Section 404 wetlands. (Blue Ribbon Panel for Bottomland Hardwoods 1984). Contrary to the COE regulatory program, the Western Judicial District of Louisiana decided in 1979 (Avoyelles Sportsmen's League vs. Alexander) that most of the bottomland hardwoods on the so-called Lake Ophelia tract were Section 404 wetlands. The species considered by the court were representative of several bottomland hardwood communities that occur at higher elevations than the communities used by the COE in making Section 404 wetland determinations, not only on the Lake Ophelia tract, but elsewhere in the LMV. Specifically in the Lake Ophelia case,

Table 1. Changes in flood control objectives in the LMV, 1849 to present (from Reinecke et al. 1985).

Phase	Principal objective	Time period
Regional settlement	Local flood control and land reclamation	1849-1927
Flood protection	Protect existing development from major floods	1928-1943
Agricultural conversion	Convert bottomland hardwoods to agricultural production	1944-1973
Agricultural intensification	Improve existing cropland on flood-prone sites[a]	1974-present

[a]This implies that conversion of bottomland hardwoods is not presently occurring. In fact, clearing continues to occur at a rate of about 120,000 acres (48,580 ha) annually. However, the present emphasis of flood control projects is to decrease the wetness of cleared land.

the COE determined that about 30 percent of the tract was a wetland while the court's determination approached 90 percent of the tract. In a 1983 appeal in the Fifth Circuit court (Avoyelles Sportsmen's League vs. Marsh), the District court's ruling regarding wetland jurisdiction was upheld. Despite these rulings, the COE has not expanded their regulatory jurisdiction in the LMV bottomland hardwoods. Furthermore, the EPA has not chosen to exercise its authority to determine Section 404 wetland jurisdiction.

Second, indecision exists when determining whether or not discharge associated with removal of vegetation is considered a discharge of dredged or fill material under Section 404. Such a discharge into wetlands is a violation of Section 404 and thus requires a permit. This issue was also addressed in the Lake Ophelia case where the court determined that the clearing of bottomland hardwood trees for agricultural use and the removal of their roots by plowing was a discharge of dredged or fill material within the scope of regulation under Section 404. As with the question of wetland jurisdiction, the lower court ruling was upheld by the Fifth Circuit court in 1983. However, the current position of the COE is that all land clearing of bottomland hardwoods in the LMV is not conducted in the same manner as the land clearing that was ruled upon by the court in Avoyelles Parish. Consequently, each land clearing case in the LMV is evaluated individually by the COE to determine if discharge will occur (Blue Ribbon Panel for Bottomland Hardwoods 1984). As a result, a minimal number of permits are required for land clearing activities.

Third, in the few instances where permits have been required for land clearing, permit denial has not occurred because the COE maintains that significant incremental water quality degradation, relative to existing levels, cannot be demonstrated. This is reflective of the COE's narrow interpretation of the Clean Water Act; viewing the law's primary function as protecting the quality of the water, not protecting the integrity of wetlands and their values (Office of Technology Assessment 1984). Yet, it has been repeatedly documented that bottomland hardwoods and other wetlands have an integral function in water quality management.

Finally, the EPA issued policy guidance last year that basically complimented the court rulings resulting from the Lake Ophelia case. Although this policy has not been implemented at the field level, the previously mentioned EPA workshops are a step in that direction.

Because the Section 404 regulatory program in the LMV has failed to comply with the mandates of the Clean Water Act, the clearing and draining of bottomland hardwood wetlands has continued virtually unabated.

Other Factors

There are several other factors influencing the current condition of bottomland hardwoods in the LMV. Many of these are incentives in the form of federal income tax deductions, cost-sharing and technical assistance, federal disaster payments and crop insurance, commodity programs, and Farmers Home Administration loans (Office of Technology Assessment 1984). Because of Congressional interest, the Department of the Interior is currently conducting a study to better understand the impact of these incentives on bottomland hardwoods.

Land acquisition for conservation purposes has protected a minimal acreage of bottomland hardwoods in the LMV. At the present time it is estimated that the six states own 400,000 acres (161,940 ha), the Federal Government owns 380,000 acres

(153,845 ha), and private conservation organizations own 10,000 acres (4,050 ha). Although acquisition has been the most successful program for protecting bottomland hardwoods, it has lagged far behind conversion to agriculture, principally due to funding limitations.

An Agenda for Resource Conservation

It is apparent that conservation of the bottomland hardwood resource of the LMV will require changes in several policies and programs.

Modification of Federal Flood Control Policies

The water in the LMV is currently being managed to the extent of present technology and funding by the COE flood control projects. However, as explained previously, this management is presently in a phase where project benefits are derived, for the most part, from reducing the wetness of "high risk" agricultural lands or bottomland hardwood wetlands. Dependence on these type of benefits as a basis for flood control projects must be substantially reduced if wetlands are to be protected. At the same time, there must be a realization that intensification of agriculture in wetlands is not an efficient expenditure of federal funds. It appears to be an appropriate time to review the Mississippi River and Tributaries flood control program with a view toward developing amendments that will provide wetland protection.

Flood control projects that are already authorized or under construction present an opportunity for management of the hydrologic regime necessary to maintain the productivity of bottomland hardwoods and the value of cleared lands for waterfowl. Essentially a given flood control project is designed and operated solely to eliminate flooding during the crop season. Unfortunately, the same project also precludes flooding during the winter, when little or no agricultural benefits can be gained; a clear loss for migratory waterfowl. Therefore, benefits can be accrued if some of the water that would have occurred in the project area without the operation of the flood control project could be retained or replaced for wintering waterfowl. The method of retaining this water would simply be structural measures that would hold water on land during the winter when much of the flooding occurs in the LMV.

Authorization and Implementation of H.R. 1000

This bill would allow "high risk" agricultural land to be restored as bottomland hardwood wetlands and reduce the rate of clearing of the remaining forests. The areas under easement could be used for enhancement or mitigation purposes.

Rectification of the Section 404 Regulatory Program

The majority of the remaining bottomland hardwoods in the LMV could be protected by Section 404 if the previously described limitations were realized and rectified. This would include:

- Formulating and implementing a comprehensive federal approach to Section 404 wetland determination that considers all the technical elements.
- Determining that land clearing for agricultural purposes constitutes a dredge and fill activity and should therefore be regulated.

— Recognizing that the conversion of bottomland hardwoods adversely impacts water quality, and administering the Section 404 permit program accordingly.

Resolution of these issues would not be simple, but were it done Section 404 could prevent further unwise development in wetlands and diminish the need for flood protection in areas that should not be developed for agriculture.

Other Changes

Acquisition of important bottomland hardwood areas should be continued by appropriate federal, state, and private agencies. Any acquisition program should be cognizant of the importance of the hydrologic regime with a view toward future management potentials. Also, "high risk" farm lands should not be precluded from acquisition, recognizing that such lands will require revegetation and intensive management.

The incentives to clear wetlands should be carefully studied with a view toward abolishing several and replacing them with incentives to keep wetlands in their natural state. The ongoing Department of the Interior Special Wetlands study should identify the pertinent incentives and develop a plan to modify them to reduce wetland conversion.

Conclusion

The current situation in the LMV is one where the Federal Government is encouraging landowners to attempt to farm "high risk" bottomland hardwood wetlands and "high risk" wet cleared lands. This encouragement is not appropriate given the critical state of the Nation's agricultural economy. Furthermore, it is not justified when compared to the less tangible, but nonetheless real, loss of the ecologically important bottomland resource. The decision point for conserving the LMV wetland resources is long past—only concerted changes in policies and programs will save the last vestage of this valuable and vital habitat.

Literature Cited

Blue Ribbon Panel for Bottomland Hardwoods. 1984. Panel report. DOA, DOI, USDA, DOC, EPA, Vicksburg, Miss. 51 pp.

Clark, J. R., and J. Benforado, eds. 1981. Wetlands of bottomland hardwood forests. Elsevier Sci. Publ. Co., New York 402 pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. Fish and Wildl. Serv., Washington, D.C. 103 pp.

MacDonald, P. O., W. E. Frayer, and J. K. Clauser. 1979. Documentation, chronology, and future projections of bottomland hardwood habitat losses in the Lower Mississippi Alluvial Plain. Vols. 1 and 2. U.S. Dep. of the Interior, Fish and Wildl. Serv., Washington D. C.

Office of Technology Assessment. 1984 Wetlands: their use and regulation. ATS-0-206. U.S. Congress, Office of Technology Assessment, Washington, D. C. 208 pp.

Parenteau, P. A., and J. T. B. Tripp. 1980. Federal regulations: handles, effectiveness and remedies. Trans. N. Amer. Wildl. and Natur. Resur. Conf. 45:392-401.

Reinecke, K. J., R. C. Barkley, and C. K. Baxter. 1985. Water resources and the ecology of mallards wintering in the Mississippi Alluvial Valley. *In* Waterfowl in winter-symposium and workshop. Galveston, Tesxas. (In press.)

Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps of the Southeast: a community profile. FWS/OBS-81/37. Fish and Wildl. Serv., Washington, D. C. 133 pp

Perspectives on American Woodcock in the Southern United States

Gene W. Wood
Belle W. Baruch Forest Science
Institute of Clemson University
P. O. Box 596, Georgetown, South Carolina 29442

M. Keith Causey
Department of Zoology-Entomology
and Alabama Agricultural Experiment Station
Auburn University, Auburn, Alabama 36830

R. Montague Whiting, Jr.
School of Forestry
Stephen F. Austin State University
Nacogdoches, Texas 75962

Introduction

More than 80 years ago A. K. Fisher (1902) described a dismal picture for the American woodcock (*Scolopax minor*) in the 1901 Yearbook of the U. S. Department of Agriculture. He vividly presented his perception of dramatic declines in the woodcock population and linked these changes to overly liberal season lengths and market hunting in both the northern and southern portions of the species' geographic range. His discussion of the plight of the bird on both the breeding and wintering ranges demonstrated a geographically holistic perspective possibly unique in the published literature on this bird.

Once again managers and research biologists closely concerned with the woodcock have become disconcerted by evidence of adverse population changes. Graphical data in the 1984 Woodcock Status Report (Tautin 1984) indicated that the mean adjusted average seasonal bag for the period 1975 through 1983 was lower than that for 1965 through 1974 by about 26 percent in the Eastern Region and 14 percent in the Central Region management units (Martin et al. 1969, Krohn and Clark 1977, Coon et al. 1977), respectively. Interestingly, graphical data from the same report indicated a decline in the mean annual breeding population index (Tautin et al. 1983) of about 26 percent in the Eastern Region, but an increase of about 20 percent in the Central Region when the period 1966 through 1975 was compared with 1976 through 1984.

More recently, Sparrowe and Tautin (1985) reported data from waterfowl stamp buyers who participated in the woodcock wing survey in the Eastern Region. The mean values for 1973 through 1977 compared to those for 1979 through 1983 showed declines in numbers of woodcock killed per season per hunter, flushes per hunt, and kills per hunt of 23, 22 and 25 percent respectively.

Concern for the woodcock as a game species has intensified during the last several years among some northeastern wildlife agencies. In 1982, Massachusetts lowered the woodcock bag limit to 2 birds. In 1983, Pennsylvania lowered the bag limit to 3. In 1984, Rhode Island also lowered the bag limit to 3. In addition, Pennsylvania decreased its season length to 21 days in 1984. In June 1984, the Pennsylvania Game

Commission sought and obtained conceptual approval from the Northeastern Association of Fish and Wildlife Directors for a proposal to ask the U.S. Fish and Wildlife Service to lower the federal bag limit to 3 birds and decrease the season length from 65 to 40 days in the Eastern Region (memo from Peter S. Duncan, Executive Director, Pennsylvania Game Commission to Northeast Fish and Wildlife Directors dated June 7, 1984).

Ironically, during this period of increasing alarm in the Northeast, a number of articles appeared in outdoor sporting magazines advertising the woodcock as an under-utilized resource in the South. Magazines such as *Southern Outdoors, Sports Afield, Field and Stream,* and *Outdoor Life* have each averaged about one article per year since 1980 on southern woodcock hunting. Many southern state wildlife agency magazines have called attention to woodcock in recent years and the mention of woodcock hunting by outdoor writers in local newspapers has occurred with increasing frequency.

Southern biologists have reported substantial concentrations of woodcock wintering in North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and east Texas. While in many southern locations woodcock offer abundant gunning opportunities, the situation is different from that in northern areas in at least three ways. First, they are in a portion of their geographical range which, since the days of market hunting, has been a refuge from substantial gunning pressure. Second, in our experience, some wintering woodcock populations are sedentary and tolerate gunning pressure until they are depleted or an environmental stimulus causes migratory movement. This appears to contrast sharply with migrating flocks that are usually not at one location for more than a few days during the migration period in northern areas (Sheldon 1971:95, Liscinsky 1972:25). And third, the size of the harvestable increment of the population is smaller during the southern woodcock season than it is at any other time in the legal hunting period in the geographical range of the species.

Most of the research and management attention given the woodcock in the past has been focused on the northern portion of its range because of its traditional importance as a game species there. On the other hand, it is our opinion that there is considerable potential for an increase in southern gunning pressure in the future. Also we suspect that if this should occur it might well have an adverse effect on the Eastern Region population and possibly the continental population. It is the purpose of this paper to develop a perspective on woodcock and their winter range particularly with respect to: (1) the ecological data base, and (2) its past, present, and future game species status. We will also make recommendations for changes aimed at improving harvest data collection to support management for conservation of the species.

Southern Winter Range Delineation

Weather conditions will determine the actual northern limit of the wintering range of woodcock on an annual basis. Mild fall and winter weather tends to dampen the extent of southern migration in this species (Sheldon 1971:78). For the purposes of this paper, we have defined the southern range as including from the Eastern Region management unit the states of Virginia, North Carolina, South Carolina, Georgia, and Florida. We have included Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, and Arkansas from the Central Region.

Southern Data Base

Banding Data

Undoubtedly more effort has gone into banding research than any other aspect of woodcock study in the United States. According to U.S. Fish and Wildlife Service, Bird Banding Office records, 76,883 woodcock were banded in the U. S. between 1929 and 1983. Some 29.8 percent of these bandings occurred in the South. Of 4,541 band recoveries, 15.8 percent of the birds were banded in the South. Some 16.8 percent of all recoveries were made in the South.

Banding efforts have been substantial in three southern locations. Prior to 1973, Dr. L. L. Glasgow and his co-workers banded 19,659 woodcock in Louisiana. This accounted for 36.2 percent of all U. S. bandings and 97.5 percent of all southern bandings until that time. Only 64 woodcock have been banded in Louisiana since 1973.

In the past 10 years, North Carolina and Alabama have been the primary centers of banding activity in the South. Between 1973 and 1983, Dr. P. D. Doerr and his co-workers banded 1,663 woodcock in North Carolina. This effort accounted for 7.3 percent of all bandings in the U. S., 19.6 percent of all bandings in the Eastern Region, and 60.5 percent of all bandings in the South for that period. In Alabama, Dr. M. K. Causey and his co-workers banded 832 woodcock in the 1973-1983 period. This amounted to 3.7 percent of all U. S. bandings, 5.9 percent of all Central Region bandings, and 30.4 percent of all southern bandings for the period. It is important to note that over 300 of the Alabama birds were banded as chicks.

Based on band recovery records, there appears to be only a 3 percent-6 percent overlap between the Eastern and Central region populations (Table 1) (also Coon et al. 1977). Even when dealing with populations on the winter range it may be important to treat data from the different management regions at least as subsets. For example, in the Central Region, northern banded birds were 1.8 times more likely to be recovered than southern banded birds. In contrast, the same comparison in the Eastern Region yielded a difference factor of 4.3. In addition, when percentage recovery rates are compared, a bird banded in the southern Central Region was 1.7 times more likely to be recovered than one banded in the southern Eastern Region.

Interpreting these differences between management regions of the winter range is difficult because the data base is so heavily weighted for the Central Region. For example, there have been 11.4 times more bandings and 19.0 times more recoveries in the southern Central Region than in the southern Eastern Region. Furthermore, about 86 percent of all southern banding was done in Louisiana and prior to 1973.

Habitat Studies

At least 18 reports have resulted from woodcock habitat studies in the South. Fourteen of these came from the southern Central Region. Eight were from Louisiana (Glasgow 1953, 1958, Ensminger 1954, Britt 1971, Evans 1976, Dyer 1976, Dyer and Hamilton 1977, Sloan 1976), 3 were from Alabama (Roboski and Causey 1981, Horton and Causey 1981, Johnson and Causey 1982), 2 were from east Texas (Kroll and Whiting 1977, Boggus and Whiting 1982), and 1 was from Mississippi (Roberts et al. 1984).

Table 1. Summary of woodcock banding and band return data from 1929 through 1983. (File data courtesy U.S. Fish and Wildlife Service, Bird Banding Office, Laurel, MD.)

	Management Region					
	Eastern			Central		
	Northern	Southern	Total	Northern	Southern	Total
Number banded	29,712	1,852	31,564	23,538	21,121	44,602
Number recovered	2,451	36	2,487	1,371	683	2,054
% of total U.S. recoveries	54.0	0.8	54.8	30.2	15.0	45.2
% of recoveries that occurred within state of banding	73.0	25.0	72.3	77.4	31.5	62.6
% of recoveries that were banded in Eastern Region	89.6	7.0	96.6	0.6	2.7	3.3
% of recoveries that were banded in Central Region	5.6	0.3	5.9	67.8	25.2	94.0
% of recoveries that were banded in the South	16.9	1.7	18.6	35.9	45.3	81.2

Pursglove and Doster (1970) reported their observation of the types of habitat in which they found woodcock while collecting them for parasite studies from the Atlantic Coast west to Louisiana and Arkansas. Reports that have dealt exclusively with habitat in the southern Eastern Region included one from Georgia (Pursglove 1975), two from South Carolina (Pace and Wood 1979, Ingram and Wood 1982), and one from North Carolina (Connors and Doerr 1982).

With the exception of one study of nesting habitat in Alabama (Roboski and Causey 1981), all southern habitat studies have been concerned with the winter period. In the southern Central Region, Glasgow (1958) and Dyer and Hamilton (1977) suggested that wetland hardwoods were the primary diurnal habitat in Louisiana. Roberts et al. (1984) reported a similar finding in Mississippi. Kroll and Whiting (1977) and Boggus and Whiting (1982) reported substantial utilization of mixed-pine-hardwood sites and young pine regeneration areas in east Texas. In Alabama, woodcock were found to make substantial use of bottomland hardwoods and hardwood-pine cover types adjacent to bottomlands (Horton and Causey 1979). Johnson and Causey (1982) reported use of longleaf pine (*Pinus palustris*) stands that were 40-50 years old and that prescribed fire enhanced utilization.

In the southern Eastern Region, studies in Georgia and South Carolina (Pursglove 1975, Pace and Wood 1979, Ingram and Wood 1982) have all reported wetland hardwoods to be the primary diurnal habitat. Connors and Doerr (1982) reported some utilization of mature pine stands in North Carolina Piedmont. South Carolina studies have reported utilization of pine regeneration areas and mature pine stands. Mature pine stands, however, appeared to receive the most utilization when wetland hardwoods were flooded.

Nocturnal habitats in the South were reported to include pastures, fallow fields, harvested corn, cotton, soybean fields, young forest regeneration areas, and other types of forest openings (Ensminger 1954, Glasgow 1958, Dyer and Hamilton 1979, Horton and Causey 1979, Connors and Doerr 1982). Doerr and his co-workers found particularly heavy utilization of unplowed soybean fields in winter and little use of plowed soybean fields, corn fields, or winter wheat. Studies by Horton and Causey (1979) and Ingram (1981) indicated that, in some cases, woodcock may spend both the diurnal and nocturnal periods in woodland habitat.

The use of open areas for nocturnal habitat appears to be common in both the northern and southern portions of the woodcock's geographic range. Similarity in diurnal habitat appears to be primarily with respect to soils. Soils in both northern and southern habitats are typically moist, poorly drained, high in organic matter content, and have an abundance of earthworms. The main dissimilarity is in the overstory component. In northern areas, decline in woodcock habitat quality generally is concomitant with succession beyond the sapling-shrub stage. That is, the woodcock is primarily a user of early successional stage forest communities on alluvial sites (Sheldon 1971:63-65, 84, Liscinsky 1972:29, Rabe 1977). In the South, high basal area of sawtimber-sized trees is a good habitat characteristic in both wetland hardwoods (Pace 1980) and mixed pine-hardwood (Kroll and Whiting 1977).

Only one report on nesting habitat in the South has been published. Roboski and Causey (1981) investigated incidence of nesting in seven major physiographic regions. They found most nests occurring on flat bottomland sites near water.

Diet Composition

Diet composition for wintering woodcock has been studied in Louisiana (Glasgow 1958, Britt 1971, Dyer and Hamilton 1974), Alabama (Miller and Causey 1985), and South Carolina (Pace and Wood 1979). Earthworms *(Lumbricidae)* may be slightly less important in the woodcock's diet on the winter range than in northern areas. In the South, they account for 60-70 percent by volume of materials found in the upper gastro-intestinal tract. The importance of plant material in the diet appears to vary considerably. Alabama and South Carolina studies reported plant material to account for 3-4 percent of the winter diet. Britt (1971) reported a value of 16 percent in Louisiana.

Local Movements

There have been three reports from studies of local movements of woodcock in the South. Winter movements and brood member dispersal were studied in Alabama by Horton and Causey (1979, 1982). Both studies involved radio-telemetric monitoring. Winter home ranges averaged 20.0, 11.2, 10.7, and 16.9 ha for 4 adult females, 3 adult males, 3 immature females, and 2 immature males, respectively. Crepuscular movements of the 12 birds studied had a mean distance of 183 $\pm$ 28 m.

Ingram (1981) attempted to use radio-telemetry to study winter movements and habitat utilization in South Carolina, but high predation of instrumented birds prevented the assemblage of an acceptable data base. Based on 10 diel periods of continuous monitoring of 5 woodcock, he estimated the average diel home range to be 19.6 ha. Observed extremes were 6.7 ha and 50.5 ha. Crepuscular movements averaged 238 m/hr at dawn and 149 m/hr at dusk. One other study of movements and habitat utilization using radio-telemetry techniques was jointly undertaken by the U.S. Fish and Wildlife Service and the Ruffed Grouse Society, Inc. in south Georgia, but was not completed.

Reproduction

The most studied aspect of woodcock reproducton in the South has been gonadal changes as indicators of breeding activity and onset of nesting. Such studies have been made in North Carolina (Stamps and Doerr 1976, 1977, Rushing and Doerr 1984), Tennessee (Roberts and Dimmick 1978, Roberts 1980), South Carolina (Pace and Wood 1979, Ingram 1981), and east Texas (Whiting and Boggus 1982, Whiting el al. 1983). In Alabama, Roboski and Causey (1981) reported on the incidence and chronology of woodcock nesting based on observations of nests and broods. In addition, Walker and Causey (1982) reported on breeding activity correlated with occurrence of spermatozoa in the utero-vaginal glands of hens.

Whiting et al. (1983) summarized the literature on reproduction in the South and reported that testicular recrudescence began in early December and was completed in mid-February. Substantial numbers of females were reported to be approaching ovulation in February based on measurements of enlarged ova. Maximum estimates of the proportion of females in this condition were 67 percent in North Carolina (Stamps and Doerr 1977), 52 percent in Tennessee (Roberts and Dimmick 1978), 38 percent in east Texas (Whiting and Boggus 1982) 38 percent in Alabama (Walker and Causey 1982), and 8 percent in South Carolina (Pace and Wood 1979).

Glasgow (1958) believed the woodcock to be a regular although an uncommon breeder in Louisiana. Roboski and Causey (1981) suggested that woodcock reproduction in Alabama makes an important contribution to the continental woodcock population. Whiting and Boggus (1982) believed that "sizable numbers" of woodcock nested in east Texas. The data of Rushing and Doerr (1984) suggested that a substantial amount of nesting occurs in the North Carolina Piedmont.

Winter Abundance

Pursglove (1975), working in Georgia, and Pace and Wood (1979), working in South Carolina, reported that, based on flushing rates, concentrations of woodcock in diurnal coverts were comparable to those found in the northern portion of the species' range. Pursglove and Doster (1970) reported high flushing rates throughout the South. Their reported high flushing rate along the Choctawhatchee River in northern Florida was particularly noteworthy because of its deep South location.

Flushing rates on a per man-hour basis in the South include 1.84 (Pace and Wood 1979) and 1.64 (Ingram and Wood 1983) both in coastal South Carolina, 2.3 (Causey 1981) in Alabama, and 1.6 (Pursglove 1975) in Georgia. In comparison, flushing rates reported for some northern areas include 1.7 (Blankenship 1957) and 1.2-1.4 (Ammann 1969) in Michigan, 0.7 (Liscinsky 1972) in Pennsylvania and 1.3 (Goudy et al. 1970) in West Virginia.

Winter Age and Sex Ratios

Ingram and Wood (1983) summarized wing survey data from woodcock harvested in coastal South Carolina between 1977 and 1981. Among 346 birds the percentages of adult males, adult females, immature males, and immature females were 9, 32, 22, and 35, respectively. Comparable values for the Eastern Region population for this period were 20, 29, 26, and 25 percent (file data, U.S. Fish and Wildlife Service, Laurel, MD). A statewide wing survey in South Carolina for the period 1982-1984 yielded 491 wings of which 20, 29, 24, and 27 percent came from adult males, adult females, immature males, and immature females, respectively.

Stamps and Doerr (1976) reported age-sex data for woodcock harvested in North Carolina 1974-76. In the statewide collection of 728 wings there were 26, 28, 26, and 20 percent adult males, adult females, immature males, and immature females, respectively. Interestingly, their Coastal Plain sample was composed of 54 percent females and 54 percent immature birds which was substantially different from the statewide values. Similarly, the South Carolina Coastal Plain data contained 58 percent females and 57 percent immature birds. These data may suggest some differential migration in the southern Eastern Region.

Whiting and Boggus (1982) reported on a sample of 319 woodcock collected in east Texas between 1977-1981 and for which they had age-sex data. The distribution was 31, 32, 20, 17 percent for adult males, adult females, immature males, and immature females, respectively.

Game Species Status

In October 1983, ten wildlife biologists met in South Carolina to discuss the status of the woodcock as a game species in the South. These biologists were working in Texas, Louisiana, Alabama, Mississippi, Georgia, North Carolina, and South Carolina. Only three states were represented by state wildlife agency personnel, although representatives from all southern state wildlife agencies were invited. There was unanimous agreement that, relative to other game species, woodcock hunting has had a very low priority among southern hunters. The group also agreed that the bird probably receives more attention as a game species in Louisiana than any other southern state.

We canvassed most of the southern state wildlife agencies in 1984 to determine their interest in woodcock management. All agencies contacted agreed that because of the relatively low level of hunter interest in the bird they could not justify devoting any research or management efforts to it now or in the foreseeable future. Table 2 reports available harvest data from some of these states. Table 3 indicates the current importance of woodcock relative to some other small game. While these data demonstrate relatively low interest in woodcock hunting in the South, it is interesting that tabular data presented by Sparrowe and Tautin (1985) revealed that in the Eastern Region, southern states accounted for 5.3 percent of the woodcock hunters, but 8.4 percent of the harvest.

In general, southerners currently have little sensitivity toward woodcock nor have they had in the past. A review of historical literature on southern hunting discovered an article written by Thomas Thorpe in the mid-1800s describing "fire-hunting" woodcock in Louisiana (Gohdes 1967). Merovka (1939) also described night hunting woodcock in Louisiana and referred to the method as "shinning." Archibald Rutledge was the only noted outdoor writer to mention woodcock in a number of his articles about hunting in South Carolina. He often referred to the bird as the "swampland prince" (Rutledge 1937). Interestingly, Havilah Babcock, one of the South's best known outdoor writers, barely mentioned the woodcock among his numerous tales of quail hunting in the South Carolina Coastal Plain. We were not able to locate a single account written by Babcock that featured a woodcock hunt.

Sheldon (1971) wrote that most woodcock in the South were killed incidental to other upland game hunting. It is our perception that this is probably true since surveys have indicated that woodcock are shot often during hunts for wood ducks, squirrels, rabbits and bobwhite quail (Wood 1983, 1984). It has also been our

Table 2. Estimates of numbers of woodcock hunters, man-days of effort, and harvests in some southern states.[a]

State and season of survey	Estimates ± 1 Standard Error		
	Hunters	Man-days	Harvest
Alabama 1983-84	2,368 ± 580	6,196 ± 1,823	8,559 ± 2,685
Louisiana	50,000 ± 2,700	——[b]	404,000 ± 30,500
Mississippi 1982-83	8,865 ± 1,034	38,943 ± 8,282	36,352 ± 8,168
North Carolina 1983-84	4,645 ± 348	21,832 ± 5,021	14,219 ± 1,706
South Carolina 1981-82	6,563 ± 1,036	20,310 ± 9,739	34,175 ± 17,647

[a]Based on most recent mail questionnaire surveys conducted by the state wildlife agency.
[b]Data not available.

Table 3. Ratios of numbers of hunters, man-days of hunting, and harvests of quail, dove, and squirrels to woodcock in some southern states.[a]

State and season of survey	Ratios of interest in other small game to woodcock								
	Quail			Dove			Squirrel		
	Hunters	Man-days	Harvest	Hunters	Man-days	Harvest	Hunters	Man-days	Harvest
Alabama 1983-84	18.7	55.3	120.7	41.1	95.9	410.9	47.8	114.2	166.0
Georgia 1983-84	16.1	39.4	91.2	31.3	56.5	290.3	30.0	67.8	100.1
Mississippi 1982-83	6.5	10.6	33.8	15.5	14.4	92.2	19.0	27.8	72.2
North Carolina 1983-84	15.8	22.4	61.3	26.4	26.4	173.6	33.0	50.1	98.4
South Carolina 1981-82	9.0	23.4	41.1	17.4	33.0	120.1	10.3	97.5	31.8

[a]Based on most recent mail questionnaire surveys conducted by the state wildlife agency.

perception that many southern hunters do not know the difference between woodcock and snipe, nor are they knowledgeable of bag limits or season dates for woodcock.

We have reason to believe that there is considerable potential for a change in this situation. First, quail habitat, populations, and opportunities for hunting have declined dramatically across the South during the last several decades. Hunters who locate concentrations of wintering woodcock which provide ample opportunities for both the dog and the gun quickly become excited when their frequent experience has been to walk all day to find one or two coveys of quail. Second, demographic shifts in the human population to the Sunbelt probably is bringing some increased demands on southern wildlife resources. A portion of this demand may be for something to hunt with a pointing or flushing dog. And third, the recent publicity in outdoor magazines about woodcock hunting in the South may encourage both native and new resident hunters to devote more of their hunting effort to what many southern wildlife agencies believe to be an under-harvested species.

Recommendations

Our first recommendation is that the U.S. Fish and Wildlife Service be more assertive in woodcock managment matters under the authority given to the federal government under the Migratory Bird Treaty Act of 1918 (USDI 1975). The Service also needs to develop a holistic concept of woodcock management which includes both the northern and southern portions of the species' geographic range. The Service needs to become more sensitive to the potential for substantial changes in southern woodcock harvests in the future and encourage southern state wildlife agencies to do likewise.

Second we recommend that the U.S. Fish and Wildlife Service appoint an advisory committee for each woodcock management region. The committees should be made up of both managers and scientists and should have proportional representation from the northern and southern portions of each region. The purposes of the committees should be to: (1) assist the Service in coordinating the monitoring of woodcock populations, harvests, and hunting interests throughout the region; and (2) assist the Service in the decision-making process for setting bag limits, season lengths, and season dates.

Third we recommend that a federal American woodcock stamp program be initiated for the purpose of more closely identifying those who specifically hunt woodcock. The improvement on accuracy of the harvest estimates that might be obtained from such a program may be greater in the North than in the South because a great many woodcock are shot as incidental game in the latter area. On the other hand, the precision of the estimates should be greatly improved in both areas. Good precision is a prerequisite to interpreting data trends. As can be seen in Table 2, the low precision of estimates obtained from mail questionnaire surveys of license buyers makes changes, other than those which are phenomenal, impossible to statistically document at reasonable levels of confidence.

Fourth, we urge the southern states to examine the status of woodcock in terms of perceived abundance, distribution, availability on lands in various ownership categories, and hunter interest. We recommend that they consider the resource's future potential value to both consumptive and non-consumptive users.

And lastly, we support the concept of restricting harvests of a species when available data suggest that the species is in a critical decline in population size. We therefore recommend that the U.S. Fish and Wildlife Service decrease the woodcock bag limit and season length in the Eastern Region. While we have no documentation that the apparent decline of woodcock in this Region is a result of hunting, it is unlikely that decreasing hunting pressure would hurt the resource, and it might help it. Such action could help the public image of the hunter's conscience as well as the image of the wildlife manager's accountability for a public trust. The regulation of harvests is our most important wildlife conservation tool. To refuse to use it in a conservative manner in situations such as this may create an appearance of a callous attitude towards resource welfare.

Literature Cited

Amman, G. A. 1969. The 1968 grouse season, with prospects for 1969. Michigan Dep. Natur. Resour. Rep. No. 2651. 3pp.

Blankenship, L. N. 1957. Investigations of the American woodcock in Michigan. Ph.D. dissertation, Michigan State Univ., East Lansing. 217pp.

Britt, T. L. 1971. Studies of woodcock on the Louisiana wintering ground. M.S. Thesis. Louisiana State Univ., Baton Rouge. 105 pp.

Boggus, T. G., and R. M. Whiting, Jr. 1982. Effects of habitat variables on foraging of American woodcock wintering in east Texas. Pages 148-153 *in* Woodcock ecology and managment. Wildl. Res. Rep. 14. USDI, Fish and Wildl. Serv.

Causey, M. K. 1981. Alabama woodcock investigations. Final report on Project No. W-44-5. Study No. 11. Alabama Dep. of Conserv. and Nat. Resour., Montgomery. 22pp.

Connors, J. I., and P. D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. Pages 139-147 in Woodcock ecology and management. Wildl. Res. Rep. 14. USDI, Fish and Wildl. Serv.

Coon, R. A., T. J. Dwyer, and J. W. Artmann. 1977. Identification of potential harvest units in the United States for the American Woodcock. Proc. Woodcock Symp. 6:147-154.

Dyer, J. M. 1976. An evaluation of diurnal habitat requirements for the American woodcock in southern Louisiana. Ph.D. Dissert. Louisiana State Univ., Baton Rouge. 228pp.

______, and R. B. Hamilton. 1974. An analysis of the feeding habits of the American woodcock *(Philohela minor)* in Southern Louisiana. Proc. 5th Woodcock Workshop. Athens, Georgia 11pp.

Dyer, J. M., and R. B. Hamilton. 1977. Analyses of several site components of diurnal woodcock habitat in southern Louisiana. Proc. Woodcock Symp. 6:51-62.

Ensminger, A. B. 1954. Earthworm populations on wintering areas of the American woodcock in the vicinity of Baton Rouge, Louisiana. M.S. Thesis. Louisiana State Univ., Baton Rouge. 97pp.

Evans, D. L. 1976. Relative abundance of deer and woodcock in the 3 major forest types of the Atchafalaya River Basin, Louisiana. M.S. Thesis. Louisiana State Univ., Baton Rouge. 111pp.

Fisher, A. K. 1902. Two vanishing game birds—the woodcock and the wood duck. Pages 447-458. 1901 Yearbook of the U.S. Department of Agriculture. Washington, D.C.

Glasgow, L. L. 1953. The American woodcock *(Philohela minor)* in Louisiana. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 7:31-48.

______. 1958. Contributions to the knowledge of the ecology of the American woodcock, *Philohela minor* (Gemlin), on the wintering range in Louisiana. Ph.D. Disser. Agricultural and Mechancial College of Texas, College Station. 159pp.

Gohdes, C., ed. Hunting in the Old South. Louisiana State Univ. Press, Baton Rouge. 176pp.

Goudy, W. H., R. C. Kletzly, and J. C. Rieffenberger. 1970. Characteristics of a heavily hunted woodcock population in West Virginia. Trans. N. Amer. Wildl. and Natur. Resour. Con. 35:183-194.

Horton, G. I., and M. K. Causey. 1979. Woodcock movements and habitat utilization in central Alabama. J. Wildl. Manage. 43:414-420.

Ingram, R. P. 1981. Woodcock habitat utilization and availability on the Francis Marion National Forest. M.S. Thesis. Clemson University, Clemson, SC. 65pp.

______, and G. W. Wood. 1982. Woodcock and woodcock habitat in coastal South Carolina. Dept. of Forestry, Clemson Univ., Clemson, SC. For. Bull. No. 34. 6pp.

Ingram, R. P., and G. W. Wood. 1983. Characteristics of woodcock harvest data in coastal South Carolina. Wildl. Soc. Bull. 11:356-359.

Johnson, R. C., and M. K. Causey. 1982. Use of longleaf pine stands by woodcock in southern Alabama following prescribed burning. Pages 120-125 *in* T. J. Dwyer and G. L. Storm. Woodcock ecology and management. Wildl. Res. Rep. 14. USDI, Fish and Wildl. Serv.

Krohn, W. B., and E. R. Clark. 1977. Band-recovery distribution of eastern Maine woodcock. Wildl. Soc. Bull. 5:118-122.

Kroll, J. C., and R. M. Whiting. 1977. Discriminant function analysis of woodcock winter habitat in east Texas. Proc. Woodcock Symp. 6:63-72.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Res. Bull. No. 171. Pennsylvania Game Comm., Harrisburg. 95pp.

Martin, F. W., S. O. Williams, III, J. D. Newsom, and L. L. Glasgow. 1969. Analysis of records of Louisiana-banded woodcock. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 23:85-96.

Merovka, L. J. 1939. The woodcock in Louisiana. Louisiana Conservation Review, Winter 1939-1940.

Miller, D. L., and M. K. Causey. 1985. Food preferences of American woodcock wintering in Alabama. J. Wildl. Manage. 49:492-496.

Pace, R. M., III. 1980. Aspects of the ecology of American woodcock wintering in coastal South Carolina. M.S. Thesis. Clemson University, Clemson, SC. 96pp.

______, and G. W. Wood. 1979. Observations of woodcock wintering in coastal South Carolina. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildl. Agencies 33:72-80.

Pursglove, S. R, Jr. 1975. Observations on wintering woodcock in northeast Georgia. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 29:630-639.

______, and G. L. Doster. 1970. Potentialities of the woodcock as a game bird resource in the southeastern United States. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 24:223-231.

Rabe, D. 1977. Structural analysis of woodcock diurnal habitat in northern Michigan. Proc. Woodcock Symp. 6:125-134.

Roberts, T. H. 1980. Sexual development during winter in male American woodcock. Auk 97:879-881.

______, and R. W. Dimmick. 1978. Distribution and breeding chronology of woodcock in Tennessee. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 31:392-399.

Roberts, T. H., E. P. Hill, and E. A. Gluesing. 1984. Woodcock utilization of bottomland hardwoods in the Mississippi delta. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildl. Agencies. (In press).

Roboski, J. C., and M. K. Causey. 1981. Incidence, habitat use, and chronology of woodcock nesting in Alabama. J. Wildl. Manage. 45:793-797.

Roboski, J. C., and M. K. Causey. 1982. Association among woodcock brood members after brood breakup. Pages 71-74 *in* T. S. Dwyer and G. L. Storm. Woodcock ecology and management. Wildl. Res. Rep. 14. USDI Fish and Wildl. Serv.

Rushing, E. L., and P. D. Doerr. 1984. Breeding biology of the American woodcock in Piedmont North Carolina. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildl. Agencies. (In press).

Rutledge, A. 1937. An American hunter. J. B. Lippincott Co., New York. 223pp.

Sheldon, W. G. 1971. The book of the American Woodcock. Univ. of Massachusetts Press, Amherst. 227pp.

Sloan, M. C. 1976. An evaluation of Louisiana pine sites as diurnal cover of American woodcock. M.S. Thesis. Louisiana State Univ., Baton Rouge. 75pp.

Sparrowe, R. D., and J. Tautin. 1985. Department of Interior Environmental Assessment: Proposed regulations on eastern population of woodcock, 1985. USDI, Fish and Wildl. Serv., Laurel, MD. 13pp.

Stamps, R. T., and P. D. Doerr. 1976. Woodcock on North Carolina wintering grounds. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 30:392-399.

Stamps, R. T., and P. D. Doerr. 1977. Reproductive maturation and breeding chronology of woodcock in North Carolina. Proc. Woodcock Symp. 6:185-190.

Tautin, J. 1984. Status of American woodcock. Admin. Rep., USDI, Fish and Wildl, Serv., Laurel, MD. 14pp.

______, P. H. Geissler, R. E. Munro, and R. S. Pospahala. 1983. Monitoring the population status of woodcock. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 48:376-388.

USDI. 1975. Final environmental statement for the issuance of annual regulations permitting the sport hunting of migratory birds. USDI, Fish and Wildl. Serv., Washington, D.C. 710pp. XI Appen.

Walker, W. A., Jr., and M. K. Causey. 1982. Breeding activity of American woodcock in Alabama. J. Wildl. Manage. 46:1054-1057.

Whiting, R. M., and T. G. Boggus. 1982. Breeding biology of American woodcock in east Texas. Pages 132-138 *in* T. J. Dwyer and G. L. Storm. Woodcock ecology and management. Wild. Res. Rep. 14. USDI, Fish and Wildl. Service.

Whiting, R. M., R. R. George, M. K. Causey, and T. H. Roberts. 1983. February hunting of American woodcock: breeding implications. Proc. Symp. Game Harvest Strategies. Caesar Kleberg Institute, Texas A and I Univ., Kingsville. (In press).

Wood, G. W. 1983. Annual report 1982-84 South Carolina woodcock study. Belle W. Baruch Forest Science Institute of Clemson Univ., Georgetown, SC. 14pp.

______. 1984. Annual report 1983-84 South Carolina woodcock study. Belle W. Baruch Forest Science Institute of Clemson Univ., Georgetown, SC. 17pp.

Population Status and Management Efforts for Endangered Cranes

George Archibald and Claire M. Mirande
International Crane Foundation
Route 1, Box 230 C, Shady Lane Road
Baraboo, WI 53913

The Endangered Cranes

The World's cranes can be considered as two groups, the migratory cranes of the northern continents and the nonmigratory cranes of subtropical and tropical regions. There are 15 species of cranes; eight of these are migratory, six are nonmigratory, and the Sandhill Crane (*Grus canadensis*) of North America has both migratory and nonmigratory subspecies. The conservation of migratory species involves protecting widely separated breeding and wintering habitats, and critical regions where the cranes rest during migration. Public education efforts must be promoted over the extensive regions through which the cranes migrate. The wintering grounds of the migratory species are in the southern areas of the northern continents. The limiting factor for most of these species is provision of winter habitat in the warm climates, where the pressures from man are so severe. Although the nonmigratory species are easier to conserve because of their smaller ranges, the pressures from man are greatest in the warm climates and, in the near future, the most endangered cranes may be the tropical forms (Archibald 1981).

In this section we will review the status of the endangered cranes and factors contributing to their decline. Although the problems each crane species faces are different, there are common underlying themes which can be applied to management strategies. In the second half of this paper, we will examine the success of various management efforts to protect cranes including the restriction of hunting, habitat protection, the establishment of artificial feeding stations, captive breeding, and reintroduction. The paper will be concluded with recommendations for future management efforts.

Most people are aware of the dramatic recovery of the North American Whooping Crane (*Grus americana*) from 14 individuals in 1941 to 116 in the wild today (Pratt 1985). Two factors have been vital ingredients in this success story. The first is cooperation in conservation between Canada, where the birds breed, and the United States, where they winter. The second factor is input from private organizations, such as the National Audubon Society and the Whooping Crane Conservation Association, which have promoted public concern for the cranes (Pratt 1984, pers. comm.).

The Whooping Cranes nest in the muskeg wilderness of Wood Buffalo National Park in Alberta and the Northwest Territories (Figure 1). In 1984-85, the traditional flock numbered 84 birds of which 12 were young-of-the-year and represented the net productivity of the nesting efforts of 29 pairs that defended breeding territories the previous spring (Kyte 1984, pers. comm.). A second experimental flock of 31 birds had been established in western USA by substituting Whooping Crane eggs into the nests of Sandhill Cranes. In addition, 35 birds were held in captivity.

The traditional flock is slowly increasing. Its productivity is reduced during

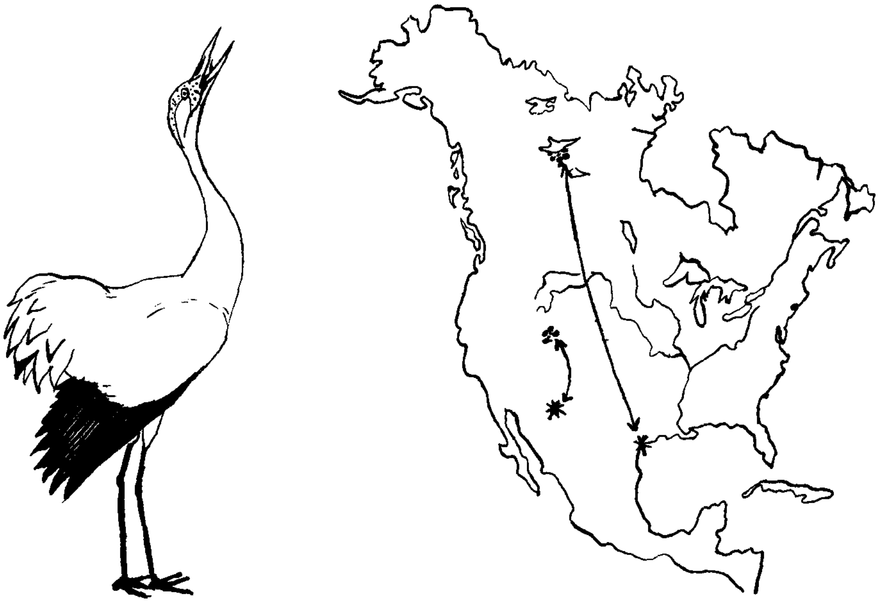


Figure 1. Distribution and migration routes of the Whooping Crane in North America (Sketches in Figure 1-7 are by Diane Pierce; dots indicate breeding areas, lines or asterisks indicate wintering areas, arrows indicate migration routes, dots with line indicate a sedentary population.)

drought years when the limitation of aquatic animal food may cause starvation in chicks and/or increased predation. Extremely cold weather following the hatch of Whoopers in late May or early June can result in the loss of chicks, and wolves probably consume several pre-fledged chicks each year (Drewien 1984, pers. comm.). On migration the greatest mortality arises from collision with elevated wires that crisscross the continent. Their wintering grounds at the Aransas National Wildlife Refuge in Texas are secure, but a spill of toxic chemicals from barges traversing the refuge on the Intracoastal Canal could conceivably decimate much of the traditional flock that feeds in shallow lagoons that border the Canal (Archibald 1983).

Next in rarity may be the Black-necked Crane (*Grus nigricollis*) of the Tibetan Plateau (Figure 2). Apparently this crane existed in large numbers when China consolidated the Plateau in the 1950s. The Tibetans are Orthodox Buddhists and, as such, they protect all forms of life. It is believed that the birds where shot by soldiers. Visitors to southern Tibet see few birds of any type, and Chinese ornithologists believe there may be only 700-900 Black-necked Cranes alive (Wang 1985, pers. comm.).

The confirmed breeding areas of Black-necked Cranes lie along the extreme northeast and southwest of the plateau in China's Chinghai Province, and India's Ladakh, respectively. Approximately 15 nesting pairs are now protected in a newly formed nature reserve at Lake Longbaotan, a narrow wetland, which is near the source of the Yangtze River. Perhaps six to eight pairs nest in Ladakh, where local

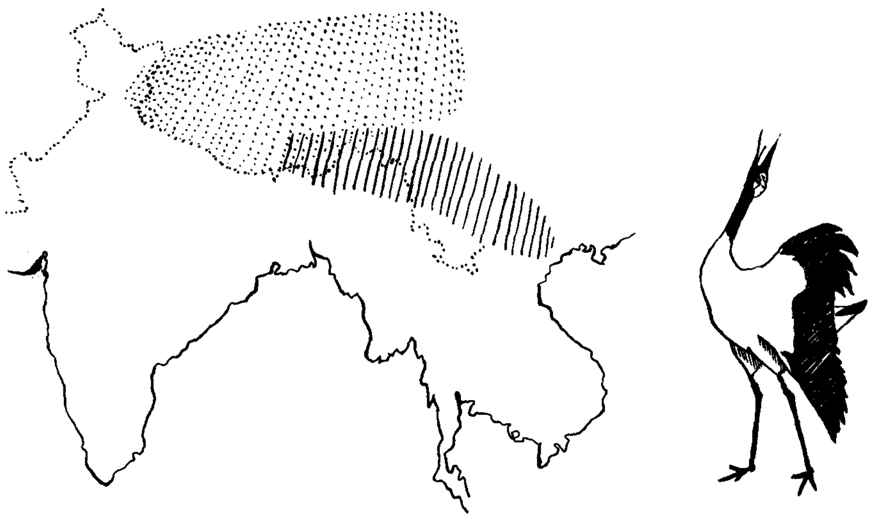


Figure 2. Distribution of the Black-necked Crane in Asia.

people protect the cranes, but Indian military personnel have sometimes shot the cranes and disturbed them at their nests.

The only known wintering areas for Black-necked Cranes are in Guizhou and Yunnan Provinces in southwest China, and in Bhutan. In a broad, high altitude valley of western Guizhou Province, a grassland-lake region known as the Sea of Grass, has recently been protected as a nature reserve because approximately 300 Black-necked Cranes winter in the vicinity. During the 1984-85 winter, 51 cranes were counted in Na Pa Hai and 20 more at La Si Hai in Yunnan Province (Zeng 1985, pers. comm.). More than 100 cranes winter in the Popshika Valley, while fewer than 30 birds are regularly seen in Boomthong Valley of Bhutan (Gole 1985, pers. comm.).

Although the popular Red-crowned Crane (*Grus japonensis*) is a symbol of good luck and long life in the Orient and is frequently seen in art, there are only about 1,000 birds in the wild and perhaps 300 in captivity. Their nesting habitats on the fertile plains of northeastern China, southeastern USSR, and eastern Hokkaido, Japan, lie at the same latitude as the northern United States (Figure 3). The summer populations in these areas are 500 (Yin-ching and Long-rong, in press), 200 (Shibaev and Gluschenko 1982), and 350 (von Treuenfels 1984) respectively. Fortunately, the human populations are concentrated in southern areas of China and Japan, and it has only been in recent decades that large numbers of people have moved into the northern frontiers. Much of the Red-crowned Crane's nesting habitat has already been converted to agriculture.

In recent years the Chinese, Japanese, and Soviets have taken an active interest in surveying the marshlands from fixed-wing aircraft in spring when the cranes nest. The large, white cranes are readily spotted and the prime breeding habitats identified.

The pressures on the habitat of the Red-crowned Cranes are enormous. Although nature reserves encompass several of the major wetlands in China, much of the land

Figure 3. Distribution of the Red-crowned Crane in Asia.

in the reserves is still owned by the communes and there are increasing demands for fisheries and farming (Masatomi 1981). In Japan, lowlands are so valuable that the government has been able to protect only parts of the Kushiro Marsh and Lake Furen, the two largest wetlands, while more than half of the cranes nest on other wetlands that are not protected.

The Japanese flock of about 300 Red-crowned Cranes is nonmigratory. The mainland birds winter on the Korean peninsula and in coastal regions of Jiangsu Province, China. Ironically, the majority of the 150-160 birds that winter in the Republic of Korea find sanctuary on the 2.5-mile (4 km) wide Demilitarized Zone that separates hostile neighbors and creates sanctuary for wildlife.

The Siberian Crane (*Grus leucogeranus*) is reduced to two (or possibly three) widely separated flocks in east and west Asia (Figure 4). The Siberian Crane has one of the longest migration routes of any crane between their nesting grounds, in arctic and subarctic tundra of the USSR, and their winter haunts in Iran, India, and China. The two western flocks are reduced to perhaps as few as 51 birds. Only ten individuals were spotted in Iran during the 1984-85 winter, a discouraging decrease from 15 birds, when the population was rediscovered in 1978. The group that winters at India's well-known Keoladeo National Park near Bharatpur in Rajastan has declined from 72 birds in the early 1970s to just 41 during the 1984-85 winter. However, this figure has increased from 37 in 1983-84 and may indicate that protection is helping. The limiting factor to the western flock is hunting. Waterfowl hunting has been rampant in the small wetlands near Feredunkenar, Iran, where the cranes winter. And, although the Siberian Cranes are strictly protected in India, the

Figure 4. Distribution and migration routes of the Siberian Crane in Asia.

birds must traverse Afghanistan and Pakistan, where crane hunting is a strong tradition among the local people.

The eastern flock of approximately 1,482 Siberian Cranes winters on the mudflats of the northwestern shore of Poyang Lake, the largest lake in China. This region has recently been declared a nature reserve by the China Ministry of Forestry. These birds spend four to six weeks at Zha Long Nature Reserve in northeast China in April and May while enroute to their nesting grounds in Yakutia, USSR.

During migration and in the winter the Siberian Crane is predominantly a specialized aquatic vegetarian, spending long hours excavating sedges from the mud in shallow wetlands. The cranes will not forage in dry open upland areas, so their survival is linked to the welfare of key wetlands and the protection of the cranes against hunting at these critical spots.

Somewhat similar to the Siberian Crane in wintering ecology is the White-naped Crane (*Grus vipio*). In winter the Siberian Crane feeds in flooded wetlands, whereas the White-naped Crane excavates sedge tubers and feeds on seeds in the upper littoral zone, where the soil is damp but not always saturated. The White-naped Crane breeds in sympatry with the Red-crowned Crane in northeast China and southeast USSR and winters in Japan, Korea, and China (Figure 5).

More than one thousand White-naped Cranes winter at Poyang Lake, China, and a similar number winter near Izumi in Kyushu, Japan. While the cranes in China forage in natural wetland habitats, the wetlands in Kyushu have been reclaimed for agriculture. If it were not for an artificial feeding station where grains and fish are scattered on the rice paddies for the cranes, the White-naped Cranes might no longer

Figure 5. Distribution of the White-naped Crane in Asia.

winter in Japan. This flock pauses in the Korean Demilitarized Zone (DMZ) in October, where it remains for up to two months before continuing on to Japan. Several hundred cranes remain on the DMZ through winter, where they feed in salt marshes of the Han River Estuary and on gleanings in the rice paddies nearby. The world population of White-naped Cranes is perhaps 2,500 to 3,000 individuals (Archibald, pers. obs.).

The final endangered crane of the northern continents is the Hooded Crane (*Grus monacha*) that breeds in tamarack bogs of eastern USSR and that winters some 7,000 strong in Japan (Harris 1984) and several hundred in China (Chi-shan and Xiao-long, in press) (Figure 6). This small crane was undoubtedly decimated by hunting and general disturbance on its wintering grounds, pressures that culminated during the Pacific War, when the Hooded Cranes and White-naped Cranes were almost extirpated from Japan. Protection and artificial feeding in Japan have resulted in a dramatic increase in Hooded Crane numbers.

Whereas most of the migratory cranes are forced into proximity to mankind only on their wintering grounds, the tropical and subtropical cranes constantly face these threats. In North America, the three migratory subspecies of the Sandhill Crane number in tens and hundreds of thousands, while the three sedentary subspecies have dwindled to several thousand Florida Sandhills (*Grus canadensis pratensis*), perhaps 200 Cuban Sandhills (*Grus canadensis nesiotes*) (King 1979), and fewer than 60 Mississippi Sandhills (*Grus canadensis pulla*) (Valentine, in press). The last two subspecies are officially designated as endangered.

The nonmigratory Eastern Sarus Crane (*Grus antigone sharpii*) of southeast Asia, a subspecies of the Sarus Crane, may already be extirpated from its former range. This subspecies may only survive in northeastern Australia, where it was first observed by an ornithologist in 1951.

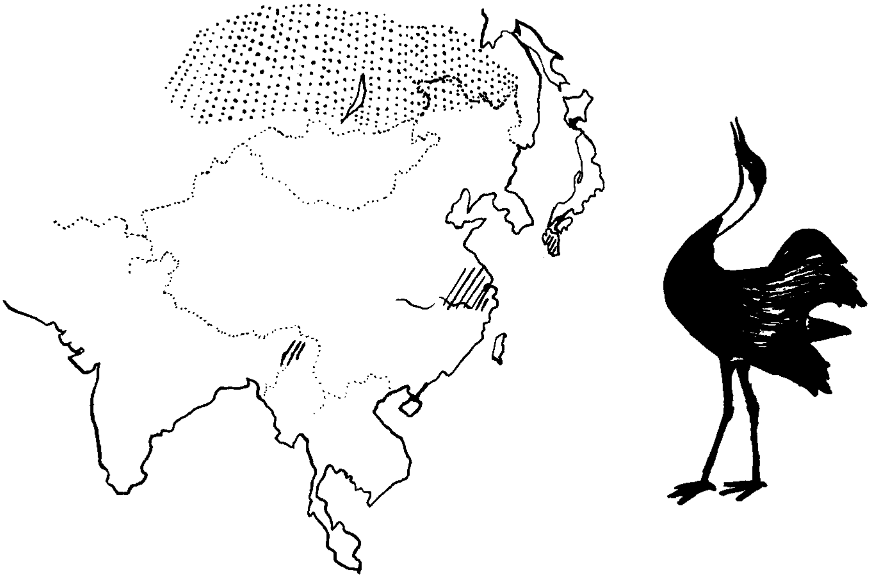


Figure 6. Distribution of the Hooded Crane in Asia

In Africa, hunting pressure from man and the attrition of wetlands are increasing in most regions. In central and southern Africa, the regal Wattled Crane (*Bugeranus carunculatus*) is in widespread decline and may number between 8,000-10,000 birds (Mundy et al. 1984, Urban, in press). This species, like the Siberian Crane, is restricted to shallow fresh water wetlands. Problems faced by this species include drainage for agriculture, subdivision, forestation, dam building, road making, and tourism (West 1982). Their strongholds are the Okavango Delta of Botswana and the Kafue Flats of Zambia (Figure 7).

On northwest Africa's Atlas Mountain Plateau, the Demoiselle Crane (*Anthropoides virgo*) may already be extirpated or reduced to a few pairs. South of the Sahara in west Africa, tens of thousands of Black Crowned Cranes (*Balearica pavonina*) recently flourished over the savannahs. The recent expansion of the desert and the widespread use of toxic pesticides have reduced these cranes to scattered hundreds (Fry, in press).

Management of the Endangered Cranes

Hunting

The two primary considerations in crane management are to prevent death from human-related agents, and to protect critical habitats. Apparently, cranes are not as sensitive as raptors to toxic environmental pollutants. Egg shell thinning and the aberrant behavior that have reduced the populations of many birds of prey as a consequence of the accumulation of toxic residues in their bodies have not been

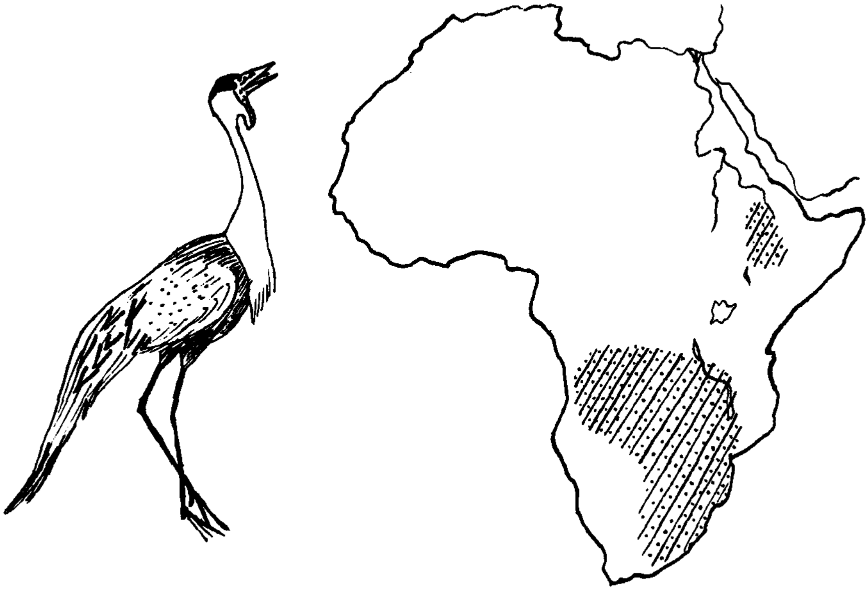


Figure 7. Distribution of the Wattled Crane in Africa.

documented in cranes. However, hunting, collision with wires, and disturbance have taken their toll on the cranes.

Strict protection of cranes against hunting arrests their decline and usually results in rapid population increases. Migratory Sandhill Cranes in North America have increased to the hundreds of thousands and are now legally hunted in several states and provinces with no apparent detriment to the overall population. However, some local populations may still be seriously reduced. Unfortunately, Whooping Cranes migrate in company with hunted Sandhills across the central plains of North America, and there is a possibility of misidentification and the death of Whooping Cranes. As yet, there is no report of such a fatality.

However, the tiny flock of Siberian Cranes that winters in India migrates through the Hindu Kashu Mountains of Afghanistan and Pakistan, a route also used by tens of thousands of Common Cranes and hundreds of thousands of Demoiselle Cranes. Until recently, all three species were hunted and the precipitous decline of India's Siberian Cranes from 72 to just 41 in the past decade is probably due to hunting in the mountains. Recently, the Siberian Crane has been declared a protected species in both Afghanistan and Pakistan. However, the enforcement of these laws is difficult in rural areas, particularly in view of the current social problems in these mountain passes and the strong tradition of crane hunting among the local people. Rampant waterfowl hunting is believed to have claimed Iran's wintering population of Siberian Cranes.

Cranes readily learn to trust, or to avoid, man. In India, where the Siberian Cranes are strictly protected, the birds can sometimes be approached within 50 meters without alarming them. In Afghanistan, where these same cranes are hunted, it is difficult to get within a kilometer before they fly.

The Florida Sandhill Crane and the Indian Sarus Crane (*Grus antigone antigone*) are both protected in their subtropical ranges, where they are year-round residents. Although Florida Sandhills were recently on the endangered species list, they have adapted to man and now nest on small wetlands near human residences. In several states of India, such as Gujarat and Rajasthan, where Sarus Cranes are revered by the Hindus, these man-sized cranes are abundant and nest in the rice paddies. In nearby states, such as the Punjab, where the cranes are not revered, none are present.

Habitat Protection

Unfortunately, even if protection is provided, some cranes are very specialized in their needs and they require natural habitats that are unaltered by man. In winter, the Whooping Cranes feed predominately in brackish water wetlands of coastal Texas, whereas Sandhills prefer to feed on gleanings in nearby upland agricultural fields. Similarly, the Siberian Cranes in India feed in shallow wetlands. Most of the fertile Gangetic plain, which was once the winter range of the Siberian Cranes, has been drained. In South Africa, the Wattled Crane is restricted to high altitude marshlands. Many of these have been lost to drainage, flooding, forestation, and burning, causing a decline of the cranes (West 1982). Surprisingly, Stanley Cranes (*Anthropoides paradisea*) and Grey Crowned Cranes (*Balearica regulorum*) still thrive in regions that once had Wattled Cranes. Their success is derived from the Stanley Crane's ability to breed in grasslands and the Crowned Crane's preference for small, seasonally produced wetlands. Clearly, the preservation of many species of cranes rests in the preservation of their natural, pristine habitats.

Since the protection of Japan's Kushiro Marsh in 1925, the breeding habitat of the Red-crowned Cranes (Koga 1975) and the Aransas National Wildlife Refuge in 1938 on the winter habitat of the Whooping Crane, millions of hectares of wetland habitat around the world have been protected because they are required by the cranes. Table 1 lists the major crane sanctuaries. China has more than a billion people, and eight species of cranes—more humanity and species of cranes than any other nation. The China Ministry of Forestry and the China Environmental Protection Agency are responsible for the protection of wildlife, and it is most reassuring that five nature reserves have been established for cranes since 1979, and there are plans to protect additional regions in the near future.

In northeast West Germany small marshes not formerly used as nesting habitat for Common Cranes, were suddenly accepted by the cranes when trees were cut from the wetlands and a shallow pond with a small island was artificially created in each wetland. The cranes sensed greater security and nested on the man-made islands and subsequently the crane population in West Germany has increased from 12 in 1974 (Makowski 1981) to 31 nesting pairs in 1983 (Ven der Ven 1983). Some former human habitats can readily become winter sanctuaries for cranes by either removing all people, as in the case on the Korean DMZ, where Red-crowned and White-naped Cranes still winter, or by creating large artificially maintained wetlands as exist at the Keoladeo National Park, India.

Perhaps the greatest challenges in crane conservation lie in Africa and southeast

Table 1. Officially protected sanctuaries for endangered cranes.

Species	Sanctuary	Location	Use
Whooping (Idaho flock)	Grays Lake National Wildlife Refuge (NWR)	Idaho, USA	Breeding
	Monte Vista-Alamosa NWR	Colorado, USA	Migration
	Bosque del Apache NWR	New Mexico, USA	Winter
Whooping (Aransas flock)	Aransas NWR	Texas, USA	Winter
	Salt Plains NWR	Oklahoma, USA	Migration
	Areas on Platte River	Nebraska, USA	Migration
	Wood Buffalo National Park incl. the Whooping Crane summer range with additional area outside park	Alberta, Northwest Territories, Canada	Breeding
	Matagorda Island	Texas, USA	Winter
Black-necked	Lake Longbaotan Nature Reserve	Chinghai, China	Breeding
	Sea of Grass Nature Reserve	Guizhou, China	Winter
Red-crowned	Kushiro Marsh	Hokkaido, Japan	Breeding-Winter
	Lake Furen	Hokkaido, Japan	Breeding-Winter
	ZhaLong Nature Reserve	Heilongjiang, China	Breeding
	Yancheng Nature Reserve	Jiangsu, China	Winter
	Incheon Mudflats Natural Monument	Republic of Korea	Winter
	Cholewon Basin	Republic of Korea	Winter
	Khingansk Nature Reserve	USSR	Breeding
	Lake Khanka Nature Reserve	USSR	Breeding
Siberian	Ob River Tundra	USSR	Breeding
	Yakutia Tundra	USSR	Breeding
	Lake Ab-i-Estada	Afghanistan	Migration
	ZhaLong Nature Reserve	Heilongjiang, China	Migration
	Feredunkenar Abbandan	Iran	Winter
	Keoladeo National Park	Rajastan,India	Winter
	Lake Poyang Nature Reserve	Jiangxi, China	Winter
White-naped	ZhaLong Nature Reserve	Heilongjiang, China	Breeding
	Khingansk Nature Reserve	USSR	Breeding
	Han River Estuary Natural Monument	Republic of Korea	Migration-Winter
	Arasaki Plains	Kyushu, Japan	Winter
	Lake Poyang Nature Reserve	Jiangxi, China	Winter

Table 1. (con't.)

Hooded	Arasaki Plains	Kyushu, Japan	Winter
	Lake Poyang Nature Reserve	Jiangxi, China	Winter
Mississippi Sandhill	Mississippi Sandhill Crane National Refuge	Mississippi, USA	Breeding-Winter
Eastern Sarus	Bang Pra Wetland	Thailand	Reintroduction Site
Wattled	Kafue Flats National Park	Zambia	Breeding-Winter
	Okavango Delta	Botswana	Breeding-Winter
	Verloren Valei Nature Reserve	Transvaal, South Africa	Breeding-Winter
	Colesford Nature Reserve	Natal, South Africa	Breeding-Winter
	Himeville Nature Reserve	Natal, South Africa	Breeding-Winter
	Stille Rust Nature Reserve	Natal,South Africa	Breeding-Winter

Asia, where there are few constraints on the proliferation of humanity, where there are serious social and political problems, and where there is not an historical tradition of protecting wildlife. In meeting these challenges, much can be gained by examining management techniques used for cranes in several countries.

Artificial Feeding Stations

Since 1952, the three species of cranes that winter in Japan have benefited from the provision of daily handouts of grain and sometimes fish at selected agricultural fields known as feeding stations. Feeding greatly benefits the cranes since most of their natural winter habitat in Japan has been destroyed. The local people revere the cranes. The Japanese Government provides the food and pays wardens to feed the cranes. Due to artificial feeding, the winter counts in Kyushu have increased from 811 to 7,036 for the Hooded Cranes and from 96 to 1,095 for the White-naped Cranes since the winter of 1962-63 (Koga 1981, Harris 1984). Now, there are new risks. Thousands of cranes concentrate at the feeding station on the Arasaki Plain in Kyushu. Cranes are susceptible to communicable diseases such as tuberculosis, inclusion body disease of cranes, and avian cholera. Were one of those diseases to erupt at Arasaki, the majority of the Hooded Cranes on earth would be jeopardized. Recommendations have been advanced that the amount of feed be tapered and that birds be encouraged to use other newly established feeding stations. Although the provision of natural habitat is desirable, the Japanese people must be applauded for the consistent help to the cranes, and it is encouraging to know that winter flocks of these species can be aided by artificial feeding. It is possible that a specialized aquatic forger like the Siberian Crane would not learn to feed at an upland feeding station if vital wetlands were destroyed. However, stray Siberian Cranes in Japan have fed through the winter with the White-naped Cranes and Hooded Cranes in Arasaki.

Collision with Wires

Suspended wires are a hazard to cranes. When birds are flushed, when the light is poor, and when the wind is strong, cranes have died from collisions with wires. Japanese researchers determined that if 90 cm sections of orange plastic tubing are clamped over the highest wire at approximately five meter intervals, the cranes gauge their flight to clear this highest point. Mortality from this cause has been almost eliminated in an area where as many as 20 birds from a flock of 200 cranes died each winter by striking wires (Yamaguchi 1985, pers. comm.).

Captive Breeding

Cranes adjust well to captivity and they breed readily in confinement if provided with proper facilities, diet, and care. A number of articles have been published describing successful crane management techniques (Archibald and Veiss 1979, Gee and Sexton 1979, Serafin 1982). Fourteen of the 15 species have been bred successfully in captivity. A breeding center for the Whooping Crane and the Mississippi Sandhill Crane has been established at the Patuxent Wildlife Research Center in Laurel, Maryland, USA, since 1967. Japan has established a Crane Park for Red-crowned Cranes near Akan, Hokkaido, and a special breeding center has been built by the Ministry of Education at the nearby Kushiro Zoo. Since 1979, the Soviet Ministry of Agriculture has built a substantial breeding center for the Siberian Cranes at the Oka State Nature Reserve near Ryazan. The China Ministry of Forestry has established a large captive breeding center for cranes and a public education center beside the Zha Long Nature Reserve near Qiqihar.

Many private institutions have also developed major breeding centers for endangered cranes. These include the International Crane Foundation (ICF) in Wisconsin, USA; the New York Zoological Society (NYZS) and its Wildlife Survival Center in Georgia, USA; the National Zoo Conservation and Research Center in West Virginia, USA; the Baltimore Zoo in Maryland, USA; the Tokyo Zoological Society in Japan; and Vogelpark Walsrode in Germany. Many other zoos are becoming actively involved in the propagation of cranes. Organizations involved with captive propagation are cooperating to develop sound genetic management and husbandry techniques. Studbooks have been developed for the White-naped Crane, the Red-crowned Crane, and the Siberian Crane. The White-naped Crane is currently designated under the Species Survival Plans (S.S.P.) administered by the American Association of Zoological Parks and Aquariums. Petitions for studbooks for the Hooded Crane and the Wattled Crane have been recently approved. A list of studbook keepers is provided in Table 2.

As a result of these efforts, all the endangered species of cranes except the Black-necked Crane are breeding and becoming well-established in captivity. However, the captive populations are still small and sound management is vital to maintaining their genetic diversity. For most species the number of founder individuals is low and it is desirable to collect new founder lines from the wild. Although this can be accomplished by collecting wild birds, it may also be achieved by the collection of eggs from wild nests and hatching and rearing the chicks in captivity. Since most species raise only one young or will renest after their nest is destroyed, this method insures the least harm to the wild population. Another advantage of this method is that the birds will be better adjusted to captivity. A disadvantage of this method is that it takes several years for the cranes to mature and breed. Wild individuals may sometimes be collected without reducing the size or gene pool of the population by obtaining cranes that are wounded, injured, or incapable of surviving in the wild (Carpenter and Derrickson 1981).

Table 2. Studbook keepers for endangered cranes.

Species	Studbook Keeper	Studbooks
Whooping	Patuxent Wildlife Research Center U.S. Fish and Wildlife Service Laurel, Maryland 20811 USA	In-house records
Red-crowned	*International* Shigeharu Asakura Director—Ueno Zoo Ueno-ku Tokyo, Japan	Published 1973-present
	Regional-North America Claire Mirande, Curator of Birds Scott Swengel, Aviculturist International Crane Foundation Rt. 1, Box 230 C, Shady Lane Road Baraboo, Wisconsin 53913 USA	Proposing
Siberian	Vladimir Panchenko Oka State Nature Reserve Ryazan Oblast, USSR	Compiling
White-naped[a]	Christine Sheppard Associate Curator of Birds New York Zoological Society 185th St. & Southern Boulevard Bronx, New York 10460 USA	Published 1983-1984
Hooded	Bruce Bomke Curator of Birds Kansas City Zoological Gardens Swope Park Kansas City, Missouri 64132 USA	Compiling
Wattled	Fred Beall Curator of Birds Baltimore Zoo Druid Hill Park Baltimore, Maryland 21217 USA	Compiling

[a]This species is designated under the Species Survival Plan (SSP) of the American Association of Zoological Parks and Aquariums.

The captive "habitat" may be saturated in the near future. A questionaire is currently being distributed by ICF and the NYZS to evaluate the carrying capacity for cranes in captivity and to balance available space between common and endangered species. Fortunately, many small zoos and private breeders would like to breed cranes. Many of these places are starting to work with the common species and shifting to endangered species once their breeding programs are adequately developed. This will increase the carrying capacity of cranes in captivity in the future. Limited breeding of common species is advised to accommodate the endangered ones.

Some question the value of keeping captive collections of endangered species. Carpenter and Derrickson (1981) have compiled an excellent review of captive propagation in preserving endangered species. They feel that captive propagation can complement or enhance standard conservation techniques by: (1) producing stock for release to the wild, (2) preserving genetic variability through periods of high risk, (3) producing stock for studies that yield information necessary for managing wild populations, and (4) producing animals for public education. They state that additional advantages of captive propagation include: (1) stock can be obtained from the wild with little, if any, sacrifice to the productivity of the wild population, (2) captive animals can be more productive than their wild counterparts, (3) captive breeding permits selective breeding, and (4) captive propagation provides a measure of insurance against extinction in the event of a catastrophic loss of the wild population.

Reintroductions

In the late 1970s Common Cranes wintered in southeastern England for the first time in centuries. Since 1982 a pair has successfully bred and the small but growing flock is nonmigratory (Buxton 1983, pers. comm.). The Common Cranes reintroduced themselves into the British Isles, an occurence that would have been improbable were it not for the conservation-minded attitude of several persons who guarded the founder birds from disturbance.

Other cranes that lack a large population from which individuals can recolonize former habitat will need help in order to expand their ranges. Since 1976, an ambitious experiment has been undertaken to establish a new flock of Whooping Cranes that breeds on the alpine wetlands of Idaho and that winters in the Rio Grande Valley of New Mexico. This flock has a separate migratory route from the original flock and provides a buffer to the population in case of catastrophe. Greater Sandhill Cranes at Grays Lake National Wildlife Refuge, Idaho, have been foster parents to Whooping Cranes hatched from eggs laid by both the wild Whoopers in Canada and the captive birds at Patuxent. The foster chicks are reared by the Sandhills, learn the migration route to New Mexico, and readily feed in the agricultural fields with the wintering Sandhills. The true test of this program depends on whether foster-reared Whooping Cranes pair and breed with their conspecifics. Unfortunately, this has not yet happened, although adult males defend large territories at Grays Lake each spring and summer. An uneven sex ratio, with a predominance of males, and the wide dispersal of the solitary Whooping Cranes, makes it difficult for potential mates to meet (Archibald 1983). Thirty-one Whooping Cranes reached their wintering grounds during the winter of 1984-85.

The outcome of this experiment remains to be determined. If it is successful it opens an avenue to creating a third migratory flock of Whoopers by using eastern Greater Sandhill Cranes as the foster parents. This population would breed in the Great Lakes region and winter in the southeastern United States. Similar plans are underway between ICF and the USSR to initiate a new flock of Siberian Cranes by substituting captive-produced eggs into the nests of Common Cranes at the Oka State Nature Reserve.

Researchers at Patuxent and in Mississippi have bolstered the relict flock of Mississippi Sandhills by releasing captive-reared birds into flocks of wild cranes (Valentine, in press). Mississippi Sandhill Crane chicks are reared by captive Florida Sandhills at Patuxent. The fledged birds are relatively wild because they have been reared by cranes. After they fledge, their wings are brailed and they are placed in a large fenced enclosure beside the habitat of the wild Mississippi Sandhills. After the captive-produced cranes acclimate to their new surroundings and are actively feeding on the artificial food in feeders, several are allowed to fly. They explore areas near the release site but always return for food and a reunion with flock members. Eventually all wing brails are removed and the birds are given their freedom. This "soft release" has successfully reintroduced birds to the wild population.

ICF and Vogelpark Walsrode are working closely with the government of Thailand on a reintroduction program for the Eastern Sarus Crane. This subspecies formerly ranged throughout Southeast Asia. Since 1968 sightings have been rare and unconfirmed.

In 1984 ICF collected eggs from a population of several thousand Eastern Sarus Cranes in northern Australia that has grown rapidly since this crane colonized Australia around 1950. Six of the 17 young raised from these eggs at ICF are now settled into a breeding center in the Bang Pra wetlands of central Thailand. In time their young will be allowed to fly free and it is hoped that they will spread and recolonize the area. These efforts are augumented by an extensive public education campaign.

ICF is also conducting research on chick-rearing techniques aimed at improving reintroduction success. To overcome problems associated with hand-rearing, ICF is working to develop techniques to rear chicks in visual and acoustical isolation from humans. During the spring of 1985 ten Greater Sandhill eggs will be collected from the wild and reared at ICF. The chicks will be imprinted on their own species through the use of crane models, vocalizations, and contact with live cranes. They will be taught foraging behavior and vigilance against predators. These birds will be radio-tagged and soft-released in the fall. Their success will be closely monitored.

Recommendations

Although much has been achieved in preserving cranes, there is still much to be done to insure that these birds survive the difficult years ahead. The following measures are recommended to further conservation of the migratory species. Efforts should be made to divert the Intracoastal Canal away from the marshes used by Whooping Cranes at Aransas so that a possible spill of chemicals does not decimate the traditional flock. A constant vigil must be kept to assure that development projects in Hokkaido, Japan, northern China, and southeastern USSR do not erode the wetlands vital to the breeding of Red-crowned and White-naped Cranes. Wintering Hooded and White-naped Cranes should be carefully dispersed from Arasaki and additional feeding stations should be initiated. Efforts must be expanded to educate the hunters in Iran, Afghanistan, and Pakistan not to shoot Siberian Cranes. More research must be undertaken on the Tibetan Plateau to identify and protect critical habitats of the Black-necked Cranes. No species should be concentrated in one breeding center to protect against significant losses due to disease or natural disasters. The Black-necked Cranes should be well established in captivity and breeding programs should be expanded for other endangered species. The momentum for crane conservation in recent years encourages one to believe that migratory cranes of North America and Asia will enter the next century in much better shape than has been their status in recent decades.

The nonmigratory cranes of Africa and southeast Asia are now the greatest challenge for conservation efforts. Critical habitats of the Wattled Crane should be identified and protected. Also, further research is needed to determine the factors contributing to the decline of the Black Crowned Crane in West Africa.

Acknowledgements

We would like to thank Jim Lewis, Steven Nesbitt, Ernie Kuyt, Warwick Tarboton, and Ma Yi-ching for their assistance in compiling information on crane sanctuaries. We also thank Jim Harris, Scott Swengel, and Lisa Hartman for their helpful comments in developing this manuscript.

Literature Cited

Archibald, G. W. 1981. Endangered cranes. Pages 1-13 *in* J. C. Lewis and H. Masatomi, eds. Crane research around the world. Robinson Printing, Fort Collins, Colo. 259 pp.

______. 1983. Status of Whooping Crane conservation efforts. Pages 117-122 *in* S. Temple, ed. Bird conservation, vol. 1. University of Wisconsin Press, Madison. 148 pp.

______, and D. Viess. 1979. Captive propagation at the International Crane Foundation, 1973-78. Pages 51-73 *in* J. C. Lewis, ed. Proc. 1978 Crane Workshop. Colorado State Univ. Printing Service, Fort Collins. 259 pp.

Armstrong, E. A. 1979. The crane in the British Isles and crane traditions as evidence of cultural diffusion. Pages 237-248 *in* J. C. Lewis, ed. Proc. 1978 Crane Workshop. Colorado State Univ. Printing Service, Fort Collins. 259 pp.

Carpenter, J. W., and S. R. Derrickson. 1981. The role of captive propagation in preserving endangered species. Pages 109-113 *in* R. Odom and J. W. Guthrie, eds. Proc. of the Nongame and Endangered Wildlife Symposium. August 13-14, Athens, GA. GA Dept. Nat. Resourc., Game and Fish Div., Tech. Bull. WL5.

Chi-shan, W., and H. Xiao-long. In press. Wintering ecology of Hooded Cranes on the lower reaches of the Changjiang (Yangtse) River, China. *In* R. F. Pasquier and G. W. Archibald, eds. Proc. 1983 Int. Crane Workshop. International Council for Bird Preservation, Cambridge.

Fry, C. H. In press. New data on the west African status of the Black Crowned Cranes. *In* R. F. Pasquier and G. W. Archibald, eds. Proc. 1983 Int. Crane Workshop, International Council for Bird Preservation, Cambridge.

Gee, G. and T. Sexton. 1979. Artificial insemination of cranes with frozen semen. Pages 89-94 *in* J. C. Lewis, ed. Proc. 1978 Crane Workshop. Colorado State Univ. Printing Service, Fort Collins. 259 pp.

Harris, J. 1984. Winter crane counts. ICF Bugle 10(2):2.

King, W. B., ed. 1979. Endangered birds of the world: ICBP red data book. Reprinted in handbook form by Smithsonian Institution Press, Washington, D.C.

Koga, T. 1975. On the cranes of Japan in the wild and in captivity. Zool. Garten N. F. 45:81-96.

______. 1981. Wild and captive cranes in Japan. Pages 50-51 *in* J. C. Lewis and H. Masatomi, eds. Crane research around the world. Robinson Printing, Fort Collins. 259 pp.

Makowski, H. 1981. Common cranes in the German Federal Republic. Pages 188 *in* J. C. Lewis and H. Masatomi, eds. Crane research around the world. Robinson Printing, Fort Collins. 259 pp.

Masatomi, H. 1981. Population of Red-crowned Cranes in Hokkaido, Pages 86-89 *in* J. C. Lewis and H. Masatomi, eds. Crane research around the world. Robinson Printing, Fort Collins. 259 pp.

Mundy, P. S., A. Morris, and P. Hougaard. 1984. Aerial survey for Wattled Cranes, 1983. Honeyguide 30:98-104.

Pratt, J. ed. 1985. Whooping Crane wintering populations. Grus Americana 24 (Supplement No. 1):1-2.

Putnam, M. E. 1982. Refined techniques in crane propagation at the International Crane Foundation. Pages 250-258 *in* J. C. Lewis, ed. Proc. 1981 Crane Workshop. National Audubon Society, Tavernier. 296 pp.

Serafin, J. 1982. The influence of diet composition upon growth and development of Sandhill Cranes. Condor 84:427-434.

Shibaev, Y. V., and Y. N. Gluschchenko. 1982. Modern status and problems of conservation of Japanese Cranes on Khanka Plain. Pages 27-34 *in* Cranes of East Asia. Far East Science Center, Academy of Sciences of the USSR, Vladivostok.

Urban, E. K. In press. The cranes of Africa—an overview. *In* R. F. Pasquier and G. W. Archibald, eds. Proc. 1983 Int. Crane Workshop. International Council for Bird Preservation, Cambridge.

Valentine, J. M. In press. Management of the Mississippi Sandhill Crane. *In* R. F. Pasquier and G. W. Archibald, eds. Proc. 1983 Int. Crane Workshop. International Council for Bird Preservation, Cambridge.

van der Ven, J. A. 1983. ICF Europe circular letter no. 2. 2 pp.

von Treuenfels, C. A. 1984. Sie mússen sterben, weil sie wardern. GEO 1984(6): 128-146.

West, O. 1982. The Wattled Crane *Grus carunculatus* (Gmelin), an endangered species. The Naturalist 27(1):2-9.

Yin-ching, M., and J. Long-rong. In press. Distribution and numbers of the Red-crowned Crane in northeast China. *In* R. F. Pasquier and G. W. Archibald, eds. Proc. 1983 Int. Crane Workshop. International Council for Bird Preservation, Cambridge.

Symposium: The Role of Diseases in Marine Fisheries Management

Chairman:
AARON ROSENFIELD
Director
Oxford Laboratory
National Marine Fisheries Service
Northeast Fisheries Centers
Oxford, Maryland 21654

Introduction

Aaron Rosenfield
National Marine Fisheries Service
Northeast Fisheries Center
Oxford Laboratory
Oxford, Maryland

Good morning, ladies and gentlemen. My name is Aaron Rosenfield. I am the director of the National Marine Fisheries Service, Northeast Fisheries Center, Oxford Laboratory, located in Oxford, Maryland, on the Eastern Shore of the Chesapeake Bay.

In convening this symposium with Mr. Benson Drucker of our Washington office and Dr. Carl J. Sindermann, director of the Sandy Hook Laboratory, I am happy to say that we received enormous support and encouragement from NOAA's assistant administrator for fisheries, Mr. William G. Gordon.

Mr. Gordon and I go back together a long way beginning as members of our predecessor agency, the Bureau of Commercial Fisheries, under the Department of the Interior. Mr. Gordon has long been recognized worldwide as a fisheries officer. His contributions and accomplishments as a manager and administrator in the field of fisheries are many. He has not only served importantly as a headquarters official in Washington, D.C., but he has also served as deputy director of the National Marine Fisheries Service, northeast region, then as director of the region, and today as our highest fisheries administrator. I know he has some important remarks to make and it is a pleasure at this time to present Mr. Gordon.

Role of Disease in Marine Fish and Shellfish Management

William G. Gordon
National Marine Fisheries Service, NOAA
Washington, D.C.

Thank you for your kind introduction, Dr. Rosenfield. It is indeed a pleasure to be here today and to welcome so many of my colleagues and friends, all of whom have a strong and abiding interest in the theme of this meeting—the "Role of Disease in Marine Fish and Shellfish Management."

The subject of this meeting is relatively new—that is, the linkage of disease studies to fisheries management. Most meetings, symposia, workshops, and other dialogues covering the subject of diseases of marine animals are on a scientist to scientist basis with coverage primarily on the characteristics of the disease organism, how it is spread, etc., with little concern to the fishery(ies) itself. When I was approached by members of my research staff requesting support from my office to hold this symposium, I agreed, but only if certain conditions were met, namely:

1. That the information be put together and presented in such a way that it has meaning and relevance to the managers, the decision makers, as well as to plans and policy makers;
2. That the scientists go back and reexamine their data and be able to demonstrate to their audience that disease really has an important influence on the population dynamics of marine fish and shellfish, *and most importantly*,
3. That the information generated from these data will demonstrate that we may be able to do something about the effects of disease; for example, ensure product quality and human safety, predict when epidemics occur, control the spread of disease or prevent infection, and mitigate the effects of disease through environmental conservation or, if need be, habitat modification.

I must mention that many factors other than the influence of disease must be taken into consideration when developing and implementing marine fishery programs and management strategies. However, disease as a factor is often ignored or at best only marginally included in the decision and policy making and budgeting processes. Although the reports to be given here will emphasize infectious diseases—that is, disease caused by living agents such as viruses, bacteria, fungi, protozoa, and other micro- and macroparasites—I trust the audience accepts the notion and will always keep in mind that pollution and natural environmental stresses can exacerbate the effects of infectious agents on the animal. Just as importantly, animals weakened by an infection or by parasitism can be rendered more susceptible to pollution and other stress conditions, thereby possibly affecting their health, their behavior, or their reproductive capability or potential.

Finally, some infectious agents and parasites and some pollutants or contaminants, in addition to directly affecting the well being of marine animals and populations, can enter the food web to affect other living forms, including domestic animals and man!

Today, we will hear from Dr. William J. Hargis who will discuss epidemics (epizootics) in populations of marine fish and shellfish and how the information derived from these epidemiologic studies can be used in developing fishery management plans and strategies. Dr. Hargis is well known in the marine community for his contributions to fishery biology and management of wild stocks, and for his broad background in the field of parasitology.

Dr. Hargis will be followed by Dr. Carl J. Sindermann who will discuss the role of disease in the cultivation of marine fish and shellfish. Dr. Sindermann is recognized internationally in this field and he will describe the usefulness of his experiences and information derived from them in developing national and international plans for the control of marine diseases and propose systems and present guidelines that are designed to prevent the spread of diseases from one marine or estuarine ecosystem to another.

Dr. Spencer Garrett has spent most of his professional career working in the field of marine product quality and safety, as well as developing inspection guidelines and regulations for interstate shipment of all types of marine seafood. He is particularly interested in ensuring that harmful microbial agents, parasites, and chemical contaminants do not reach and affect the health of man.

Our last speaker will be Dr. Ivar E. Strand. Dr. Strand has taken on a most difficult but essential task. He is an *economist* and not an *expert* in the field of marine diseases, or public health. However, Dr. Strand brings to us information on the economic impact of the direct and indirect effects of diseases on marine populations. His perceptions are those of a resource economist. He recognizes that real dollar amounts represent the losses or gains associated with the effects of disease, contamination, or poor quality of marine animals and their products.

In summary then, I congratulate the convenors of this symposium. I believe and I think you will agree that they have brought together an eminently qualified group to address us on this important subject and that by the end of this symposium we will have gained enormously from the reports we will hear and the discussions in which we will participate.

With that, I now turn the program over to Dr. Rosenfield who will chair the first segment of this symposium.

Remarks of the Chairman

Aaron Rosenfield
Northeast Fisheries Center
National Marine Fisheries Service
Oxford, Maryland

If I may exercise my prerogative as chairman, I would like to highlight some perplexing problems that now confront marine fisheries managers, all of which require immediate study and resolution. Some of these problem items may only be touched upon by the speakers, and in some cases the speakers may take considerable time elaborating upon these examples.

Molluscan Diseases: At least four virus entities are now known to affect marine molluscs. In addition, a number of other microbial agents, such as bacteria, fungi, and protozoa are known to cause extensive marine shellfish mortalities. There is some speculation that one of these viruses (presumably an IPN virus) may also infect fishes. Another infectious agent, although not yet confirmed as being a virus, may yet be implicated in neoplasia of soft clams, causing depletion of populations throughout the range on the northeast coast of the United States. An as yet unidentified and unnamed organism has been reported to have caused devastating mortalities of razor clams on the U.S. West Coast, thereby destroying a large and important recreational fishery. There is considerable concern in this country and throughout the world regarding systems to prevent or control the spread of shellfish pathogens, how to diagnose their presence, what quarantine and embargo systems can be put in place, what helpful laws and regulations are there to protect ecosystems and their biota, and do these laws and regulations have meaningful enforcement capability. Federal and state governments are now working together to devise sanitary codes to ensure quality and safety standards for growing waters and for shellfish are fully met, thereby protecting the health of the public. Furthermore, government agencies, state fishery commissions, industry, and regional councils are attempting to implement a molluscan shellfish health and inspection system modeled after the Department of Agriculture's Animal and Plant Health Inspection Systems (APHIS) and Poultry Improvement Plan that should markedly enhance shellfish productivity and quality.

Crustaceans: At least nine virus entities have now been described from blue crabs. In addition, five new virus disease entities have been reported from commercially important shrimp species that affect various stages of their development. The fishery manager is now confronted with such questions as to what role do these viruses play in causing epizootics (epidemics) of crustaceans, what environmental conditions exacerbate viral infections, and what must we do to prevent or mitigate the effects of viral diseases in culture systems or in the marine environment. These are but a few questions that confront the fishery manager at this very moment on the Gulf Coast of the United States, Hawaii, and throughout the world, or wherever shrimp are being cultured and transported.

Fishes: A number of parasites, both micro and macro, are now known to cause disease and affect fish health. Some of these organisms may act in an adventitious way to infect or overcome the host when the host's immune or disease resistance mechanisms are reduced by environmental stress, be these stresses, natural toxins, man-introduced contaminants, or environmental extremes. New virus diseases of fish are continually being found. Papers are being prepared to describe viral agents and other microbial agents that apparently affect clupeids and flatfish along the Middle Atlantic Coast, dramatically reducing population abundance. I'm certain you will hear more about these and other epizootics as this symposium progresses.

Probably one of the largest issues facing fishery managers today relates to the tumors and neoplasms, or cancers, if you will, that are being found in surprisingly high numbers in some marine and freshwater fish populations. These conditions may be caused by man's effluvia into the oceans and estuaries. These are issues that the fishery managers cannot ignore. It indicates that not only do fishery managers have to manage fish stocks, but they also have to manage the habitats as well. It is necessary for both the scientist and the manager to work together and look into such questions as cause and effect relationships, risk assessments, and how to calculate and model the effects of disease, and to use this information to predict disease outbreaks, or control them.

It goes without saying that people management is important also. Socioeconomics always enter the picture, as well as political considerations. Those of us working in the field of marine diseases have a lot of work to do, and in most cases because there are so few among us in the field, we have to find our own answers, have to find our own support, and do our own educating. We are indeed fortunate to have the medical, biomedical, and veterinary communities to call upon when certain needs arise. However, these groups are not all-knowing. For, after all, our patients are the inhabitants of the seas, the estuaries, and other aquatic environments such as culture ponds and tidal tributaries, and it is only occasionally possible to make definitive comparisons and draw parallels with homeothermic (warm-blooded) forms in our marine disease studies. These inhabitants belong to a wide array of phyla with many families, and classes, and subordinate taxa. All are poikilotherms (cold blooded), almost totally at the mercy of their environment and/or man's actions. Furthermore, these creatures range in size from the miniscule to the relatively gigantic (some of the larger sharks and tunas). Their diversity of shape, external and internal structure and anatomy, physiology, and biochemistry are staggering, making the logistics of capture, dissection, examination, and analyses very difficult indeed.

I have just touched upon a few highly visible problems. There are many, many more that could have been mentioned and used as examples. However, I am sure you will hear about many of these from our speakers, whom I would like now to present.

Quantitative Effects of Marine Diseases on Fish and Shellfish Populations

William J. Hargis, Jr.
School of Marine Science and
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

Introduction

Wildlife specialists probably do not need convincing of the importance of the several components of "natural" mortality in populations dynamics of their organisms. Predators, parasites, and pathogens are regular, potent, and familiar threats and their effects are observed and counted relatively easily. Those of fish or mammals living in large lakes, inland seas, estuaries, embayments, and oceans are not readily visible and marine ecologists, fishery scientists and fishery managers generally seem unconvinced of the significance of natural mortality, especially disease, in determining availability and survival of their subject resources. Developing or enhancing their appreciation of natural factors as determiners of individual survival and population strength, i.e., the elements of natural mortality, is one objective of this review.

Quantitative studies of morbidity and mortality and their most probable causes are easiest when dealing with humans in "civilized" countries or situations. Records of births, deaths, and ages are maintained. Efforts are made to establish the health of individuals seen by medical personnel or determine and record cause(s) of death by attending physicians. In such situations great social concern results in expenditures of energy and resources in determination and enumeration of illnesses and deaths and their causes.

The same, to a somewhat lesser degree, can be said for animals and plants of economic value, i.e., pets, livestock, ornamental plants, agricultural crops, species of research interest, and trees (forests) under cultivation and management. In such managed circumstances the numbers of individuals in populations of interest can be counted, and the condition, or status of health, of individuals can be observed and causes of morbidity and mortality determined, usually. In the wild, terrestrial animals and plants can often be directly observed and enumerations are often possible; live and dead animals and plants or their condition, traces, and remains can be examined and counted.

Generally the most difficult of the ecologically and economically important organisms to observe for condition and mortality are aquatic species (or groups of species) which live in large bodies of water. The larger rivers; great inland seas or lakes such as the Great Lakes of the United States and Lake Baikal, and the Aral, Black and Caspian Seas of the Soviet Union and its borders, and many others; large estuaries, coastal waters and shelf waters of the seas (where most commercially important marine species reside); and, the deep oceans, in that order, are especially refractory to observations and enumeration.

Thus, quantitative observations of economically or ecologically valuable marine populations, surrounded and obscured as they are by water or silt and sediments, are

VIMS Contr. No. 1250.

comparatively more difficult and usually much more expensive than those on land. Accurate and precise population enumerations and epidemiological studies are difficult. However, there are some epidemiological or quantitative bright spots, mostly among the invertebrates. The larger, sessile molluscs whose shells often protect moribund bodies and contain their remains for brief periods after death can be counted and even examined if samples are taken frequently and carefully. For example, one can sample coastal oyster beds and secure healthy oysters, obviously moribund "gapers" (alive but sick), and recent and old "boxes" (i.e. older or recently dead individuals) with relative ease. Population levels can be managed on oyster beds by careful replacement and more tightly-controlled caged populations can be maintained in nature for experiments. By determining condition index and judicious subsampling or biopsy the observer can obtain data on many elements of health (or illness), death, and the etiological agent or other possible causes pertaining. Thus, certain aspects of individual condition, prevalence of disease, incidence of infection and degree, level, or severity of infection may be determined quantitatively in accessible populations of large molluscs. (Some aspects of condition and possible cause of death can even be determined in the remains of large fossil bivalves.) Soft-bodied or otherwise fragile or cryptic invertebrates are less easily observed and counted.

Marine vertebrates (finfishes), being mobile and generally fragile, are more difficult of enumeration than molluscs (though advanced acoustic and other survey and quantification techniques enable improved *in situ* observations of finfish) and leave fewer traces. Weak ones are quickly culled, dead bodies rapidly consumed or rotted and their fragile remains quickly scattered. Hence estimates of the effects of an epidemic's existence and mortality often are difficult.

Marine fishery population dynamicists regularly develop and employ numerical and graphical models while attempting to estimate the size and future availability of the useful resource. They also use them to estimate the actual and potential effects or mortality caused by harvesting activities (total fishing-related mortality) on those stocks. Such determinations, or estimations, are extremely useful to marine fishery managers. Without them effective management is impossible!

More particularly, such models are used in attempts to determine, in advance, the various levels of harvesting activity which may be allowed. One goal, of course, is to allow commercial catches at levels which will provide product and income for harvesters, processors, retailers and other economic participants and quality food for consumers (at affordable prices). Supplies are needed for subsistence and recreational fishermen also. A second, and even more essential, goal is to retain sufficient numbers of sexually active, mature animals to allow their reproduction and continuation of the target stock at certain required levels.

A large number of mathematical and graphical methods and models is available for making estimates of present and future stock sizes and biomass (Beverton and Holt 1957, Gulland 1969, Lackey and Nielson 1980, Pitcher and Hart 1982, Ricker 1958, 1975, Royce 1972, and Sissenwine et al. 1978). Most are relatively simple (and/or straightforward) but even those simplified versions in general use are based upon certain basic assumptions which, though specific, may be partially unverified and of varying levels of uncertainty and significance. Futher, the better ones require considerable quantities of current and long-term data regarding estimated stock-sizes, fishing mortality (usually reported as catches), natural mortality, and other important relevant factors or parameters. Were the models to be operated at peak efficiency, these estimates or actual numbers should also include actual fishing effort expended per-unit-of-catch and all other significant elements of fishing-related mortality (i.e., deaths caused by or during the harvesting process, such as handling and culling, and gear damage) as well. Ideally, natural mortality (deaths due to non-harvesting related causes—such as predation, environmental stress of all origins, and senescence and disease of all types) also would be measured and not merely inferred or deduced. In practice, natural mortality is usually assumed at some constant level or calculated or graphically derived by some indirect method.

Natural mortality varies with age, involving not only deaths due to senescence or old age, but also those occurring among younger cohorts since large numbers of deaths occur among zygotes, embryos, larvae, and juvenile stages (see May 1973). Environmental stress, natural and anthropogenic, may also be large contributors to deaths of estuarine and marine organisms directly and indirectly (Swanson and Sindermann 1977, Sindermann 1980). The significance of major alterations in climatic or long-term weather patterns which produce abnormally cold winters, dry springs and summers (and increased salinities in estuarine and coastal waters), prolonged unusual wind patterns, altered currents and abnormal downwelling or upwelling at sea (El-Nino for example), long suspected or inferred, is now being observed and measured (Austin and Ingham 1978, Joseph 1972, Knauss 1978, Norcross 1983, Simpson 1953). Actual numerical estimates based upon observations are rarely available for either of these components of M, or even for M itself.

Considering the frequency and efficiency of commercial fishing harvesting activities, one would infer or conclude, quite naturally, that fishing mortality should be easily quantifiable with accuracy as well as precision. Quite often, however, it is not because of inadequate reporting by harvesters and, at times, port samplers. The primary causes of continued inadequacy of fishing mortality data (which really should be fishing-related mortality) are the common lack of data on culls (deaths or survivals) and gear-caused mortality (i.e., net and dredge damage resulting in death). Further, fisheries whose target resources are of small body size, such as shrimp, frequently destroy large numbers of juvenile finfishes of commercial or recreatonal value. These young fishes are captured and killed where they are most vulnerable, on their nursery grounds. No records of these mortalities exist in most cases. In some instances effort data are not recorded in useful form. Often reliable estimates of or data on fishing effort are unavailable from harvesters even where records exist. Usually, long-term catch and effort data from recreational fisheries, which for some species in some places equal or exceed commercial catches, are unavailable or weak,

Thus, accurate and/or precise data often are unavailable for use in calculations or models. Also, the equations and graphical models themselves are frequently based upon weak numbers and often involve unverified and possibly specious assumptions. Consequently, estimates of the (presumably) observable, controllable, and quantifiable element in the total mortality equation (Z), fishing mortality (F) are, themselves, often uncertain. Since estimates of the other, and equally important element in the total mortality equation, natural mortality (M), are usually derived from already inaccurate, and possibly imprecise, estimates deriving from fishery catch data, they too must be of questionable accuracy and precision.

In their study of the epidemiology (epizootiology) of infectious disease in commercially important feral marine fish populations, Munro et al. (1983) stressed these points, indicating especially that natural mortality *(M)* usually involves elements of predation, reproductive debilities, food-limitations, senility, and disease, certain of which are known to be or can be quite large. Making the picture even more distressing is the general lack of quantitative data on host-parasite, host-pathogen,and other biotic and abiotic disease interactions.

Undoubtedly parasites and pathogens have attacked marine animals for eons. The interactions, challenges, and accommodations apparent in present-day species generally testify to long relationships. Existence of parasites was first recorded by Aristotle in his De Historia Animalium in 330 B.C. (McGregor 1963). Numerous reports have followed, with most appearing since 1850. Most past studies of marine parasitism have focused primarily upon the parasites of the hosts, their identification and distribution on the host as well as geographically. Interactions between host and parasite and the qualitative and quantitative effects of parasitism and disease upon individual hosts and populations have been largely ignored. Fortunately this situation is changing and marine parasitologists and disease specialists devote increasing attention to the responses of the hosts to parasitic challenges and to pathogen-related disease (Kennedy 1976). Concern is for responses of the hosts as individuals and in groups (populations). As a result, qualitative knowledge of host/parasite and host-pathogen interactions has improved considerably.

More directly to the focus of this report, quantitative efforts to evaluate the biotic factors contributing to morbidity and mortality and their effects on host groups are improving also (Aho and Kennedy 1984, Anderson 1979, 1982, Anderson and May 1979, 1980, 1982, Andrews 1984a, b, Bradley 1982, Campana 1983, Crofton 1971a, b, Eisen 1983, Esch 1977, Ford and Haskin 1982, Grizel 1983, Haskin and Ford 1982, Hassell 1982, Holmes 1982, Jones 1973, Lester 1984, McVicar 1980, 1981, May 1973, 1982, 1983, May and Anderson 1979, Möller 1984, Munro 1983, Munro et al. 1983, Ossiander and Wedemeyer 1973, Worlund and Taylor 1983). Valuable and encouraging as such efforts are, they remain hampered by the weaknesses in the fishery information mentioned above, which make realistic quantification of total mortality and its components extremely dificult.

Management of fisheries and of the natural stocks upon which they depend is important and must continue despite softness in population estimates and in quantification of *Z, F,* and *M.* Available models and estimates involving both fishing and scientific survey data must be used in population dynamics calculations regardless of weaknesses. Survival of the species and of the stocks, continued availability of suitable supplies of food and recreational fishes and shellfishes, and the economic viability of commercial and recreational fishing industries are important to the country and world. Existing fishery populations and epidemiological equations and models, necessary bases for such management, are the only available foundations of stock estimates, and for allocations.

Continuing efforts at improving data, equations, models, and management decisions based thereupon must be pressed. The need is for improvements in understanding, estimation,and quantification of all causes of natural mortality and for data on fishing mortality, including damage and deaths caused incidentally as well. Fishing mortality equations, models, and estimations can be improved relatively easily if industry and managers wish to do so. Acquisition of direct natural mortality information will be more difficult, requiring specially planned and directed, large-scale scientific surveys, field studies, and laboratory research.

For the efforts to be increased significantly (necessary for understanding to improve) marine fishery specialists and managers must be stongly convinced of the need for such information. Encouragement of their conviction is another objective of this review. To assist in its accomplishment, several significant examples of host-parasite-disease interactions are presented and discussed below. Examples, stressing well-documented or recently discovered disease situations, include three invertebrates, mollusc (the Atlantic oyster, *Crassostrea virginica)* and two crustaceans (the blue crab, *Callinectes sapidus,* and the Tanner crab, *Chionoecetes bairdi)* and four finfishes, the herring *(Clupea harengus),* the summer flounder *(Paralichthys dentatus),* the white perch *(Morone americana)* and the menhaden *(Brevoortia tyrannus).*

Invertebrates

Invertebrates are of especial interest to marine epidemiologists because of the apparent lack of ability in individuals to develop acquired immunity in response to challenge from pathogens. This affects their vulnerability as well as the course, severity, and outcome of any disease they may fall prey to. The extensive records of sickness and mortality of certain economically important ones are valuable epidemiological resources.

The Atlantic oyster, Crassostrea virginica, *versus MSX, or Delaware Bay Disease.*

Perhaps the most intensively studied of all marine invertebrates are oysters of the genera *Ostrea* and *Crassostrea.* Employed as food worldwide for centuries, their socioeconomic importance probably exceeds that of any other molluscan group. Problems associated with the oyster have occupied many practical culturists and scientists since recorded Roman times at least. In the United States, records of oyster production and problems extend well into the nineteeth century (Brooks 1905, Galtsoff 1964, Haven et al. 1978).

Tighly-closing calcarious valves prevent dessication and enable oysters to survive long periods of time out of water. Hence, they have been transferred from one body of water to another the world around. Movement of populations, species, and genera coastwide and across continents and oceans have resulted in introductons of alien hosts, competitors, predators, parasites, and pathogens into new areas (Hargis and DuPuy, in press, Sindermann 1970).

Oysters are hardy, extensively harvested and sampled, under culture, and frequently transplanted great distances, and they occur mostly in relatively accessible shallow estuaries and coastal waters of the world. Sessile and easily manipulated and sampled, they are readily observed in the wild, under culture, and in the laboratory. Further, even in the wild those of greatest economic importance occur in beds or shoals consisting of many relatively-long lived individuals. Such oyster communities may become fairly stable and attract large number of taxonomically-varied associates, including commensals, mutuals, competitors, predators, parasites, and facultative and obligate pathogens. As filter-feeders they take in large volumes of particle-laden water in the processes of feeding and respiration. As an example, a mature (4-inch, or 10.16 cm, shell-length) *Crassostrea virginica,* the commercially valuable native oyster of the northwest Atlantic coast, can pump and process as much as 450 litres (or up to 119 gallons) of water in a 24-hour period. (Rates vary, of course, and are often much lower. Three hundred 1/day, or 79.26 gallons, is considered a "safe" average, Morales, pers. comm.). Because they usually occur in large masses of individuals, they are capable of creating significant currents around their beds. Judging from the volume of water moved during laboratory observations and from measurements of water processed and the large amounts of feces (ingested and processed materials) and pseudofeces (consisting of agglomerated particles not taken into the gut) deposited by a single oyster, the opportunity for accumulation and ingestion of large numbers of cysts, eggs, and other potentially infective particles of varous parasites and pathogens is great.

Were one searching for a marine organism upon which mortality models (including fishing-related mortality and natural mortality of all types) could be based, the oyster should be hard to surpass. Records indicate epidemics of various sorts in wild and cultivated populations for decades. Extensive disease studies have been reported (i.e., Andrews 1982, 1984a, b, Ford and Haskin 1982, Galtsoff 1964, Hargis 1985a, Haskin and Ford 1982, Prytherch 1931, and many others).

Among the recorded occurrences of large-scale mortalities of oysters in the mid-Atlantic region, one, occurring during the winter of 1929-30 in the lower Chesapeake region (Virginia), is said to have caused the loss of over one-half million bushels of oysters (and one-half-million dollars), attributed to pathogen-related disease and environmental stress (Prytherch 1931). Mortalities of oysters in the Chesapeake region continued sporadically, prompting more intensive studies of the factors involved. Though interrupted by World War II, researches were resumed and intensified in the late 1940s at the Virginia Fisheries Laboratory in Yorktown (forerunner of present-day VIMS) by Drs. J. D. Andrews, Willis Hewitt, and others. Discovery of the fungus-disease (previously known from the Gulf of Mexico) called "Dermo" after *Dermocystidium,* the genus to which it was then ascribed, in oysters of the lower Bay was a milestone in Chesapeake Bay disease studies. The etiological agent, now called *Perkinsus marinus,* was found to be a cause of continuing chronic-level mortalities in oysters in the region.

Of greater significance recently has been the occurrence of the more virulent MSX disease in 1959 in these same areas and in Delaware Bay, where it had apparently started two years earlier in 1957 (Andrews 1982, Andrews 1984a, b, Hargis 1985b). According to Ford and Haskin (1982) 90-95 percent of oysters in lower Delaware Bay died shortly after the mortality began. Forewarned, Chesapeake Bay scientists anticipated mortalities in local populations and developed special disease survey programs to record their onset and progress. They were not disappointed, and by 1960 mortalities in the lower Chesapeake reached as high as 80 percent. Subsequent research by scientists from all Delaware and Chesapeake Bay states and the National Marine Fisheries Service established the most-probable etiological agent as the protozoan *Haplosporidium nelsoni* (Phylum Ascetospora: Class Stellatosporea), which has been the subject of intensive study since. Though Koch's postulates have not yet been satisfied for MSX (or Delaware Bay), disease, epidemiological, and correlated histopathological evidence is so strong as to be almost undeniable that *H. nelsoni* is the cause. This situation is not unusual among marine diseases, the effectors of many of which have not yet been rigorously proven. Efforts continue to isolate the most-probable etiologic agent, use the isolate to produce the disease in disease-free susceptibles, and then reisolate it to remove all possible doubt.

More to our immediate purposes however, annual harvesting data obtained before, during, and after the onset of the disease in Delaware and Chesapeake Bays show severe reductions in yields due to resulting mortalities. Independent scientific sampling programs, always useful in augmenting and verifying commercial catch records, confirms the decimation of populations on cultured and "feral" beds in the higher salinity portions (i.e., >15-18 ‰) (Haskin and Ford 1982). As Sindermann (1968) explained, oyster production in Delaware Bay, where most oysters were cultured on high-salinity beds, plummeted in 1957 and has remained low since (Figure 1). Virginia production also declined during 1959-60 and has remained depressed (Figure 2). Private (planted or cultured) beds in Virginia subsided after 1959 and, though compensating plantings made on private beds in lower-salinity regions prevented total yields from dropping even further, the high-salinity beds most heavily infested were abandoned and have been essentially out of production since (Figure 3) (Andrews 1984a, Hargis 1985b, Haven et al. 1978, Sindermann 1968). These disease-related declines in oyster production in Delaware and Chesapeake Bays added greatly to the recent abrupt downward perturbations in the long-declining curve of east-coast U.S. oyster production (Figure 4).

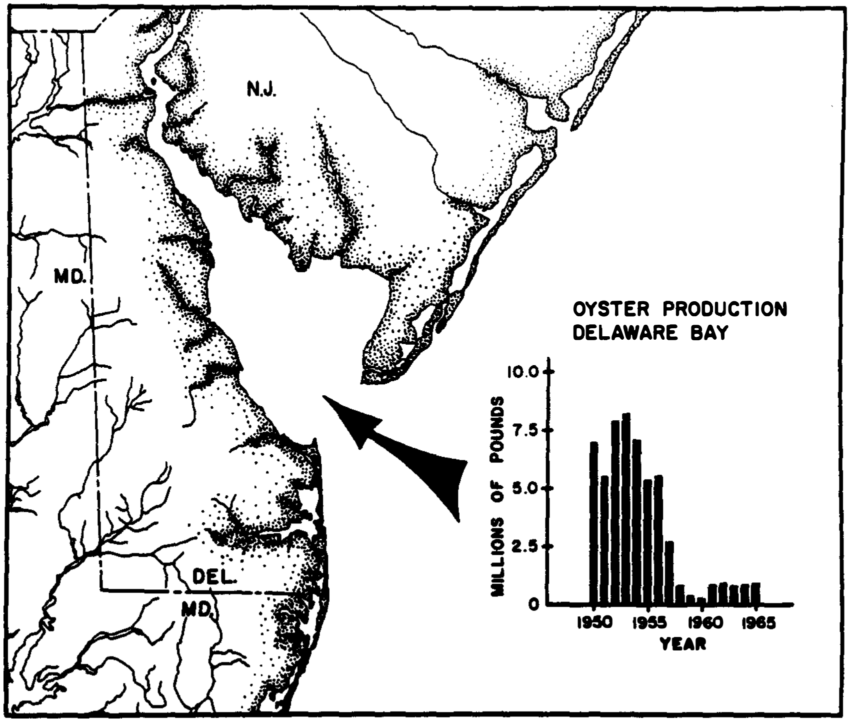


Figure 1. Oyster production in New Jersey waters of Delaware Bay, 1950-65 (from Sindermann 1968).

Infected areas in Delaware Bay show signs of recovery, probably due to development of resistance in progeny of survivors (Andrews 1984a, Ford and Haskin 1982). Recent data (Andrews, pers. comm.) indicates that MSX disease may be showing signs of remission in certain previously heavily infested areas in the lower Chesapeake also. Whether or not these signs of surcease precede a longer period of remission or even disappearance, a quarter-century of disease-caused scarcities and difficulties and continued overfishing have caused resource reductions and economic losses of great magnitude (see Strand and Lipton 1985).

As shown, considerable data have been gathered by scientists and fishery managers demonstrating the effects of disease-related epidemics on wild and cultured

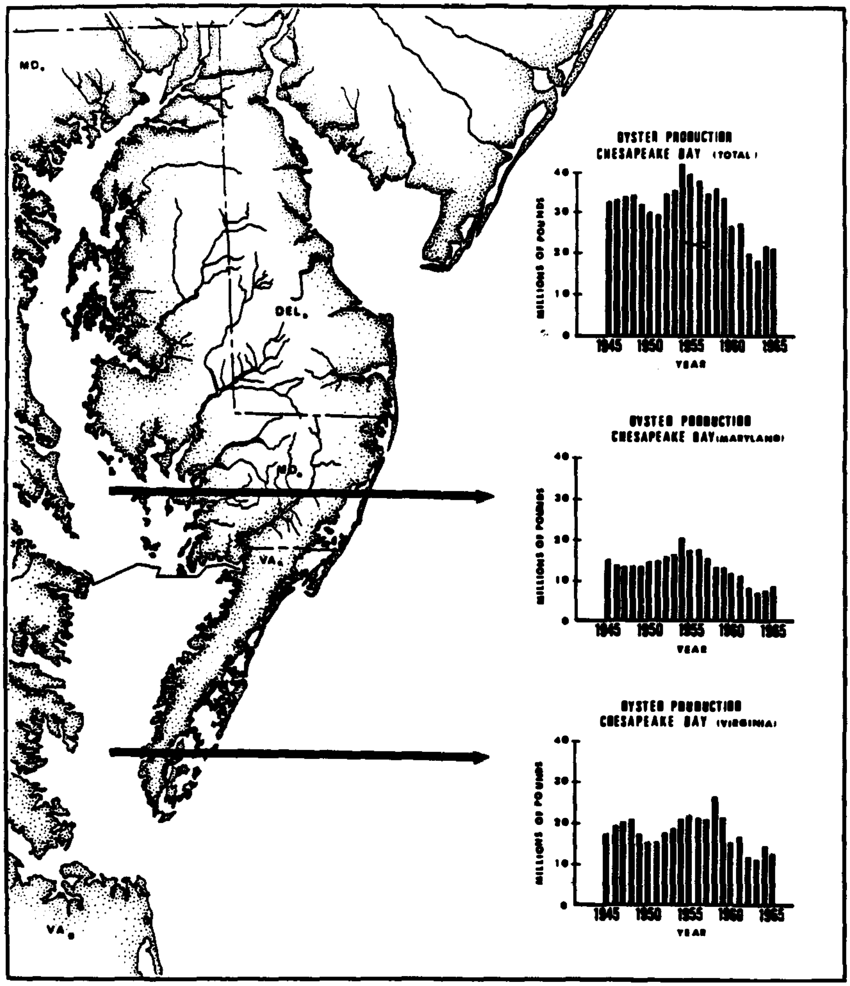


Figure 2. Oyster production in Maryland and Virginia waters of Chesapeake Bay 1945-65 (from Sindermann 1968).

Crassostrea virginica populations and on the dependent commercial fisheries. Corollary information from field and laboratory observations on reproduction, predation, survival, disease-levels, and catches provide perhaps the best intensive long-term data base on the quantitative effects of disease on estuarine/marine population ever accumulated. It has been widely publicized in public and scientific media and the results employed by public and private managers alike. Undoubtedly, much remains to be learned regarding the effects of known disease incidents upon these mollusc populations. However, the fishery and disease data available should enable population dynamicists and epidemioloigists alike to test and refine concepts of F and M.

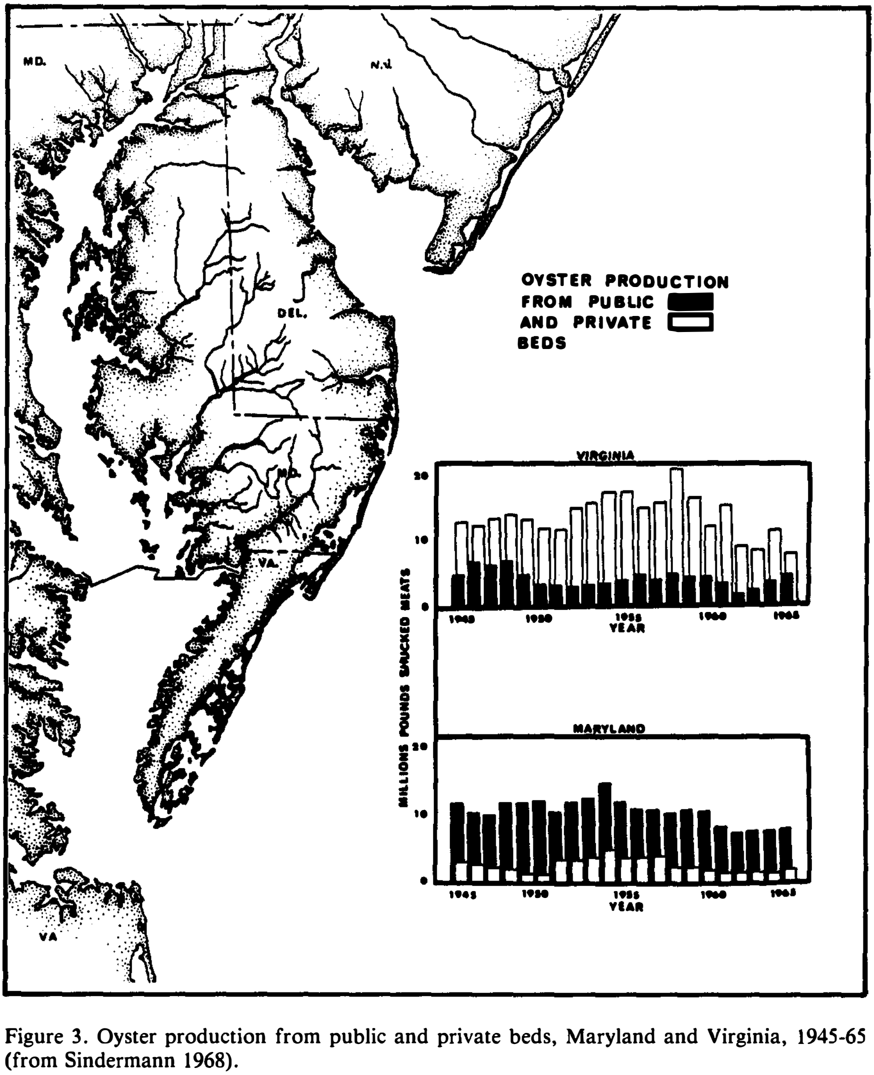


Figure 3. Oyster production from public and private beds, Maryland and Virginia, 1945-65 (from Sindermann 1968).

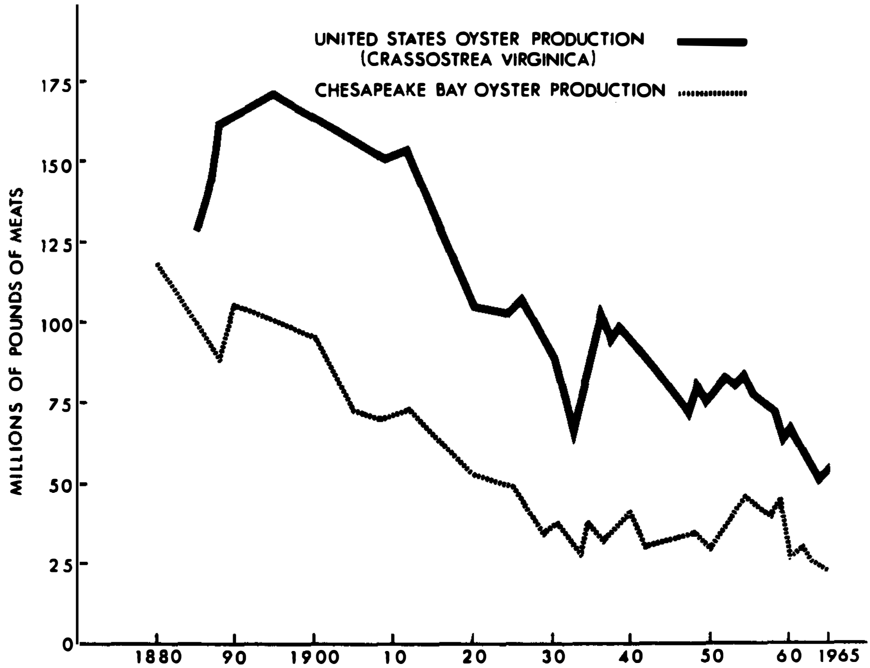


Figure 4. Production of oyster *(Crassostrea virginica)* in Chesapeake Bay and in the United States, 1880 to 1965. Modified from Galtsoff (1956) and Engle (1966). (From Sindermann 1968.)

The blue crab, Callinectes sapidus, *versus Gray Crab Disease*

This condition of gray exoskeletal patches with associated deaths of blue crabs was first noted in soft-crab shedding tanks on the Eastern Shore of Maryland and Virginia in 1965. Up to 30 percent of the animals involved in these commercial-shedding operations died. In 1967 dead crabs bearing similar gray discolorations appeared in crab pots and on beaches in South Carolina and Georgia. Moribund crabs found in South Carolina were examined in 1968 and a small number, 3 percent in one sample and 5 percent (or 14 of 277) in another, were found infected by an ameboid organism in the host's hemolymph or blood. These epizootics were attributed to the protozoan, *Paramoeba perniciosa,* and more careful field studies and laboratory experiments were planned.

In the laboratory it was found that the hemolymph from heavily infested (gray-appearing) crabs would not clot and that all animals with "very heavy" infections (i.e., a ratio of amoebae to total cells of 0.96-1.00) of *P. perniciosa* died within 24 hours after those infection levels were reached. Based upon survivorship in laboratory-held animals, Newman and Ward (1973) concluded that the blue crab population of Chincoteague Bay had been reduced by over 30 percent during June of 1971. A relationship between death and rising water temperatures is suspected because deaths increased as the water warmed.

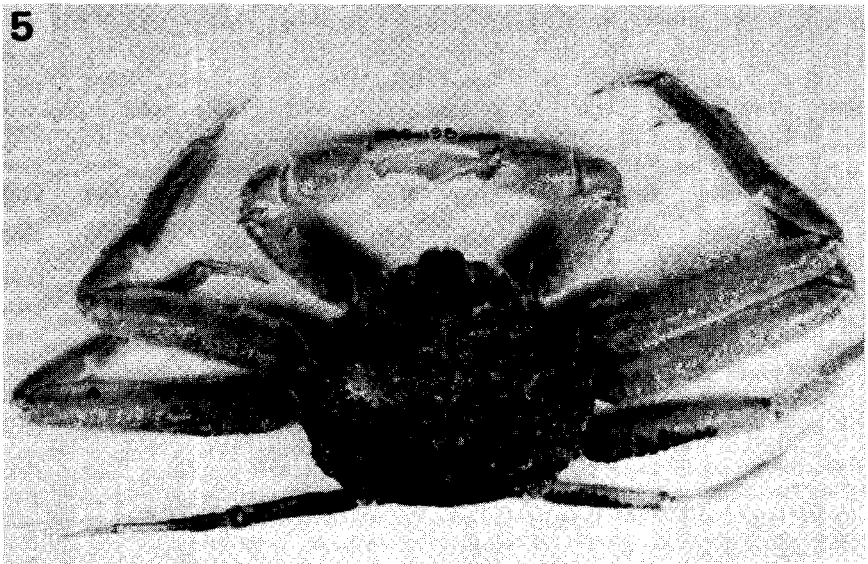
Data from the studies of Newman and Ward (1973) indicated 100 percent morbidity of infected animals and the authors concluded that "gray crab disease was probably responsible for previously reported mass mortalities of blue crabs." They suggested that fishermen do not notice or do not report deaths or mortalities in years when crabs are abundant but do when crabs are scarce. Experience with the fisheries and fisherman supports the likelihood of this occurring. Blue crabs are hosts to many other parasites and pathogens, some of which have been discovered only recently. (For a discussion of the viruses see Johnson 1984).

Thus far, catches of the blue crab, which has high reproductive potential and a short life span, show no signs of long-term decline despite these mortalities and growing commercial fishing pressure. This pattern is not unusual among such marine populations, but theoretically total mortality *(Z)* could attain levels sufficiently high to produce downward pressures on future stocks. Unusual natural mortalites would then be decisive in reducing stocks. The question of what level of *Z* will produce noticeable declines remains to be established. Possible roles of both the disease and other elements of natural mortality and fishing pressure should be examined. Regular and detailed monitoring of both its elements, *F* and *M,* are required.

Tanner or snow crab versus Black Mat Syndrome (BMS)

Occurrence of an encrusting fungus on the exterior surfaces of snow or Tanner crabs, *Chionecetes bairdi,* causing infected individuals to appear to have been coated with thick tar, has been noted for decades (Figures 5 and 6). Because particles tended to flake off during processing and contaminate the meats, the fungus affected marketability of the product. Processors avoided heavily-encrusted crabs and harvesters heavily-infested areas, and the condition caused significant reduction of useful resources and losses due to rejection of product. Black Mat Syndrome was regarded for a time as being primarily an economic nuisance (Sparks 1982, 1984).

During early studies the causative organism was misidentified as an ubiquitous soil fungus (*Phoma fimenti*). Later it was found to be a new species and named *Trichomaris invadens* (Hibbits et al. 1981). It infected mostly *C. bairdi* and occurred mainly in certain geographical areas and was believed not to invade internal organs of the hosts. Through histological studies the fungus parasite was found to be a more serious pathogen, penetrating the exoskeleton, proliferating in subepidermal tissues, and invading other internal organs (Sparks and Hibbits 1979). It also caused a statistically significant shift in the blood picture of infected crabs. Individuals with greater numbers of internal organs showed more pronounced shifts of differential hemocyte counts, featuring marked increases in percentages of eosinophilic granulocytes in those infected (Mix and Sparks 1980). Gonads in heavily-infected females contain necrotic and disintegrating ova. That reproductive potential is reduced is demonstrated by reduction of egg-clutch sizes in infected females and the fact that >90% of barren females had BMS (Hicks 1982). Gill lamellae are destroyed and replaced by proliferating hyphae. Presence of large numbers of "skip molt" crabs in infected populations indicates that molting is probably hindered. Should later



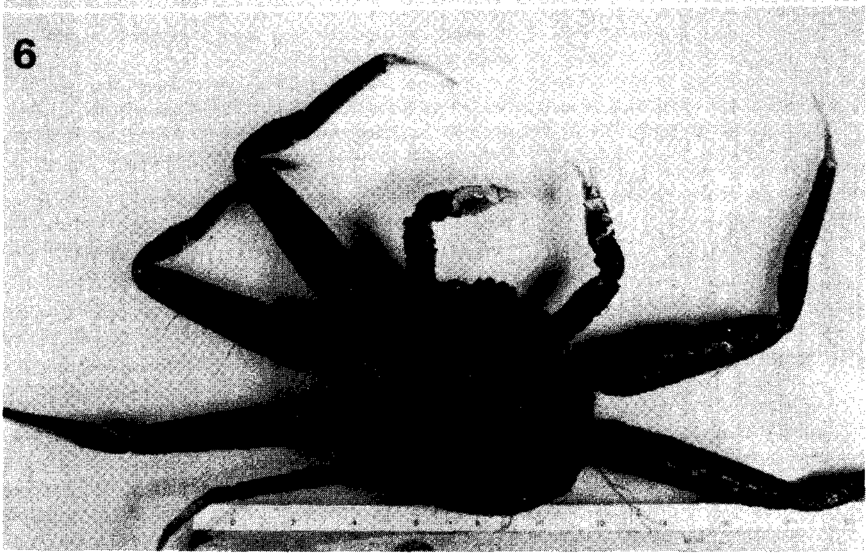


Figure 5. A Tanner crab with black mat syndrome (BMS). Most of the dorsal cephalothorax is covered and the encrustation is spreading to the legs.Most of the round structures on the 3rd right walking leg are epibionts, not fruiting bodies (after Sparks 1984).

Figure 6. A heavily encrusted crab, almost completely covered by fungal hyphae and fruiting bodies (BMS) (after Sparks 1984).

investigations confirm this effect, it would become evident that growth of individuals to legal size is retarded, affecting recruitment into the fishery because infected females would be prevented from reproducing, reducing larval production. Losses due to predation of small, enfeebled individuals likely would be higher in heavily-infested populations, further affecting total numbers.

Though there is some evidence of its occurrence on the related species of crabs, *Chionoecetes grilio* and *C. tanneri*, in the Bering Sea and Gulf of Alaska, Black Mat Syndrome occurs primarily on *C. bairdi* (Hicks 1982). Reported research has involved around 50,000 individuals. (By now probably many more have been studied). In some areas of the Gulf of Alaska 65 percent of females are infected, as are large numbers of males.

Recent declines in fishery catches from areas known to be infected by *Trichomaris invadens* indicate that it may be a factor in reducing harvestable populations (and harvests) of Tanner crabs. Widespread invasiveness of important internal tissue and organs and the weakening of host defensive mechanisms supports the conclusion that BMS is a fatal disease and is causing declines. These aspects must be investigated further, but it is already obvious that BMS is a factor in harvestability and marketability. Heavily infested areas must be avoided and contaminated meats and legs cannot be marketed.

Vertebrates

Finfishes are more advanced in their capabilities of defense than invertebrates. Development of acquired immunity by individuals is possible where pathogenic challenges are not overwhelming. Consequently their responses to disease are somewhat more sophisticated than those of the molluscs and crustaceans discussed above. These aspects deserve special attention by pathologists and epidemiologists. Despite their special defense mechanisms, disease can cause significant mortality in finfishes. When hosts are stressed by other factors, sudden and massive mortalities often result, as some of the following case histories will show.

Herring (Clupea harengus) *versus* Ichthyophonus *Disease*

Tibbo and Graham (1963) reviewed the effects of disease on herring stocks of Chaleur Bay in the Gulf of St. Lawrence. This study of the heavy and widespread herring mortalities which occurred in 1954 concluded that an epidemic caused by the fungus, *Ichthyophonus hoferi*, was the primary cause of the decline in herring fisheries of the Gulf and on the west coast of Newfoundland (Figure 7). Earlier, dead and dying fish in the Gulf of St. Lawrence had been found infected by the organism. Also, Sindermann (1958) had demonstrated that the pathogen caused systemic infections which, in the acute phase, resulted in the deaths of the fishes involved.

During those herring kills, moribund individuals were seen in the waters and dead fish littered the beaches and were caught in the trawls of ground-fish draggers. The number and rate of deaths must have been immense since predators and scavengers could not remove them in timely fashion. The magnitude of the mortality and its effects on the abundance of herring could only be estimated roughly. Sindermann (1958) conservatively estimated that one-half of the mature *C. harengus* in the Gulf of St. Lawrence were destroyed during the period 1954-1956.

From careful examinations of available data, Tibbo and Graham (1963) attributed an observed decrease in mean age and reduction in number of year-classes represented in commercial catches following the epidemic to the disease. They also concluded that the faster-than-normal growth rate noted in surviving herring stocks resulted from the decrease in competition among survivors for food and other density-dependent factors due to removals by death from those stocks. A decrease in the abundance of herring larvae following the epidemic (epizootic) was also detected and these authors hypothesized a connection. Interestingly, they observed that Kohler (1961) has associated a rapid increase in mean-lengths of 6-10 year old Atlantic cod (*Gadus morhua*) in the Gulf of St. Lawrence with the abundance of moribund [and recently dead?] herring, normally less readily available to them, upon which they had fed. Thus, though numbers and probably total biomass of the herring were reduced, faster and greater growth of surviving individuals of host populations and of their predators and scavengers likely compensated somewhat. These compensatory ecological effects did little to reduce the economic losses of local herring fishermen.

In reaching the conclusion that this pathogen had, indeed, caused decimation of herring stocks, a number of environmental and biological factors, which could have theoretically produced the decline, were carefully considered and ruled out by Tibbo and Graham (1963). These authors concluded by saying that "the effect of disease on a marine fish population is usually included in estimating mortality rates but seldom is it accompanied by factual information." They also indicated that their "study provides some information of the ecological consequences of an epizootic in herring *and urged* [emphasis mine]" continuing efforts to describe the sequence of

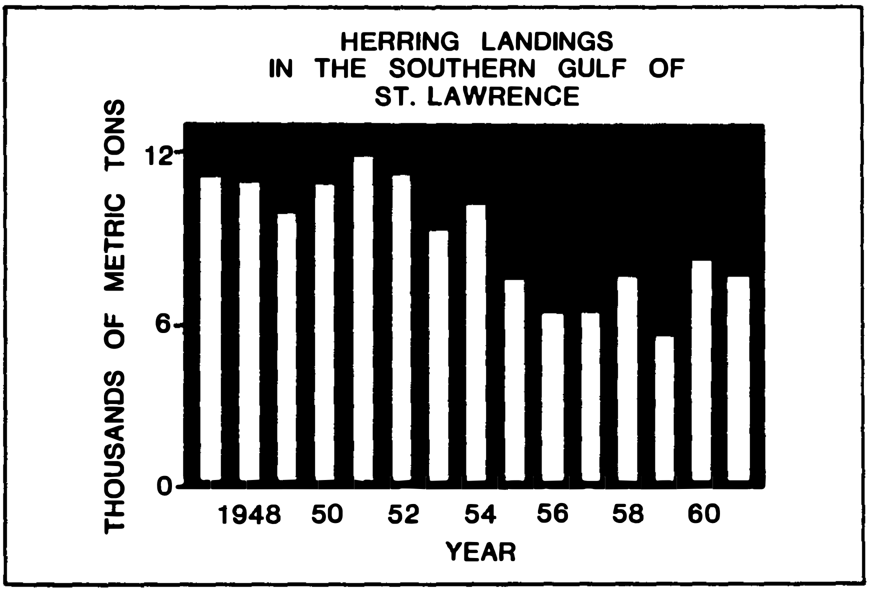


Figure 7. Herring landings in the southern Gulf of St. Lawrence (from Sindermann 1985).

events in similar disease situations, a recommendation that must be echoed. Their competent study, one of the most thorough reviews of events before, during, and after a major epidemic in an important finfish population, can be regarded as a classic amongst such works. If future efforts are as thorough, knowledge of the quantitative role of disease in wild marine fishes will be greatly improved.

Ichthyophonus disease also probably caused recorded declines of populations and fishery catches in the Gulf of Maine in the 1930s and 1940s and in both Gulfs earlier (Figure 8). The mortalities of the mid-1950s are believed responsible for the marked reductions of herring catches in the North Atlantic depicted in Figure 9 (Sindermann 1979, 1985a).

This fungus disease has killed alewives (*Alosa pseudoharengus*) and mackerel (*Scomber scombrus*), but not cod (Sindermann 1966); therefore it is not specific to the herring. Nor is it confined to the Gulf of Maine and St. Lawrence or even the western North Atlantic. It is an old and persistent disease, having been reported as early as 1893. McVicar (1982) conducted a review of this genus of pathogenic fungus and reported that other species, such as the ocean pout (*Zoarces anguillaris*) had been found infected in deep cooler waters off of Massachusetts. It has been detected in plaice (*Pleuronectes platessa*), haddock (*Melanogrammus aeglefinus*) and mackerel on the west and east coasts of Scotland, around the Isle of Man, and in the

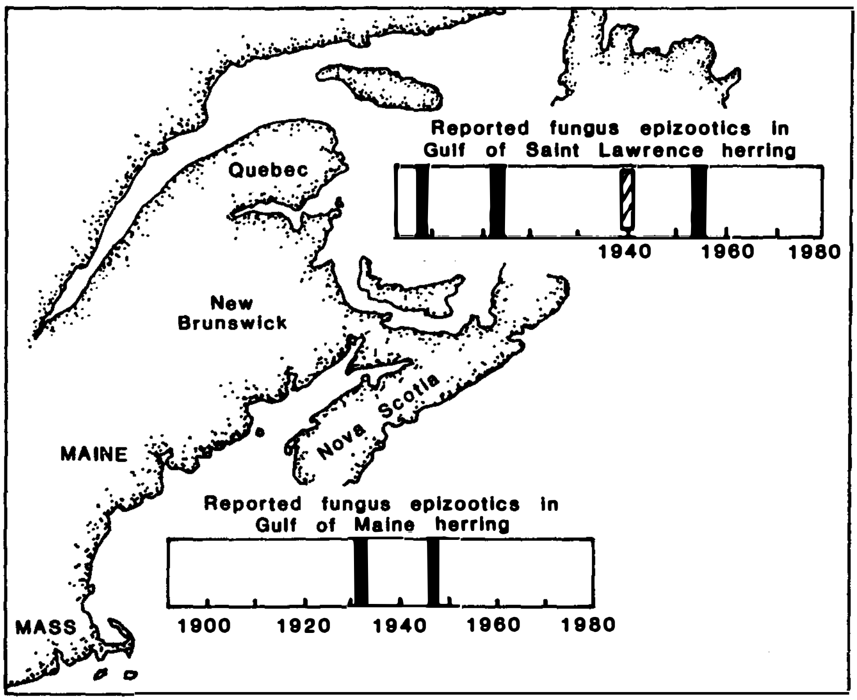


Figure 8. Reported epizootics of *Ichthyophonus hoferi* in herring of the western North Atlantic (from Sindermann 1985).

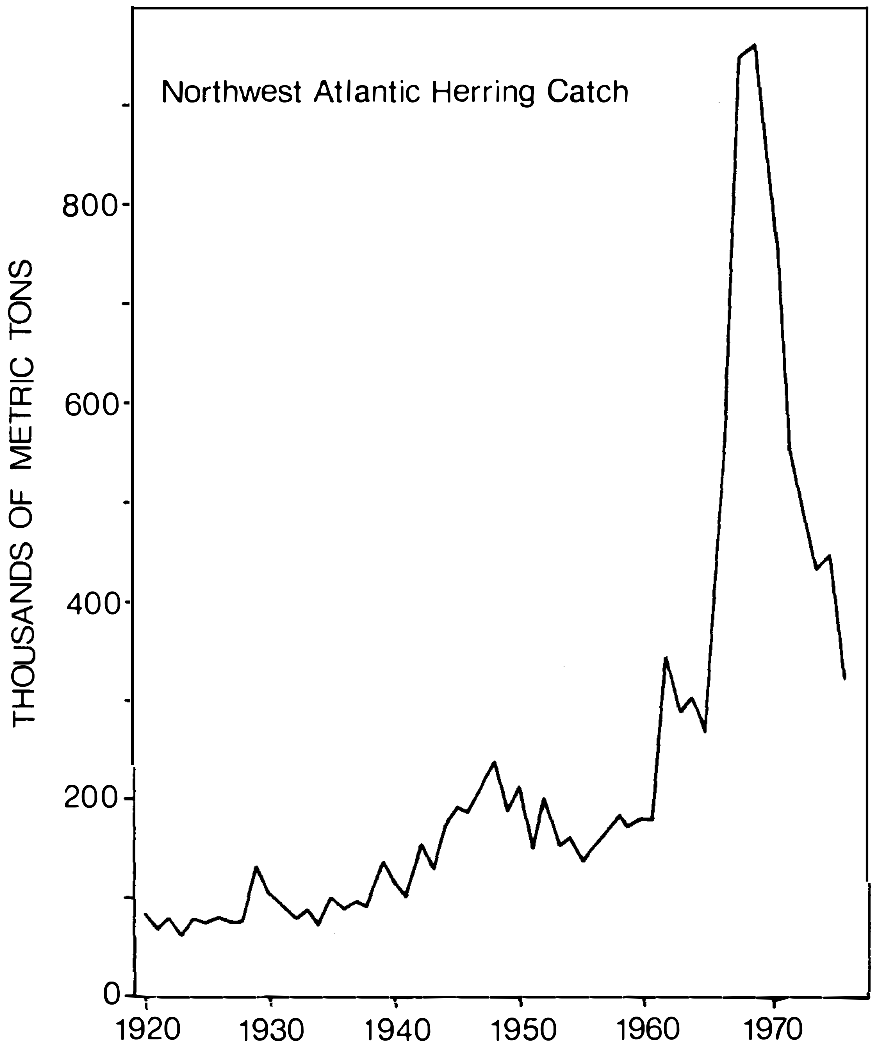


Figure 9. Recent trends in herring catches in the western North Atlantic (from Sindermann 1985).

northern North Sea. He indicated that no other records of mass fish kills due to *Ichthyophonus hoferi* have been reported in natural populations since the 1950s but has found significant annual mortalities of plaice (>55 percent) off northern Scotland. It has been reported as causing heavy mortalities of cultured rainbow trout (*Salmo gairdneri*), killing almost 50 percent of the total stock of one farm. Clearly this fungus disease requires continued attention of scientists and fishery managers alike.

Summer flounder, (Paralichthys dentatus), *versus the hemoflagellate,* Trypanoplasma bullocki

During the winter of 1974-75 several summer flounder, *P. dentatus*, held in concrete tanks at the National Marine Fisheries Service Laboratory in Oxford, Maryland on the Choptank River of the Eastern Shore of Chesapeake Bay developed signs of distress and external lesions, including ulcers, ascites with protruding intestine, and petechiae. Hemoflagellates were found in the blood. Gross external and internal examination revealed other signs, and histological preparations showed the presence of numerous hemoflagellates (then called *Cryptobia*) in the submucosa of the gut and liver (Newman 1978). Subsequently, studies of this disease of the summer flounder were undertaken at the Virginia Institute of Marine Science (Burreson 1981, 1982, Burreson and Zwerner 1984, Sypek and Burreson 1983). Burreson and his coworkers found the same hemoflagellate, more recently named *Trypanoplasma bullocki*, in feral populations of juvenile summer flounder in the lower York River and Chesapeake Bay and offshore. Also hogchokers, *Trinectes maculatus*, were found infected in nature and probably serve as resident reservoir hosts.

This blood protozoan is normally transmitted from fish to fish by the aquatic leech, *Calliobdella vivida*. Infections have been produced in the laboratory via this vector and direct injection (Burreson 1982). Infected fish developed severe-swellings of the abdominal region (ascites) and other external signs of distress (Figure 10). Protozoans from those experimental infections were found in the blood and internal organs such as the liver. Koch's postulates have been satisfied.

It has been shown experimentally that heavily-infected juvenile hosts can be killed by the pathogen and that mortalities increase as water temperatures decrease. Dead fish were found in trawl catches in January of 1981 (Figure 11). Subsequent samples taken in inshore waters north and south of Cape Hatteras, North Carolina in March of 1981 revealed a higher percentage of uninfected individuals in the sample taken south of the Cape when compared with those from the more northerly, colder waters (53 percent to 47 percent respectively). This difference, though not great, is made more significant by the finding that intensity of infection and numbers with ascites

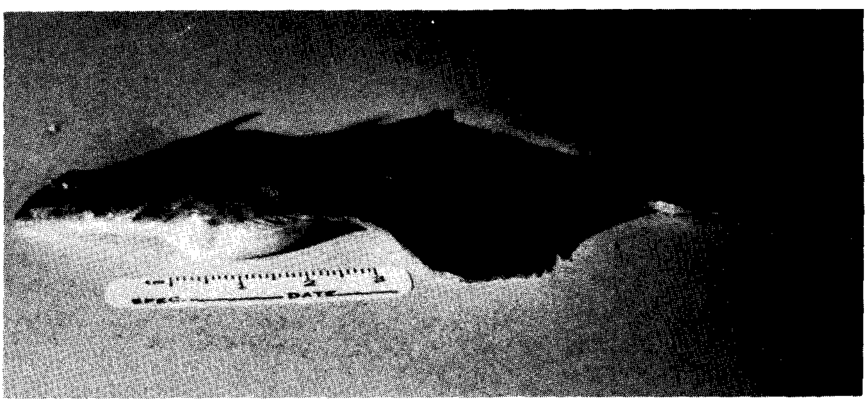


Figure 10. Juvenile Summer Flounder *(Paralichthys dentatus)* with ascites due to *T. bullocki* (Burreson photo).

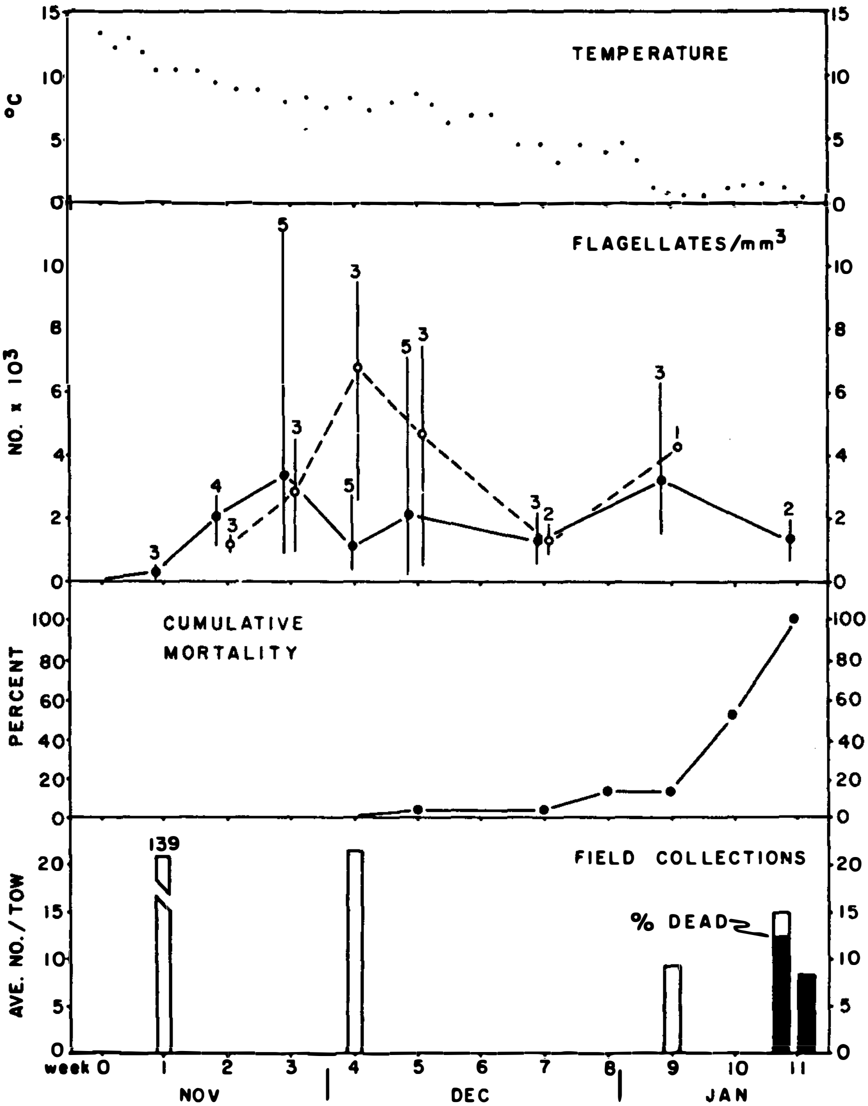


Figure 11. Results of experimental studies and field collections. Solid line in Flagellates/mm^3 connects means of syringe inoculated fish, dashed line connects means of leech inoculated fish. Vertical lines are ranges. Numbers above ranges are number of fish examined (from Burreson 1981).

were higher in the sample from the cooler waters north of Cape Hatteras. These findings confirms a relationship between pathogenicity of the parasite, or increased susceptibility of the host, and low water temperatures.

The higher incidence of parasites and increased death rates of infected hosts in laboratory populations and the evidence of morbidity and mortality in feral populations strongly indicate a potential for production of severe mortalities in juvenile summer flounder by this pathogen. Burreson's studies show that *T. bullocki* causes mortality in wild populations of juvenile summer flounder during winter in the southern mid-Atlantic (Virginian Sea) region of the western North Atlantic.

The summer flounder population has been in decline in recent years, as shown by reduced commercial catches. Questions of possible involvement of the pathogen in these reductions naturally arise and must be investigated further. This is one of the few combined field and laboratory studies which has demonstrated involvement of the pathogen with mortalities of juveniles clearly. Because juveniles are believed to suffer higher levels of mortality than adults normally (May 1973), this case deserves further careful, and expanded, studies into the quantitative aspects of the disease and its possible relations to the population dynamics of prerecruits, year classes or cohorts, and of the stocks as a whole.

White perch (Morone americana) *versus* Pasteurella piscicida *in the summer mortalities of 1963-64*

Chesapeake Bay fish mortalities of 1963-64 were examined by several especially convened task forces involving Virginia, Maryland, and federal agencies and personnel. Many of the results of their investigations, deliberations, and findings were summarized by Hargis, in an early 1965 report to the Governor of Virginia. Snieszko et al. (1964) found a *Pasteurella* species, now identified as *P. piscicida*, a bacterium of low virulence in associated samples of diseased white perch.

The mortalities, which involved millions (estimated) of fishes of several families and genera, fell most heavily on the two serranids, white perch (*Morone americana*), from 89.3 percent to 96 percent, and striped bass (*Morone saxatilis*), 2.4 percent to 0 percent, in the two detailed reliably-estimated kills, for a total of 91 and 96 percent of all recorded dead fish, respectively. Obviously white perch bore the brunt of the attacks in these instances, though striped bass and a number of other species were found dead.

The Virginia task force (Hargis 1965) concluded that the mortality was brought on by "compression" (i.e., crowding due to upriver movement of high salinity waters not suitable to white perch and ecologically similar fishes) and possibly other unfavorable hydrographic conditions resulting from prolonged drought in the Chesapeake Bay watershed. Eutrophication caused by over-fertilization could also have been involved, at least in the Potomac River below Washington, D.C. where dense algal blooms occurred. They also inferred that the final cause of many of the mortalities was attack from one or more disease-producing pathogens exacerbated by lowered resistance of the host populations. *Pasteurella piscicida* recovered from white perch and striped bass (and other fishes) in 1964, but not from normal white perch in 1965, probably was the etiological agent. Evidently it produced extensive bacteremia in infected individuals. The normally low virulence of the bacterium coupled with observations of stressful environmental conditions in the areas showing greatest kills in 1963 tend to confirm the conclusion that both were active in producing this massive mortality episode.

An estimated several million fish were involved in the 1963 mortalities involving pre-adult and adult fish. Sindermann (1970), observing that landings in 1964 (the year immediately following the 1963 epidemic) were as little as 622,000 lbs. (282,139 kg) compared with a 3-year average of 1,500,000 lbs. (680,400 kg) for the preceding years, concluded that they had produced a significant reduction in fishable stocks. However, Hargis (1965) had noted that catches in pound nets and by the recreational fishermen operating in the kill areas did not seem to be reduced because of the mortalities. This apparent inconsistency may be explained by the fact that the fishermen in question were operating in an area into which the white perch, striped bass, and other fishes had been compressed by upstream moving higher (and to white perch—intolerable) salinities. The "compression" or crowding of large numbers of individual fishes into a smaller volume of suitable water not only set up conditions of predisposition to the development of bacterial disease but made more fish available to the fishermen in the area than would have been normally. Consequently, the mortalities, extensive though they were, were not reflected in local catches. This finding would indicate that to determine the significance of such an epidemic to the fishery one would have to examine system-wide catches (as related to effort) rather than local ones for the years before, during, and after the disease incident.

Despite the shortcomings of available data there is little question that this epidemic produced significant short-term effects on the population. Longer term effects remain to be examined and quantified (if, indeed, available data would support additional study). Mortalities such as this could be important in reducing fishable stocks in affected areas (i.e., they were significant factors in the natural mortality (*M*) of fish in such areas). Until their significance is understood, population estimates and management systems involved in such epidemics will continue to be compromised. Additional effort on the part of fish disease specialists (epidemiologists) and fishery population dynamicists (demographers) and managers are justified, even required.

Juvenile Atlantic Menhaden (Brevoortia tyrannus) *versus the Ulcer Disease Syndrome (UDS)*

The active case which follows is so recent (continuing in all areas even now) that this report is based upon internal memoranda and personal communications between the agencies and specialists involved.

In October of 1984, D. E. Zwerner of the Virginia Institute of Marine Science received five lots of preserved young-of-the-year menhaden taken in the York River Virginia (lower Chesapeake Bay) and the Chester River on the Eastern Shore of Maryland (upper Chesapeake Bay). All individuals in those samples bore integumental lesions. Those from Virginia displayed ulcers, some shallow and some deep, on the ventral surfaces of their bodies, mostly around the anal vent (Figures 12 and 13). Fewer were higher up on the flanks. The Chester River samples exhibited eye lesions such as cataracts and exopthalmia (Zwerner, pers. comm.). These samples had been taken by castnet from the centers of swimming schools to reduce chances of capturing diseased and damaged stragglers confined by infirmities to the peripheries of those schools (Guthrie and Kroger 1974) during the regular prerecruit sampling program of the National Marine Fisheries Service menhaden group at Beaufort, North Carolina. The field sampler, Mr. Guthrie, requested assistance with identification of the causes of the ulcers.

Histologically-processed materials from the integumental lesions were examined and found to contain extensive necrosis of epidermal and dermal elements as well as of underlying muscles, peritoneum, and even internal organs, where the ulcers were

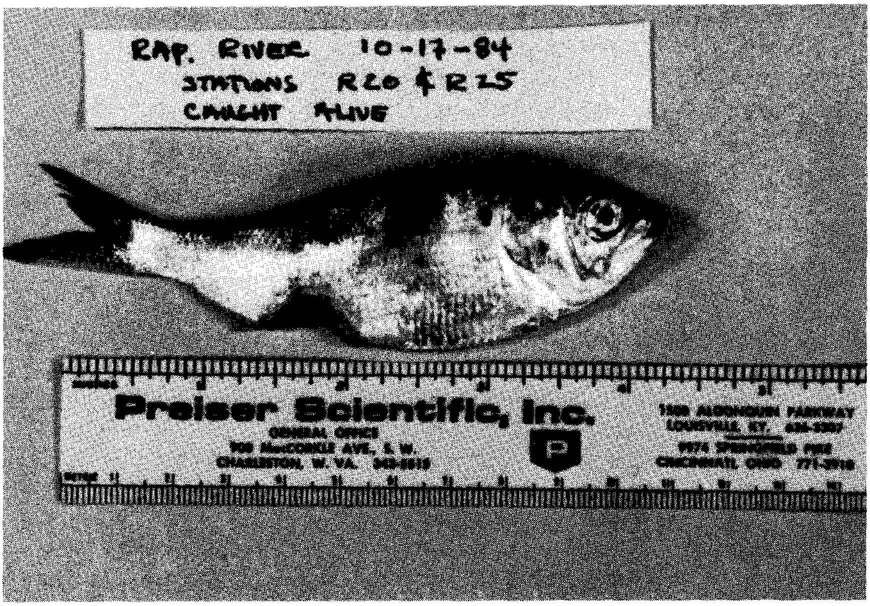


Figure 12. Juvenile menhaden *(B. tyrannus)* with U.D.S. from Rappahannock river, Va. Alive.

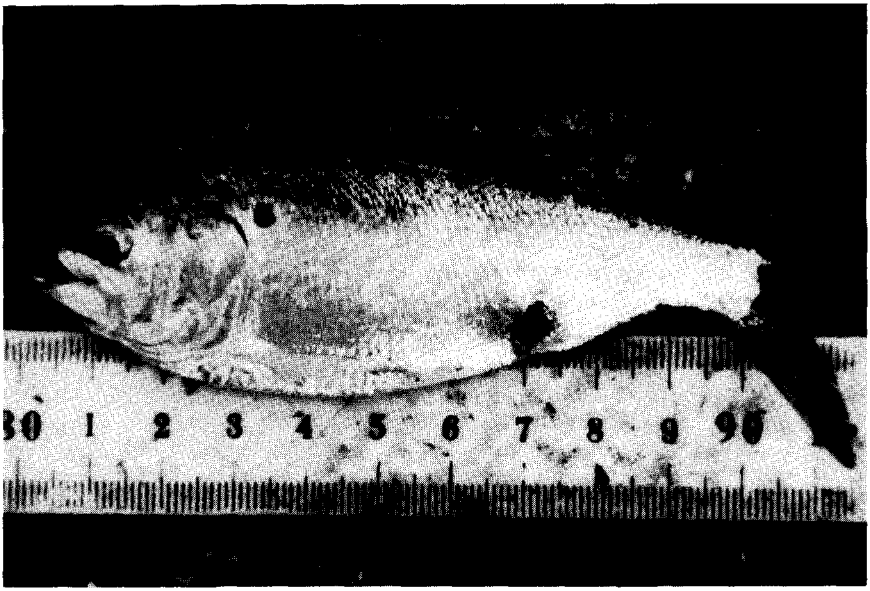


Figure 13. Juvenile menhaden *(B. tyrannus)* with U.D.S. from Rappahannock River, Va. Alive.

deep. Aseptate hyphae of fungus were found in the prepared specimens, along with bacteria. The granulomatous tissues and the hyphal structures involved resembled *Ichthyophonus* infections (Zwerner, pers. comm.).

Similar appearing skin leasions were seen by VIMS survey crews around the same time, and live samples of ulcerated individuals were taken during a specially-arranged sampling effort in November. Examinations of freshly prepared materials revealed the same hyphal-organism as seen in the earlier samples. Cultures contained both bacteria and the fungus. A few spot (*Leiostomus xanthurus*), butterfish (*Peprilus triacanthus*), mummichog (*Fundulus heteroclitus*), and hogchokers (*Trinectes maculatus*) taken during the trawl sampling efforts had similar lesions (Figure 14), but most affected were menhaden. For convenience the disease is being called Ulcer Disease Syndrome (UDS) temporarily. As in the earlier samples, the hyphae of the fungus were widespread in the ulcerous tissue and extended into underlying dermal, muscular, and peritoneal elements and into nearby organs.

(Incidentally, no eye lesions were seen in these Virginia-caught specimens. The ocular conditions found in the menhaden from Chester River, Maryland have not been investigated further as yet. Eyes from hastily prepared specimens are usually unsuitable for detailed studies and no additional fresh samples have been made available. Follow-up studies of this condition using espcially-preserved specimens are planned since cataracts are frequently seen in estuarine animals from heavily contaminated waters in the Chesapeake, such as the Elizabeth River, and we are studying them, especially for possible usage in bioassay work.)

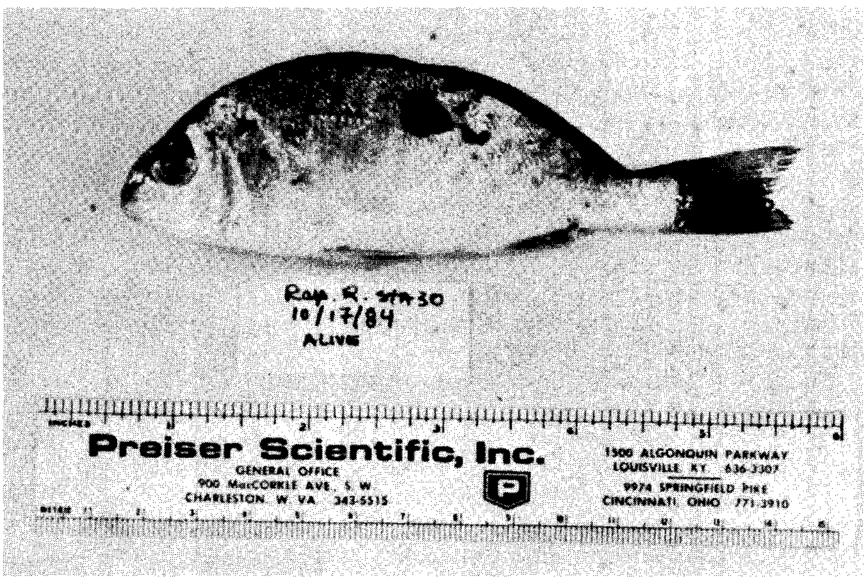


Figure 14. Spot *(Leiostomus xanthurus)* with U.D.S. taken from Rappahannock River, Va. Alive.

Contact with scientists in North Carolina revealed that ulcer-bearing menhaden had been captured two years before in 1982 in Pamlico and Albermarle Sounds and some of their tributaries. Other species such as southern flounder (*Paralichthys lethostigma*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), silver perch (*Bairdiella chrysura*), striped bass (*Morone saxatilis*), white perch (*M. americana*), and pinfish (*Lagodon rhomboides*) were found with integumental lesions. As in Virginia waters, however, 0-class menhaden were the most commonly affected species. The same condition was seen by a North Carolina scientist in menhaden from the St. Johns River in north Florida. Recent newspaper accounts from Florida indicate that the condition is severe in some reaches of that river. Florida officials are known to be concerned (Joyce, pers. comm.). Dr. Burrell, director of the state marine laboratory at Fort Johnson near Charleston, confirms (pers. comm.) that diseased menhaden have been seen in South Carolina. Ulcer-bearing menhaden are reported in Georgia waters also (Musick, pers. comm.). Evidently, this Ulcer Disease Syndrome epidemic is widespread throughout the lower mid-Atlantic and South Atlantic.

Scientists at North Carolina State University also found fungi with broad, branching aseptate hyphae in the ulcers of diseased local fishes and isolated them in culture. Efforts continue to characterize the organisms, believed by most to be the primary pathogen at this time, and to satisfy Koch's postulates.

In some samples, UDS disease was found to affect over 80 percent of the juvenile menhaden captured. Diseased portions of southern flounder (*P. lethostigma*) catches, an important commercial and recreational fish, have had to be discarded at sea, dockside, or in the marketing and distribution systems in North Carolina, representing an economic loss to industry caused by UDS. Dead juvenile (prerecruit) menhaden were taken in scientific survey trawl samples in North Carolina waters later in the fall, indicating that predators and scavengers were not able to consume all of the dead individuals. Deaths must have been significant. Samples from commercial catches in winter of 1984-1985 were taken by NMFS Beaufort personnel. In one sample of 567 fish, 7 individuals (1.2 percent) and in another of 3,395 fish, 62 (1.6 percent) bore "crater-like" ulcers of the type seen in the estuaries earlier. This indicated that diseased fish from N.C. sounds and rivers from the Chesapeake system had reached the open waters of the ocean (outside of the barrier islands and inlets) where the commercial catches were taken. The low percentages of fish found infected offshore contrasted with the very much higher ones found inshore are explained by the fact that the purse-seine gear employed in the commercial fishery is biased against such young (and small) fish.

Not yet known is whether UDS has killed sufficient numbers of 0+ individuals to affect future commercial catches. Young menhaden are not recruited into the commercial purse-seine menhaden fishery in significant numbers before reaching 2 years of age. Nor is it known whether species of predatory fishes dependent upon juvenile menhaden for forage have been affected. Data on numbers of predators affected by possible reduction of forage reduction, if indeed it occurs, will probably never be of sufficiently high resolution to show such changes. These two questions are the most significant practical ones involved in evaluating the significance of this disease. An assessment of these effects should be attempted. The possible long-term effects of the disease on the other involved species should also be considered in future research and surveys.

The disease evidently will continue into 1985 since field survey crews of North Carolina have reported the appearance of several diseased menhaden (and the gizzard shad, *Dorosoma cepedianum*) in samples in March of this year (Hawkins, pers. comm.)

Normally, fungi of the type these appear to resemble most are not primary but secondary invaders. Consequently many feel that the fishes become infected and eventually die because they have been stressed, possibly due in part to unfavorable environmental conditions. This is an interesting surmise since many of the estuarine waters in which it is found, for example, the Rappahannock and York Rivers of Virginia and the Sounds of North Carolina, are not ordinarily thought of as being contaminated. Large population centers and heavy industries are not located upon them and none are known to be experiencing significant environmental problems. Water quality problems may be involved, however, and the U.S. Fish and Wildlife Service has taken water samples in North Carolina for analysis to help investigate the possibility that environmental contamination might be involved. The results are not available to us as yet. The possibility also exists that bacteria are the primary invaders and the fungus secondary. There are several marine fungi, including *Ichthyophonus hoferi*, discussed above, which have been known to be primary pathogens of certain estuarine and marine species for decades.

The state and federal agencies involved, concerned over the welfare of the species affected, the upper level predators dependent upon them, and the commercial fisheries which are based upon them, plan continuing studies. Their purposes are: (1) to identify the organism(s) involved, (2) determine whether it (they) causes the ulcer disease, (3) to establish the mortality level resulting, and (4) to identify the possible effects upon the numbers and biomass of pre-recruits and recruits. Perhaps this work will be of value in determining the possible significance of this currently active disease in natural mortality.

Discussion

The cases described above provide support for concluding that disease is a significant factor in causing death, and determining survival, in several different marine populations. Though the invertebrate cases cited are few, involving only one mollusc and two crustaceans, many more examples are available.

Cases of diseases in molluscs are especially numerous. Viruses, chlamydians, bacteria, protozoans, and metazoans are found in a wide variety of molluscs (and crustaceans) of economic importance. Hargis (1985b) presented a partial list of identified diseases of bivalves in North American waters alone. Twenty-one different diseases, syndromes, or conditions involving *Crassostrea virginica, C. gigas,* several *Ostrea* spp., *Mercenaria mercenaria, Mya arenari, Argopecten irradians,* and other hosts based upon various reports (especially Sindermann 1977 and Farley 1981) were noted. The list undoubtedly can be increased.

For example, in one currently active case, that of the razor clam (*Siliqua patula*) on the coast of Washington State, the estimated population fell from 20 million clams in June of 1983 to 1.5 million in the winter of 1984-85. Public harvesting of this popular clam was stopped in 1983 and the ban has continued since. The closure, supposed to remain through the 1984-85 season, at least until July of 1985, may end sooner since the clam populations seem to have made a rapid recovery (Sparks, pers.

comm.). A likely etiological agent, found associated with lesions of the gills, has been termed NIX (Nucleus Inclusion X) since it occurs in the nuclei of cells in infected hosts.

Molluscs in other parts of the world are affected by pathogens also. Diseases with significant effects on host populations have been found in many coastal waters of France in *Ostrea edulis* (the European flat oyster) and *Crassostrea gigas*, (the Japanese oyster, imported ultimately from the far East) as well as in *Crassostrea angulata* (the Portugese oyster). A translation of the report by Henri Grizel (1983) by Sally V. Otto, pathologist of Maryland, discusses oyster diseases in France in some detail. Pathogens have also been found and, in some cases, implicated in deaths of oysters and other molluscs in Japan, Australia, New Zealand, Holland, and in the Mediterranean among other likely places.

Crustaceans of socioeconomic importance also are affected by virus, bacterial, protozoan, and metazoan diseases both in culture situations (Overstreet 1983, 1985) and in wild populations (Overstreet 1978, 1983). As with the molluscs, examples other than the case histories mentioned above are available. That the list of hosts includes mostly animals of economic importance such as the blue crab (*Callinectes sapidus*), the several commercial shrimps of the Gulfs of Mexico and Maine, and those of the northeast Pacific among others is no surprise. Research has been concentrated on them.

Lobsters, like blue crabs and other valuable decapods, including *Carcinus* and *Cancer*, have a number of diseases. Of the many known symbiote[1]/host relationships, that caused by the bacterium *Aerococcus viridans* (var.) *homari* is the most noteworthy. The disease, termed gaffkemia, occurring on both sides of the Atlantic is the most serious lobster malady known. This pathogen does its damage mostly in confined host populations, but the causative organism (Koch's postulate have been satisfied) occurs free-living in sea water. Not only do protozoan micro-organisms cause problems in lobsters but metazoans do also. For example, a nemertean worm of the Order Hoplonemertea has been implicated in predation or motality of the egg-masses of ovigerous females in confinement. It has also been found in wild lobsters. "The historical and potential impact of this nemertean on the reproductive potential of wild lobsters is not known" (Aiken et al. 1981). These and other diseases of *Homarus* species should be further followed to determine their role in feral populations as well as those in captivity.

Though many other examples of parasitism and disease in mollusc and crustacean invertebrates of socioeconomic importance could be cited (for examples, see Overstreet 1978, 1983, 1985, Sindermann 1977), considerable ignorance exists regarding their significance in mortality. Stewart (1984) has remarked that "Most parasitologists associated with lobsters believe strongly that this situation should be rectified." The same could be said about most important invertebrate diseases. Expressed more generally, there is a need to understand the role of disease in feral and cultured populations of all important marine organisms and its significance in the natural mortality factor (*M*) of fishery models.

As with the invertebrates, many other published examples of parasitism and disease among finfishes (teleosts and cartilaginous species alike) could be cited.

[1]The word symbiote, used here in the broad sense, includes and subsumes commensalism, mutualism, phoresis, and parasitism.

Bauer et al. (1981) discuss many of them, citing a number of examples and including an extensive list of references. Several of the papers in Hargis (1985a) also describe many cases of parasitism and pathogenicity in finfishes and include many citations. (See also Colwell and Grimes 1984, Dethlefsen 1984, Hetrick 1984).

Some recent work has dealt with metabolic responses of hosts to their parasitic invaders. For example, see van den Broek, (1978) who examined the effects of the copepod *Lernaeocera branchialis* upon the lipid biochemistry of the host whiting, *Merlangus merlangus*, (Linnaeus described both, early on). He reported that an average of 40.4 percent of the whitings were infected by copepod between 1973 and 1975 after the 0-class fish had moved inshore where they are "particularly vulnerable to parasitic infection." His experiments indicated that mature adults of *L. branchialis* cause significant reduction in weight of infected individuals. He found that the lipid content of their livers was more than 50 percent lower than those of uninfected fish. Phospholipids were lower also. These studies showed that whitings are adversely affected by the parasites, which cause physical damage to the gills as well as changing the host's metabolism. Other scientists, who reported that extent of injury to the host can vary from insignificant to complete emaciation, have studied the deleterious effects of parasites and pathogens upon their hosts more broadly. Kazachenko and Tatar (1985) concluded that parasitic copepods actually reduce the biomass and fishery yields of heavily infected stocks significantly. Kuperman (1973) discussed the importance of tapeworms in the ecology of their hosts. Collard (1970) considered parasites of mesopelagic fishes and their interactions and importance as has Campbell (1983) for deep-sea species.

Most parasitologists and other marine disease specialists are convinced that parasites and pathogens play a significant role in the ecology of fishery populations they affect. The case histories presented above are but a few which undergird their convictions. Though results of these and other studies of the effects of parasites and pathogens on their hosts often have not unequivocally established, the magnitude of possible reductions in biomass or numbers of individuals resulting, evidence that they are significant is sufficiently strong to warrant continuing and more definitive field and laboratory studies.

Summary

The extensive literatures of human medicine and epidemiology, agronomy, forestry, animal husbandry, and wildlife biology contain numerous historical and recent examples of the importance of disease in affecting health and survival of individuals and controlling population levels. Qualitative and quantitative evidence supports this contention. Numerous specific references establishing these statements are available, but citations should not be necessary. Disease and death are deemed important factors affecting health, welfare, and productivity of human populations. Whole systems of preventative and remedial human and veterinary medicine have been developed in most stable societies. Tremendous human and financial resources are involved.

Undoubtedly disease exerts significant pressures in fishery populations also. Fishery science, too, should attend disease closely. Scientists involved with scientific and economic aquaculture of shellfish and finfish are often made acutely aware that parasites and diseases can reduce the condition of their stocks and cause extensive mortalities if not controlled (Overstreet 1985, Sindermann 1977, 1985a,b). Despite these findings, scientists and managers dealing with wild populations of marine shellfish and fish often ignore disease as an element in population estimation and in management procedures. But disease is not the only cause of natural mortality which is assummed or inferred in management of feral fishery resources; the factors of deaths or removals due to predation, environmental stress, and senescence are also.

Most population equations use sequential age-catch statistics to establish total mortality (Z). These same fishery statistics (preferably with effort data) are used to establish fishing mortality (F). Subtraction of F from Z ($Z-F=M$) provides natural mortality M. Two problems persist: (1) natural mortality (consisting of the natural extractive factors of obvious importance—predation, environmental stress, and death due to old age as well as disease) are assumed or inferred but not known, and (2) equally or more damaging, fishing mortality estimates are usually weak, either not including or assuming too many factors. Inaccuracy of catch data, lack of or weakness in effort statistics, and ignorance of fishing-related mortality, (i.e., gear damage, culling deaths and by catch deaths) reduce the accuracy and precision of fishery-related data available. In many instances long-term data on sportfishing catches are not available or incomplete. Therefore fishing mortality (F) estimates are somewhat weak. As a result, total mortality (Z) often is not accurately known. Obviously, natural mortality estimates, derived as they are by subtracting F from Z are often "soft" also.

The necessity of management has driven the development and application of the several equations and models employed in making population estimates, predictions, and allotments. The statistics generated must be used despite their limitations since they are the only "game in town" and the urgency of wise allocation, use, and distribution of marine fishery resources for human purposes is obvious. Marine fishery populations, long pressured in heavily-fished areas like the North Sea, the several fishing banks of the North Atlantic and the mid-Atlantic Bight as well as those of the northeast Pacific and elsewhere, have come under stress around the globe since high seas fishing was increased after World War II. Further, increasing fishing pressure on available stocks has been augmented by the deleterious effects of environmental degradation as shown above.

Though we must use the data bases and models (numerical and graphical) now available in making management decisions since they are the only scientific bases or estimates available, efforts should be vigorously pursued to improve them. There is no clear evidence that present management practices are succeeding in reversing population declines in most fishery resources now in demand. Whatever the cause or causes involved, most of the pressured stocks and fisheries operating upon them continue troubled. (Excellent examples supporting these statements are the sea scallop [*Placopecten magellanicus*] and the multispecies demersal finfisheries of New England and the upper Virginian Sea [mid-Atlantic Bight], both of which show signs of continuing decline.)

Several elements appear to be involved in the persistence of overharvesting in many fisheries. One is insufficient determination on the part of most governments or the societies they represent to take the steps necessary to acquire needed data and effectively regulate withdrawals. Other contributing factors identified above are the lack of detailed knowledge of the resources and the forces acting upon them and the persistent softness of stock estimates. Ignorance of the dynamics and amounts of pressure caused by the several elements of natural mortality (*M*) plays a role. Overfishing is relative, depending not only upon the activities of the fishing industry but the "instantaneous" and long-term ability of the stocks being exploited to withstand those fishing withdrawals or pressures applied. All of the dynamic elements of natural mortality (*M*) are involved. Axiomatically, we would be better able to manage both stocks and fisheries (the socioeconomic activities based upon them) if all elements acting upon those stocks (and fisheries) were understood and incorporated in the equations and models upon which biological and economic decisions are based. Until we understand those factors in detail, management perforce must be conservative and buffers or reserves must be maintained, leaving untouched and unharvested stock that might have been otherwise used with no danger to the natural resource base. To manage with close tolerances requires accurate and precise information!

Science should never be satisfied with incomplete understanding or partial answers but should strive toward complete comprehension and for accuracy and precision in its information and predictions.

Aside from the continuing need for development of improved scientific and managerial understanding, are there other reasons for pursuing additional information on the quantitative significance of disease? After all, in-depth research on disease and essential monitoring of wild populations are costly of time, energy, and money and we cannot afford to waste effort and finances upon unimportant or unnecessary research.

Without the ability to assess the significance of parasites and pathogens (and other elements of disease) in the population cycles of important fishery resources, we cannot determine the risks and possible deleterious results, or the benefits in possible savings of energy, time, and money, of ignoring them. What we don't know could hurt us! If disease (by itself or interacting with metabolic deficiencies, natural catastrophes, or man-caused environmental stress) acts to severely and quickly reduce one or more cohorts of a fishery stock and fishing effort is not curtailed in time to relieve punishing pressure, long-term resource damage and severe economic dislocations could result.

Fishery populations are among the best known of Earth's living estuarine and marine systems. Much effort has been devoted to matching water quality to needs of those plants and animals. (Evidently not enough, however, since signs of increasing contamination of many—even most, estuarine and marine waters continue to mount!). As the ultimate bioassay systems, the living organisms against which we can measure adequacy of the environment must be fully and accurately understood and must be regularly measured (monitored) with accuracy and precision. More complete understanding of the factors involved in causing mortalities in marine populations will allow development of more adequate and effective environmental criteria and standards against which water quality management and enforcement activities can be planned, pursued, and evaluated. Fishery populations which are assured of future survival and abundance and are safe for use as human foods are guarantees of adequate water quality.

Finally, some aspects of disease-related mortality can almost certainly be managed (Sindermann 1977). Disease resistance can be produced by immunization, by deliberate encouragement of the development of resistant stocks in nature, or by genetic manipulation in the laboratory. Purposeful "cropping" and control of planned or accidental transferrals of susceptible hosts or alien predators, parasites, and pathogens into an unprepared population are other options open to managers. To understand the possibilities of undertaking such management efforts and the necessity and justification for doing so we must know which controls are applicable and needed and where and when they could be applied, as well as the possible benefits and costs resulting.

Clearly, significant scientific, sociological, and economic reasons suggest continuation of present efforts to establish and understand the role of disease (and other elements of natural mutility) in wild, and captive, estuarine and marine populations. Equally clearly, evidence of its importance in the survival of fishery populations justifies expansion of basic and applied research and of scientifically- and managerially-oriented survey and monitoring efforts.

Literature Cited

Aho, J. M., and C. R. Kennedy. 1984. Seasonal population dynamics of the nematode *Cystidicoloides tenuissma* (Zeder) from the River Swincombe, England. J. Fish. Biol. 25:473-489.

Aiken, D. E., S. L. Waddy, L. S. Uhazy, and A. Campbell. 1981. A nemertean destructive to the eggs of the lobster, *Homarus americanus*. Paper No. 4 of the Special Meeting on Diseases of Commercially Important Marine Fish and Shellfish. Int'l. Council fo the Explor. of the Sea. 7 pp.

Anderson, R. M. 1979. The influence of parasitic infection on the dynamics of host population growth. Pages 245-281 *in* R. M. Anderson, B. D. Turner and L. R. Taylor. Population Dynamics. Blackwell Sci. Publ. Oxford, London.

______. 1982. Directly transmitted viral and bacterial infections of man. Pages 1-37 *in* R. M. Anderson, ed. The population dynamics of infectious diseases: Theory and applications. Chapman and Hall, London and New York.

Anderson, R. M., and R. M. May. 1979. Population biology of infectious diseases. Part I. Nature 280:361-367.

Anderson, R. M., and R. M. May. 1980. Infectious diseases and population cycles of forest insects. Science 210:658-661.

Anderson, R. M., and R. M. May. 1982. Population biology of infectious diseases. Report of the Dahlem Workshop on Population Biology of Infectious Disease Agents. Dahlem Konferenzen Berlin. Springer-Verlag, Berlin, Heidelberg, New York. 315 pp.

Andrews, J. D. 1982. Epizootiology of late summer and fall infections of oysters by *Haplosporidium nelsoni*, and comparison to annual life cycle of *Haplosporidium costalis*, a typical haplosporidian. J. Shellfish. Res. 2:15-23.

Andrews, J. D. 1984a. Epizootiology of diseases of oysters (*Crassostrea virginica*), and parasites of associated organisms in eastern North America. Helgolander Meeresunters. 37:149-166.

______. 1984b. Epizootiology of haplosporidan diseases affecting oysters. Comparative Pathobiology 7:243-269.

Austin, H. M., and M. C. Ingham. 1978. Use of environmental data in the prediction of marine fisheries abundance. Pages 93-106 *in* J. Knauss, Chmn. Climate and fisheries. Proc. Workshop on the Influence of Environmental Factors in Fisheries Production. Center for Ocean Management Studies, Univ. of Rhode Island, Kingston.

Bauer, O. N., S. Egusa, and G. L. Hoffman. 1981. Parasitic infections of economic importance in fishes. Pages 425-443 *in* Review of advances in parasitology. Proc. 4th Int'l. Congress of Parasitology (ICOPA IV), 19-26 Aug. 1978. Warsaw.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fishery Investigations, Ser. II, Vol. XIX, Ministry of Agriculture and Food, Her Majesty's Stationery Office, London. 533 pp.

Bradley, D. J. 1982. Epidemiological models—theory and reality. Pages 320-333 *in* R. M. Anderson. The population dynamics of infectious diseases: Theory and applications. Chapman and Hall, London and New York.

Brooks, W. K. 1905. The oyster: A popular summary of a scientific study. The Johns Hopkins University Press, Baltimore. 225 pp.
Burreson, E. M. 1981. Effects of mortality caused by the hemoflagellate *Trypanoplasma bullocki* on summer flounder populations in the middle-Atlantic Bight. I.C.E.S., C.M. 1981/a.61. Demersal Fish Comm. 6 pp.
_____. 1982. The life cycle of *Trypanoplasma bullocki* (Zoomastogophorea: Kinetoplastida). J. Protozool. 29:72-77.
_____, and D. E. Zwerner. 1984. Juvenile summer flounder, *Paralichthyes dentatus*, mortalities in the western Atlantic Ocean caused by the hemoflagellate *Trypanoplasma bullocki*: evidence from field and experimental studies. Helgolander Meersunters. 37:343-352.
Campana, S. E. 1983. Mortality of starry flounders (*Platichthys stellatus*) with skin tumors. Can. J. Fish. and Aquatic Sci. 40:200-207.
Campbell, R. A. 1983. Parasitism in the deep sea. Pages 473-552 *in* G. T. Rowe. The Sea. Vol. 8 John Wiley and Sons, Inc., New York.
Collard, S. B. 1970. Some aspects of host-parasite relationships in mesopelagic fishes. Pages 41-56 *in* S. F. Snieszko, ed. A Symposium of the American Fisheries Society on Disease of Fishes and Shellfishes.
Colwell, R. R., and D. J. Grimes. 1984. *Vibrio* diseases of marine fish populations. Helgolander Meeresunters. 37:265-287.
Crofton, H. D. 1971a. A quantitative approach to parasitism. Parasitol. (1971) 62:179-193.
_____. 1971b. A model of host-parasite relationships. Parasitol. (1971) 63:343-364.
Dethlefsen, V. 1984. Diseases in North Sea fishes. Helgolander Meeresunters. 37:353-374.
Eisen, S. 1983. An alternative model based on random distributions for density-dependent regulations in host-parasite systems. Amer. Midl. Nat. 109(2):230-239.
Esch, G. W., ed. 1977. Regulation of parasite populations. Academic Press, New York, London, San Francisco. xi +253 pp.
Farley, A. 1981. Phylogenetic relationships between viruses, marine invertebrates and neoplasia. Pages 75-87 *in* C. J. Dawe et al., eds. Phyletic approaches to cancer. Jap. Sci. Soc. Press.
Ford, S. E., and H. H. Haskin. 1982. History and epizootiology of *Haplosporidium nelsoni* (MSX), an oyster pathogen in Delaware Bay, 1957-1980. J. Invert Pathol. 40:118-141.
Galtsoff, P. S. 1964. The American Oyster. Fishery Bull. No. 64. U.S.D.I. Fish and Wildlife Service, Washington, D.C. 480 pp.
Grizel, H. 1983. Impact of *Marteilia refringens* and *Bonamia ostreae* on Breton oyster culture. C. M. 1983/Gen: 9, Mini Symp. Int'l. Council Exploration of the Sea. (In French: Translated by S. V. Otto).
Gulland, J. A. 1969. Manual of methods for fish stock assessments. Part I, Fish Population Analysis. FAO Manuals in Fisheries Science No. 4 (FRS/M4), vii-154. FAO of UN, Rome.
Guthrie, J. F., and R. L. Kroger. 1974. Schooling habits of injured and parasitized menhaden. Ecology 55:208-210.
Hargis, W. J., Jr. 1965. The 1963 Chesapeake Bay fish mortalities with notes on other Chesapeake Bay mortalities. (Notes on 1964 fish kills are also included.) Report of the Governor's Fish Kill Committee, Virginia Institute of Marine Science. 63 pp., with Addendum and Appendices.
_____, ed. 1985a. Parasitology and pathology of Marine organisms of the world ocean. NOAA Tech. Rep. NMFS 25. 135 pp.
_____. 1985b. Recent studies in the United States on parasites and pathogens of marine mollusks with emphasis on diseases of the American oyster, *Crassostrea virginica* Gmelin. Pages 101-107 *in* Hargis, W. J., Jr., ed. Parasitology and pathology of marine organisms of the world ocean. NOAA Technical Report NMFS 25.
_____, and J. L. DuPuy. In press. A case against biological pollution— introduction of predators, parasites and diseases in purposeful or accidental transplantation of estuarine and marine species. Proc. 1984 Interstate Seafood Seminar.
Haskin, H. H., and S. E. Ford. 1982. *Haplosporidium nelsoni* (MSX) on Delaware Bay seed oyster beds: A host-parasite relationship along a salinity gradient. J. Invert. Pathol. 40:118-141.

Hassell, M. P., (Rapp.). 1982. Impact of infectious diseases on host populations. Group Report. Pages 15-35 *in* R. M. Anderson, and R. M. May, eds. Population biology of infectious diseases. Dahlem Konferenzen, Berlin. Springer-Verlag, Berlin, Heidelberg, New York.

Haven, D. S., W. J. Hargis, Jr., and P. C. Kendall. 1978. The oyster industry of Virginia: its status, problems and promise. Spec. Papers in Mar. Sci. No. 4. Va. Inst. Mar. Sci. 1024 pp.

Hetrick, F. M. 1984. DNA viruses associated with diseases of marine and anadromous fish. Helgolander Meeresunters. 37(1-4):289-307.

Hibbits, J., G. C. Hughes, and A. K. Sparks. 1981. *Trichomaris invadens* gen. et sp. nov., an ascomycete parasite of the Tanner crab (*Chionoectes bairdi* Rathbun, Crustacea; Brachyura). Can. J. Botany 59(11):2121-2128.

Hicks, D. M. 1982. Abundance and distribution of Black Mat Syndrome on stocks of Tanner crabs, (*Chionoectes bairdi*), in the northwestern Gulf of Alaska. Proc. Int'l. Symp. on the genus *Chionoectes*.

Holmes, J. C. 1982. Impact of infectious disease agents on the population growth and geographical distribution of animals. Pages 37-51 *in* R. M. Anderson and R. M. May, eds. Population biology of infectious Diseases. Dahlem Konferenzen, Berlin. Springer-Verlag, Berlin, Heidelberg, New York.

Johnson, P. T. 1984. Viral diseases of marine invertebrates. Helgolander Meeresunters. 37:65-98.

Jones, R. 1973. Density dependent regulation of the numbers of cod and haddock. Rapp. P.-v. Reun. Cons. Int. Explor. Mer. 164:156-173.

Joseph, E. B. 1972. The status of the sciaenid stocks of the middle Atlantic coast. Ches. Sci. 14:87-100.

Kazachenko, V. N., and V. M. Tatar. 1985. Special features on the geographical distribution and practical significance of the parasitic copepods of fishes of the Pacific. Pages 85-88 *in* W. J. Hargis, Jr., ed. Parasitology and pathology of marine organisms of the world ocean. NOAA Technical Report NMFS 25.

Kennedy, C. R., ed. 1976. Ecological aspects of parasitology. North Holland Publ. Co., Amsterdam/Oxford. 474 pp.

Kohler, A. C. 1961. Variations in the growth of cod (*Gadus morhua* L.). Ph.D. Thesis. McGill University, Montreal.

Knauss, J., Chmn. 1978. Climate and fisheries. Proceedings from a Workshop on the Influence of Environmental Factors in Fisheries Production. Center for Ocean Management Studies, Univ. of Rhode Island, Kingston. 136 pp.

Kuperman, B. I. 1973. Tapeworms of the genus *Triaenophorus*, parasites of fishes. Acad. of Sci. USSR. (Translated from Russ. by B. R. Sharman, Edited by V. S. Kothekar) NTIS Springfield, Va., USA. viii-222 pp.

Lackey, R. T., and L. A. Nielson, eds. 1980. Fisheries management. Halsted Press, John Wiley and Sons, New York-Toronto. x + 422 pp.

Lester, R. J. G. 1984. A review of methods for estimating mortality due to parasites in wild fish populations. Helgolander Meeresunters.

McGregor, E. A. 1963. Publications on fish parasites and diseases, 330 B.C. - A.D. 1923. Special Scientific Report—Fisheries No. 474. U.S. Fish and Wildlife Service, U.S. Dep. of the Interior, Washington, D.C. 84 pp.

McVicar, A. H. 1980. The effects of *Ichthyophonus* infection in haddock *Melanogrammus aeglefinus* and plaice *Pleuronectes platessa* in Scottish waters. ICES Special Meeting on Diseases of Commercially Important Marine Fish and Shellfish 1980/16., 8 pp. with tables and figures.

______. 1981. An assessment of *Ichthyophonus* disease as a component of natural mortality in plaice populations in Scottish waters. CM 1981/G:49 Demersal Fish Committees. Int'l. Council for the Exploration of the Sea. 7 pp. with table.

______. 1982. *Ichthyophonus* infections of fish. Pages 243-269 *in* R. J. Roberts, ed. Microbial diseases of fish. Publ. for the Soc. Gen. Microbiol. Academic Press, London-New York.

May, R. M. 1973. Larval mortality in marine fishes and the critical period concept. Pages 1-19 *in* J. H. S. Blaxter, ed. The early life history of fish. Springer-Verlag, Berlin, Heidelberg, New York.

______. 1982. Introduction. Pages 1-12 *in* R. M. Anderson and R. M. May, eds. Population biology of infectious diseases. Dahlem Konferenzen, Berlin. Springer-Verlag, Berlin, Heidelberg, New York.

______. 1983. Parasitic infections as regulators of animal populations. Amer. Sci. 71:36-45.

______, and R. M. Anderson. 1979. Population biology of infectious diseases, Part II. Nature 280:455-461.

Mix, M. C., and A. K. Sparks. 1980. Hemocyte classification and differential counts in the Dungeness crab, *Cancer magister*. J. Inverteb. Pathol. 35:134-143.

Moller, H. 1984. Dynamics of fish diseases in the lower Elbe River. Helgolander Meeresunters. 37:389-413.

Munro, A. L. S. 1983. Are cummunicable diseases a significant source of mortality in exploited marine fish populations? ICES CM 1983/ Gen: 5. Marine and Environmental Quality Committee. Int'l. Council for the Exploration of the Sea. 11 pp.

______, A. H. McVicar, and R Jones. 1983. The epidemiology of infectious disease in commercially important wild marine fish. Rapp. P.-v. Reun. Cons. Int. Explor. Mer. 182:21-32.

Newman, M. W. 1978. Pathology associated with *Cryptobia* infection in a summer flounder (*Paralichthys dentatus*). J. Wild. Dis. 14:299-304.

______, and G. E. Ward, Jr. 1973. An epizootic of blue crabs, *Callinectes sapidus*, caused by *Paramoeba perniciosa*. J. Invert. Pathol. 22:329-334.

Norcross, B. L. 1983. Climate-scale environmental factors affecting year-class fluctuations of Atlantic croaker (*Micropogonias undulatus*) in the Chesapeake Bay. Ph.D. Dissertation. School of Marine Science, The College of William and Mary, Williamsburg, Virginia. xxviii + 388 pp.

Ossiander, F. J., and G. Wedemeyer. 1973. Computer program for sample sizes required to determine disease incidence in fish populations. J. Fish. Res. Bd. Can. 30:1383-1384.

Overstreet, R. M. 1978. Marine maladies? Worms, germs and other symbionts from the northern Gulf of Mexico. Miss.- Ala. Sea Grant Consortium Publ. MASGP-78-021. 140 pp.

______. 1983. Metazoan symbionts of crustaceans. Pages 155-250 *in* A. J. Provenzano, ed. The biology of crustacea. Academic Press, New York.

______. 1985. Some parasitological aspects of shrimp culture in the United States. Pages 117-122 *in* W. J. Hargis, Jr., ed. Parasitology and pathology of marine organisms of the world ocean. NOAA Tech. Rep. NMFS 25.

Pitcher, T. J., and P. J. B. Hart. 1982. Fisheries ecology. AVI Publ. Co., Inc., Westport, Conn., U.S.A. 414 pp.

Prytherch, H. F. 1931. Report of the investigation on the mortality of oysters and decline of oyster production in Virginia waters. An internal report of the Bureau of Fisheries of the U.S. Department of Commerce. 12 pp.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 119:300 pp.

______. 1975. Computations and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. No. 191. xviii + 382 pp.

Royce, W. F. 1972. Introduction to the fishery sciences. Academic Press, New York, San Francisco, London. x + 351 pp.

Simpson, A. C. 1953. Some observations on the mortality of fish and the distribution of plankton in the southern North Sea during the cold winter 1946-47. J. Cons. Perm. Int. Explor. Mer. 19:150-177.

Sindermann, C. J. 1958. An epizootic in Gulf of St. Lawrence fishes. Trans. N. Amer. Wildl. Conf. 23:349-360.

______. 1966. Diseases of marine fishes. TFH Publications, New Jersey.

______. 1968. Oyster mortalities, with particular reference to Chesapeake Bay and the Atlantic coast of North America. Spec. Sci. Rep., Fisheries no. 569. iii + 10 pp.

______. 1970. Principal disease of marine fish and shellfish. Academic Press, New York and London. x + 369 pp.

______, ed. 1977. Disease diagnosis and control in North American marine aquaculture. Developments in Aquaculture and Fisheries Science, No. 6. Elsevier Sci. Publ. Co., New York. 330 pp.

_____. 1979. Status of northwest Atlantic herring stocks of concern to the United States. Tech. Series Report No. 23 of the Northeast Fisheries Center, NOAA/NMFS. vii + 449 pp.
_____. 1980. Pollution effects on fisheries-potential management activities. Helgolander Meeresunters. 33:674-686.
_____. 1985a. Recent studies on marine fish parasites and diseases. Pages 7-18 *in* W. J. Hargis, ed. Parasitology and pathology of marine organisms of the world ocean. NOAA Tech. Rep. NMFS 25.
_____. 1985b. The role of disease in the management of cultivated marine fish and shellfish populations. Trans. North. Amer. Wildl. and Natur. Resour. Conf. 50:641-649.
Sissenwine, M. P., B. E. Brown, and J. Brennan-Hoskins. 1979. Brief history and state of the art of fish production models and some applications to fisheries off the northeastern United States. Pages 25-48 *in* J. Knauss, Chmn. Climate and fisheries. Proc. Workshop on the Influence of Environmental Factors on Fisheries Production. Center for Ocean Management Studies, Univ. Rhode Island, Kingston.
Snieszko, S. F., G. L. Bullock, E. Hollis, and J. G. Boone. 1964. *Pasteurella* sp. from an epizootic of white perch (*Roccus americanus*) in Chesapeake Bay tidewater areas. J. Bacteriol. 88:1814-1815.
Sparks, A. K. 1982. The histopathology and possible role in the population dynamics of Tanner crab, *Chionoectes bairdi*, of the fungus disease (Black Mat Syndrome) caused by *Trichomaris invadens*. Proc. Int'l. Symp. on the genus *Chionoectes*:539-545.
_____. 1984. An invasive fungus disease of the Tanner crab and its aquacultural connotations. Pages 61-67 *in* C. J. Sindermann, ed. Proc. 9th and 10th. U.S.-Japan meetings on aquaculture. NOAA Tech. Rep. NMFS 16.
_____, and J. Hibbits. 1979. Black Mat Syndrome, an invasive mycotic disease of the Tanner crab, *Chionoectes bairdi*. J. Invertbr. Pathol. 34:184-191.
Stewart, J. E. 1984. Lobster diseases. Helgolander Meeresunters. 37:243-254.
Strand, I.E., and D. W. Lipton. 1985. Disease organisms, economics and the management of fisheries. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 50:655-674.
Swanson, R. L., and C. J. Sindermann, eds. 1977. Oxygen depletion and associated benthic mortalities in New York Bight, 1976. NOAA Professional Paper II. U.S. Dep. Commerce, Washington, D.C. v + 345 pp.
Sypek, J. P., and E. M. Burreson. 1983. Influence of temperature on the immune response of juvenile summer flounder, *Paralichthys dentatus*, and its role in the elimination of *Trypanoplasma bullocki* infections. Devp't. and Comp. Immunology. 7:277-286.
Tibbo, S. N., and T. R. Graham. 1963. Biological changes in herring stocks following an epizootic. J. Fish Res. Bd. Can. 20:435-449.
van den Broek, W. L. F. 1978. The effects of *Lernaeocera branchialis* on the *Merlanguis merlanguis* populations in the Medway estuary. J. Fish. Biol. 1978 :709-715.
Worlund, D. D., and G. Taylor. 1983. Estimation of disease incidence in fish populations. Can. J. Fish. and Aquatic Sci. 40:2194-2197.

The Role of Disease in the Management of Cultivated Marine Fish and Shellfish Populations

Carl J. Sindermann
U.S. Department of Commerce, NOAA
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732

Introduction

Wherever animals are crowded together under abnormal conditions, opportunity exists for the spread of infectious disease and for mortality of a significant part of the population. This principle, so dramatically demonstrated in Europe during the great plagues of the Dark Ages, forms a part of the management information base in marine aquaculture, and the reality of the principle has been affirmed repeatedly. In the past three decades, disease has emerged as one of the most significant technological problems in marine culture—to the point where, in some instances such as pen culture of Pacific salmon, the continued existence of the industry depended on solution of an existing disease problem (in this instance vibriosis).

Disease control is complicated by the continuing interplay of host susceptibility, pathogen virulence, and environmental influences. Frank pathogens and their effects can be dealt with reasonably well, but much of the damage to cultured populations is caused by facultative pathogens (bacteria and viruses especially) which exert effects when water quality is not maintained or when other stressors (abnormal temperature, oxygen deficiency, inadequate diet, overcrowding) exist in culture facilities. Disease is often the overt symptom of marginal culture conditions; control frequently consists of improving those conditions.

This brief review of highly selected aspects of the role of disease in management of cultivated marine fish and shellfish populations emphasizes only the following components of a very complex interaction of host, pathogen, and environment:

- disease control in extensive and intensive culture;
- variability in disease effects;
- disease control at different life history stages;
- long-term requirements for disease control;
- disease control by restricting transfers and introductions; and
- assessment of the significance of disease in marine aquaculture.

A principal message is that in the developing technology of marine aquaculture, the assurance of reasonable health of cultivated populations must be a major management objective.

Some Commonalities and Differences in Disease Control in Extensive Versus Intensive Culture

Marine aquaculture as it is practiced today can be artificially divided into *extensive aquaculture,* utilizing natural bodies of water, with only modest technological sophistication, with little environmental control, and with low growout densities, and *intensive aquaculture,* in artificial bodies of water (raceways, tanks, constructed ponds), with higher levels of environmental control, higher technology applications, and high growout densities. Extensive culture would include oyster culture, as conducted in many countries, and ocean ranching of shrimp and salmon. Intensive culture would include shrimp culture in large circular tanks (as used in Japan) and cage culture of salmon or yellowtail.

Considering only the disease control component in managing such systems, some factors are common to both types, and some are unique to one or the other (Table 1). A healthy seed stock, adequate nutrition, prophylactic immunization of fish (particularly against vibriosis), good water quality, and early recognition and diagnosis of disease problems are control ingredients of universal application in any kind of system. Extensive culture methodology also includes environmental or stock manipulation (moving oysters to low salinities to reduce effects of particular pathogens, for example), and the necessity for quarantine and disease inspection of non-endemic animals being considered for introduction into natural waters. Intensive culture, on the other hand, can take advantage of chemoprophylaxis and chemotherapy not feasible in extensive systems, and must be concerned continuously with stress reduction (in the form of maintenance of adequate water quality, nutrition, and population density in particular).

Figures 1 and 2 visualize the principal components of disease control programs in both types of culture systems.

Variability in Disease Effects on Cultivated Marine Populations

The phenomenon that we call "disease" in a cultivated fish or shellfish population represents a dynamic interactive complex of processes. These include, but are not limited to, whether the pathogen is primary or facultative; whether its infectivity and virulence are high or low; what the level of resistance of the host population is; whether recovered individuals act as carriers of infection; what reservoir hosts exist; and what environmental barriers to the spread of infection exist. Translated into effects on cultured populations, a particular disease may produce (1) a low (and usually tolerable) continuous background mortality; or (2) a moderate peak of mortality, after which the population is resistant; or (3) a sharp increase in mortality

Tablel. Principal elements of a disease control program in marine aquaculture

Extensive culture	Intensive culture
• Healthy seed stock	• Healthy seed stock
• Adequate nutrition	• Adequate nutrition
• Prophylactic immunization (fish)	• Prophylactic immunization (fish)
• Good water quality	• good water quality
• Early recognition of a problem and diagnosis of its cause	• Early recognition of a problem and diagnosis of its cause
• Environmental/stock manipulation	
• Control of transfers and introductions	
	• Chemoprophylaxis and chemotherapy
	• Stress reduction

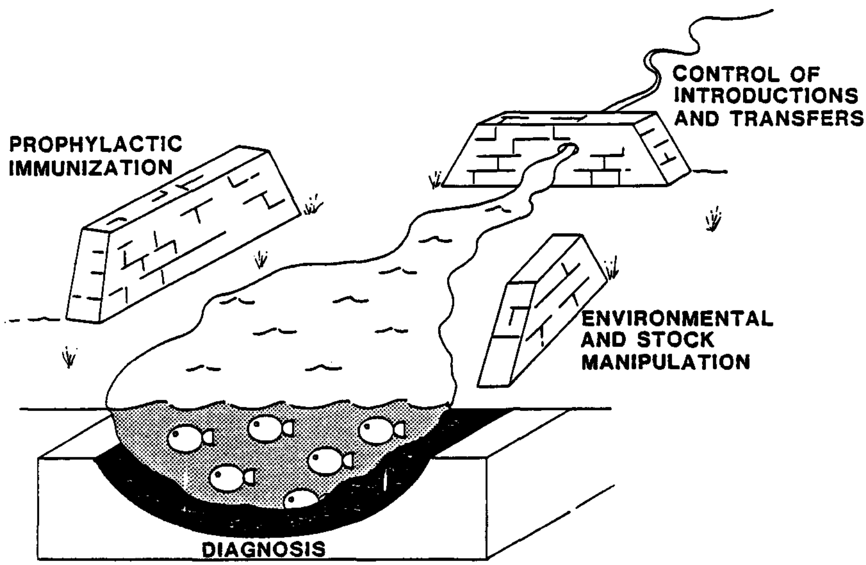


Figure 1. Disease control in extensive marine aquaculture.

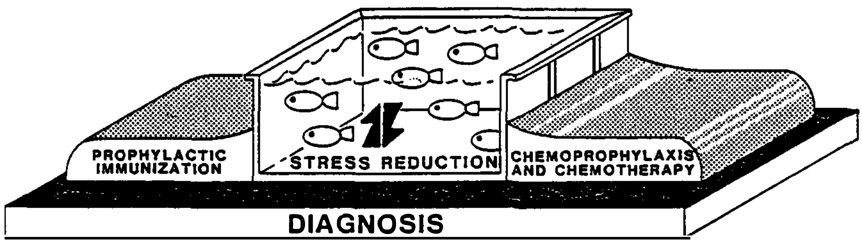


Figure 2. Disease control in intensive marine aquaculture (modified from Sindermann 1984)

(usually the loss of a significant part of the population) (Figure 3). Often, too, several concomitant diseases may produce low background mortalities; these may be masked by an epizootic caused by one of the pathogens, or by a different pathogen.

Faced with this array of possible effects, management strategies will vary with the extent of impact on the cultured population—usually assessed as the percentage of individuals that can be extracted by disease from the population daily and still make a profit. If the effect is small, the producer will usually decide to live with the disease; if the effect is moderate, the producer will invest modestly in disease control; if the effect is catastrophic, caused by an epizootic, panic results, but the damage has usually been done.

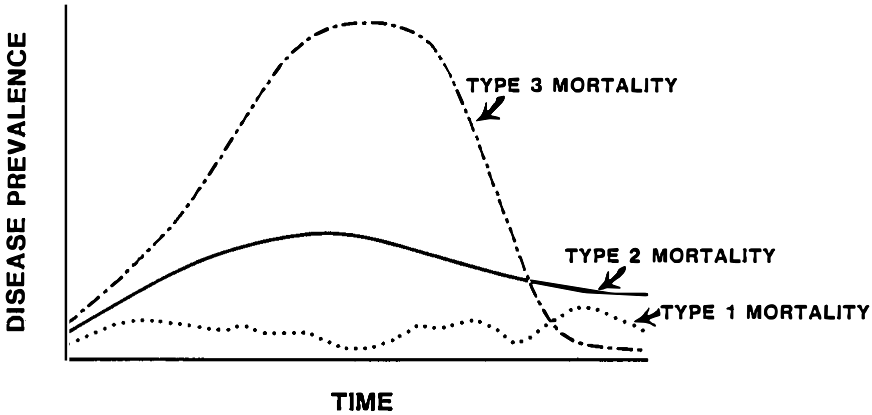


Figure 3. Disease effects on cultured populations

Disease Control at Different Life History Stages of Cultured Animals

An important but often overlooked truism in disease mangement of cultured animals is that the problems and the control strategies may be drastically different at each life history stage, from egg to adult (Table 2). This is in part because different pathogens may be involved, and in part because the extent of investment in and value of the animal increases with increasing age. Eggs and larvae of many marine species are usually available in quantity, but their *quality* must be maintained by investment in expensive equipment and careful environmental control—otherwise the entire subsequent history of the cohort may be characterized by lingering difficulties (slow growth, abnormalities, higher than average mortality rates). Poor culture conditions may encourage outbreaks of facultative pathogens such as vibrios in larval populations, often accompanied by extensive mortalities. Frequently, if production schedules can tolerate it, the method of choice in dealing with a "problem batch" of larvae is to discard it and start fresh, since the investment to that point has been relatively low.

Post-larval and juvenile populations may also be subject to epizootics and mass mortalities, but nutritional deficiency diseases and chronic diseases producing low but continuous mortalities emerge as additional problems. This combination of acute and chronic diseases persists right up to market size.

A new disease factor enters with management of brood stocks—the presence, often in latent form, of infectious diseases which may be transmitted vertically through eggs. This can be a particular problem with some viral diseases (such as that caused by Infectious Hematopoietic Necrosis Virus—IHNV—in salmon) (Pilcher and Fryer 1980), and also some of the bacterial diseases (such as bacterial kidney disease of salmon) (Fryer and Sanders 1981).

Long-Term Requirements for Disease Control in Marine Aquaculture

Principal technological requirements for marine aquaculture are adequate nutrition, maintenance of good water quality, efficient system engineering, genetic

Table 2. Disease problems related to life history stages.

Culture phases	Principal disease problems
Seed stock (eggs and larvae)	Epizootic microbial diseases of larvae. Facultative pathogens enhanced by poor culture conditions.
Growout (post-larvae)	Epizootics of frank pathogens. Nutritional deficiency diseases. Chronic diseases producing slow growth and low mortalities.
Market sizes	Epizootics of frank pathogens. Chronic diseases producing slow growth and low mortalities.
Brood stock (spawning adults)	Chronic diseases leading to low continuous mortality. Pathogens which may be transmitted vertically through eggs.

selection, and disease control. Of these, disease control can be among the most demanding, since new disease entities appear, and those already recognized must be controlled. Where culture has persisted for long enough—as, for example, in Japanese yellowtail culture—the pattern that has emerged is one of sequential appearance and spread of new diseases, often accompanied by significant mortalities until control methods are developed (Table 3). The new diseases may persist at epizootic levels for several years, and then subside to form part of background mortalities, especially if effective control methods are developed. Almost invariably, though, there are additional disease entities, some already enzootic in the population and some introduced from other areas, which may emerge as problems in marine aquaculture. The process appears to be unending, and calls for availability of unique expertise in pathology at times of crisis, to insure early diagnosis and development of control measures.

Sometimes,though, even when expertise is available, years of study may be needed to develop understanding of the pathogen, its method of transmission, its life cycle, and its environmental requirements. This has been the case with recent mortalities of oysters in France and United States, in which obscure but virulent protistan pathogens have been recognized as etiological agents (Grizel et al. 1974, Ford and Haskin 1981) Fortunately, even in the absence of adequate scientific information, empirical methods of stock and environmental manipulation can be and have been developed, which allow the industry to survive, even in the presence of epizootic disease. These methods—in the case of the oyster diseases mentioned—include delayed planting of seed until after the infectious period is past (France) or planting seed in low salinity areas where the pathogen will not multiply (United States).

Virus diseases of fish and shellfish present a particularly difficult problem. Since aquaculture provides opportunity for close observation of all life stages of selected aquatic animals, information about their virus diseases has increased enormously in the past decade. This is especially true of shrimp, crabs, oysters, salmon, and eels. It is likely that the virus diseases already recognized, and many others not yet recognized, exist in latent form in populations, and may be provoked into potency by stresses of the culture environment (abnormal temperature or oxygen levels, high

Table 3. Sequential appearance of microbial diseases of cultured yellowtail (after Egusa 1980).

Disease	1960	1965	1970	1975	1980	% of total losses (1978)
Vibriosis		1963 × × × × × × × × × × × × × × ×				5
Nocardiosis		1967 × × × × × × × × × × × ×				<1
Ichthyophoniasis		1967 × × × × × × × × × × × ×				<1
Pseudotuberculosis			1969 × × × × × × × × ×			28
Streptococcosis				1974 × × × × ×		63
Lymphocystis					1975 × × ×	<1

population densities). Control of virus diseases is difficult, particularly in marine populations. Immunization and chemotherapy are not effective, so it is particularly important that the etiological agents not be introduced into cultured populations or culture facilities from infected sources (for an example of the potential consequences of such actions, see Lightner et al. 1983). Control measures at present consist principally of viral eradication by destruction of infected stocks and sterilization of facilities.

Understanding diseases and limiting their effects are clearly long-term needs in marine aquaculture. The required technology does not appear quickly or inexpensively, but satisfying progress has been made in recent decades.

Disease Control by Restricting Transfers and Introductions

Aquaculture exploitation has been a principal motivation for the movement of fish and shellfish from one geographic area to another—even from one continent to another. One possible consequence of such transfers and introductions is the insertion of pathogens into new host populations in recipient areas.

Within the past decade there has been growing national and international concern about possible consequences of such movements. State natural resource managers, faced with the necessity to make decisions about shipments of fish and shellfish destined for waters under their control, have been sensitized to the possibility of spreading diseases, and have been forced into risk assessments. International organizations, such as the International Council for the Exploration of the Sea (ICES), have developed codes of standard practices, by which national authorities can make decisions about international shipments on some rational scientific basis, rather than on a purely economic one.

At present, treatments for many marine fish and shellfish diseases are unavailable. This is particularly the case for viral and protozoan diseases. Thus limiting the spread of pathogens through aquaculture practices is therefore of particular importance. Quarantine and inspection procedures, and politically insensitive policies and regulations about imports of live animals, can be major deterrents to dissemination of pathogens.

The history and consequences of movements of salmonids worldwide provide an excellent case history of disease dissemination with infected exports. The history includes negative examples of failure of barriers or absence of barriers, as well as positive examples of exclusion of pathogens by vigilance and enforcement of reasonable regulations. Failures include the spread of whirling disease of salmonids (caused by the protozoan *Myxosoma cerebralis)* from Europe to United States, and the introduction of Infectious Hematopoietic Necrosis Virus (IHNV) into Japan with salmon eggs from United States. Successes include the prevention of introduction of chum salmon virus to United States from Japan, and the exclusion (to the present time at least) of IHN virus from United States east coast salmon stocks.

Exclusionary practices should not, however, be too inflexible. Transfers and introductions for aquaculture purposes should be feasible, once adequate study has been made and risks assessed. Use of standard inspection protocols, possible quarantine provisions, and limited initial quantities of imports all provide a measure of assurance of reduced danger from the spread of disease. Figure 4 illustrates proposed steps in introducing a new species, following the ICES Code of Practice.

Assessment of the Significance of Disease in Marine Aquaculture

Accumulated evidence from oyster, shrimp, and salmon aquaculture demonstrates that disease-caused mortalities, and the necessity for disease control measures, are significant factors in evaluating profitability of any venture (Sindermann 1977). Some data exist, particularly for fresh-water species, about the costs of disease control. In United States federal salmonid fish hatcheries, for example, disease control costs have been estimated at 10-15 percent of total production costs, while several state hatcheries have estimated such costs at 20-30 percent. Mortalities due to disease, and the necessity for disease control measures, have been estimated at 25 percent of commercial production costs for rainbow trout, 10-25 percent for channel catfish, and 20-30 percent for shrimp.

Losses due to disease have been estimated in Japan (Kawatsu et al. 1976) for both freshwater and marine fish culture. Losses due to disease in 1973 in freshwater culture were estimated at about 5,800 tons (total harvest was 64,000 tons) and in marine culture at about 3,500 tons (total harvest in that year was 84,000 tons). These estimates are probably very conservative.

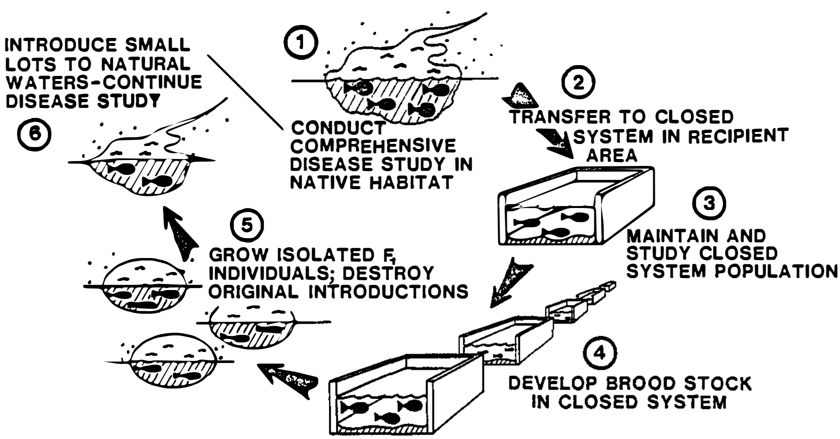


Figure 4. Proposed steps to reduce dangers of disease spread through introduction of nonindigenous species (from Sindermann 1984).

In addition to economic losses due to mortality, there are many control techniques which increase production costs:

- Disinfection of water by ultraviolet radiation, ozonization, or chlorination;
- Disinfection of holding facilities and equipment;
- Chemotherapeutic agents—used successively or alternatively to reduce likelihood of drug resistance—
- Vaccines; and
- Inspection and certification of eggs transferred from one geographic area to another.

A remarkably complete documentation of the effects of a single disease on oyster production was published recently by Haskin and Ford (1983). Their long-term study demonstrated that a disease of American oysters caused by the protozoan *Haplosporidium nelsoni* reduced production in one major area (Delaware Bay) by two-thirds, beginning in 1958, and has been responsible for suppression of the industry there since that time. High infection rates persist although recent mortalities have been only about half those recorded during the earlier epizootic peak. Stock manipulation—a shorter planting cycle in high salinity areas—and the development of disease resistance in surviving populations have allowed the industry to continue.

Conclusions: Some Implications of Disease in Management of Aquaculture Populations

Although it may seem a little unfair to other disciplines to isolate and emphasize disease control in aquaculture as a major technological objective, the reality is that the health of cultured animals must be a primary management concern. Once this mental hurdle is cleared and accepted as an operating principle, it becomes easy to construct a list of guidelines for disease management:

- Maintenance of animal health is a continuing struggle to control known agents and to diagnose and control new pathogens as they appear.
- Water quality maintenance and stress reduction should be principal foci of facility and population management actions, since disease is often a consequence of inattention to either or both of these factors.
- Disease control measures may vary significantly with life history stages, but are usually based on the triumvirate of diagnosis, prevention, and treatment.
- Disease control measures in extensive culture can be augmented by techniques of stock and environmental manipulation, and by attention to exclusionary principles based on attempts to understand the consequences of transfers or introductions of species from other geographic areas.
- Prophylactic immunization is emerging as a disease control method of choice in marine fish culture. Its present efficacy is with bacterial diseases such as vibriosis; its eventual utility may be much broader.
- Use of chemoprophylaxis and chemotherapy is feasible in intensive culture systems, but not as a substitute for good facility and population management practices. Chemotherapy should be considered a "last resort" method in disease control, if methods of prevention have failed, as was emphasized by Herman (1970) and Snieszko (1974).

This listing of management principles or operational guidelines could get extensive. Disease problems are important in aquaculture production, and effective control is a requirement for economic viability.

Literature Cited

Egusa, S. 1980. Disease problems in Japanese yellowtail, *Seriola quinqueradiata,* culture: a review. ICES, Special meeting on diseases of commercially important marine fish and shellfish, Copenhagen. Doc. No. 9. 20 pp.

Ford, S. E., and H. H. Haskin. 1982. History and epizootiology of *Haplosporidium nelsoni* (MSX), an oyster pathogen in Delaware Bay, 1957-1980. J. Invert. Pathol. 40: 118-141.

Fryer, J. L. , and J. E. Sanders. 1981. Bacterial kidney disease of salmonid fish. Ann. Rev. Microbiol. 35: 273-298.

Grizel, H., M. Comps, J. R. Bonami, F. Cousserans, J. -L. Duthoit, and M. A. Le Pennec. 1974. Recherche sur l'agent de la maladie de la glande digestive de *Ostrea edulis* Linné. Sci. Peche, Bull, Inst. Peches marit. No. 240. pp. 7-29.

Haskin, H. H., and S. E. Ford. 1983. Quantitiative effects of MSX disease *(Haplosporidium nelsoni)* on production of the New Jersey oyster beds in Delaware Bay, U. S. A. ICES, Doc. CM1983/Gen:7/Mini-Symp. 21 pp.

Herman, R. L. 1970. Prevention and control of fish diseases in hatcheries. Pages 3-15 *in* S. F. Snieszko, ed. A symposium on diseases of fishes and shellfishes. Spec. Publ. No. 5. Amer. Fish. Soc., Washington, D. C. 526 pp.

Kawatsu, H., A. Honma, and K. Kawaguchi. 1976. Epidemic fish diseases and their control in Japan. FAO Tech. Conf. Aquaculture, Doc. FIR:AQ/76/E:39, 7 pp.

Lightner, D. V., R. M. Redman, and T. A. Bell. 1983. Infectious hypodermal and hematopoietic necrosis, a newly recognized virus disease of penaeid shrimp. J. Invertebr. Pathol. 42: 62-70.

Pilcher, K. S., and J. L. Fryer. 1980. The viral diseases of fish: a review through 1978. Part 1. Diseases of proven viral etiology. C. R. C. Press 7: 187-364.

Sindermann, C., ed. 1977. Disease diagnosis and control in North American marine aquaculture. Elsevier, New York. 329 pp.

_____. 1984. Disease in marine aquaculture. Helgolander Meeresunters. 37: 505-532.

Snieszko, S. F. 1974. The effects of environmental stress on outbreaks of infectious diseases of fishes. J. Fish. Biol. 6:197-208.

Role of Diseases in Marine Fisheries Managment

E. Spencer Garrett
NMFS, National Seafood Inspection Laboratory
Pascagoula, MS 39567

It has been estimated that living marine resources contribute approximately 15 billion dollars annually to the economy through commercial and recreational fishing activities, imports, exports, and joint ventures. It serves as an international bargaining tool, employs over 300,000 people, provides recreational benefits for over 35 million people, supplies 16 pounds (7.2kg) of nutritious food annually per capita, and provides a sole way of life for many individuals and small coastal communities (National Marine Fisheries Service 1985).

The extractive uses of the living marine resources involve a broad range of activities and interests that generally fall under two needs—supplying food and/or providing recreation, including aesthetic benefits. Those who use the living marine resource normally have "expectations" that fall into two seemingly different categories: (1) the continued use of the living marine resource within the constraints of ecological balance, and (2) the actual realization of benefits, such as profits and nutrition, from resource use. An overall desire of individuals and groups within the private sector is to use living marine resources for a profit, while the public expects that the resource is renewable and should be wisely used for the common good.

We in the National Marine Fisheries Service understand these needs, and, in fulfilling our agency mission of conservation and wise use of living marine resources, often find ourselves balancing the expectations of public trust and private interests in those resources. These public and private interests may appear antagonistic, but in fact they are complimentary. For example, public sector expectations are that the marine environment and living marine resources should not be subjected to excessive exploitation or other action that may jeopardize its continued use and that appropriate conservation be conducted to assure the resource's viability while allowing optimal extractive use for the common good. These public concerns are really no different from the private interest expectation of a constant fishery supply and a stable economic climate for continuing raw material acquisition. Obviously, both the public and private interests want access to a resource that is safe for consumption. While motivations may differ, the public/private expectations from living marine resources are decidedly similar and, as such, provide the basis for management of these resources, as has been demonstrated recently through the creation and efforts of the regional Fishery Management Councils by passage of the Fishery Conservation Zone Management Act. Though these regional councils have developed fishery management plans which focus more toward identifying biological considerations for optimum sustainable yield, they do have the legal authority to address product safety issues.

By way of definition, public health protection deals with only one aspect of consumer safety and, for purposes of this discussion, will be limited to protection provided for animal proteins including fishery products intended for human consumption. Both federal and state organizations provide consumer protection in the consumption of animal and marine proteins, although the philosophical approach to each may differ. For example, the public health organizational and programmatic aspects of land-based animal food products are extensive with well-defined reporting systems and are fairly well coordinated at the national level by the U.S. Department of Agriculture. This program starts at the farm level with veterinarians who are involved with state livestock sanitary boards and animal health agencies located within each state. As the animals move from production centers to slaughterhouses and food plants, the animal health surveillance system is integrated into a formalized State/Federal Mandatory Inspection Program to ensure reasonable consumer protection by prohibiting suspect or violative products to be introduced into commerce. Complimenting this consumer protection activity are numerous technical and scientific support facilities with well-equipped and staffed diagnostic laboratories capable of examining animal disease in depth, as well as public health laboratories at the state level which process samples and reports from sanitarians at the county and municipal level. In effect then, land-based animal resources are managed for animal health and human health purposes through a formal broad scale program which integrates animal and public health disciplines (Fields 1977). This type of program evolved by a national policy recognition that (1) land-based animal production is food oriented, and (2) in the case of warm blooded animals, there are certain etiological disease agents that are directly transmitted to humans, necessitating elaborate animal health and subsequent product inspection systems. These logical combinations of animal and human health integrations have been well recognized by congress and have received modern legislative support, most recently through the passage of the Wholesome Meat and Poultry Acts of 1967 and 1968.

Such is not the case with fish and fishery products. In 1938, congress passed the Food and Drug Act, the original and sole legislative act for mandatory surveillance of fishery products. Prior to 1940, both meat inspection activities and food and drug activities were under USDA jurisdiction. During that year all foods with less than 2 percent meat or poultry flesh were transferred to what is now known as the Food and Drug Administration, and meat and poultry activities remained in USDA to be subject to subsequent integrated growth. In terms of legislation relating strictly to mandatory surveillance of fishery products, the most recent is the Food and Drug Act of 1938 as amended.

That legislation was augmented by the creation of a voluntary fishery products inspection program with the passage of the Agricultural Marketing Act of 1946. That act was focused primarily toward developing voluntary U.S. grade standards and inplant product inspections as a marketing tool to allow processors to use U.S. inspection and grading marks on fishery packages as one way to promote their products as safe, wholesome, and of high quality. In addition to being a voluntary program, that activity was also a fee for service program; that is, the participating processors had to pay for the federal inspection and grading services, a funding concept which is currently receiving renewed political interest. The program was transferred to the Bureau of Commercial Fisheries with the passage of the Fish and Wildlife Act of 1956, and subsequently to NOAA in the U.S. Department of Commerce with Executive Reorganization Plan Number Four of 1970.

Another fisheries surveillance program began in 1926 and was augmented with the passage of the Public Health Services Act of 1946. This was an industry/state/federal program specifically aimed at reducing the prevalance of bacterial disease, particularly Salmonellosis, from the consumption of contaminated raw molluscan shellfish. In terms of consumer protection relative to fisheries, this was the first program that recognized the role of fishery management as a component in preventing potentially hazardous products from reaching consumers by implementing fishery management prohibitions of harvesting shellfish from suspected contaminated waters. In the late 1950s and early 1960s, this program gained wide acceptance by the participating coastal states, FDA, and industry. At one point it had over 1,000 personnel utilizing 50 labs, 500 boats, and 8 planes participating in some aspect of growing water classifications, shoreline sanitary surverys, patrol of harvest areas, plant inspections, and product evaluations. This former cooperative program was known as the National Shellfish Sanitation Program (NSSP). Unfortunately, this program collapsed due to several weaknesses too detailed to fully discuss here. Increased urbanization of the coastal zone, failure to incorporate changes in contemporary scientific understandings on the role of microbiological standards and acceptance sampling plans, and lack of both uniform enforcement procedures and strict penalties for program violators are among the paramount reasons for the NSSP's demise. That program is currently being revised and modified by the creation of the Interstate Shellfish Sanitation Conference (ISSC) whose purpose, among other things, is to foster and improve shellfish sanitation. This is a new organization, modeled after the Interstate Milk Shippers Conference, that will take some time to become totally effective. During all of this time, still another federal agency was examining and inspecting fishery products—the Department of Defense (DOD). The DOD is one of the largest institutional purchasers of foods in this country, requiring in-plant inspections for fishery products similar to USDA inspections for red meat. In 1977, the Department of Commerce Inspection Program assumed the DOD inspection responsibilities for fishery products with USDA assuming the DOD inspection role for animal proteins.

Therefore, for land-based animal products there is a well established, logical approach to providing consumer protection, which links animal health and human health considerations into what amounts to a resource management scheme under the jurisdiction of a single federal agency cooperating with the states to provide reasonable public health protection in the consumption of redmeat and poultry products. For fresh water and marine animals, such is simply not the case. Rather, retrospection reveals a haphazard evolution of human health philosophies and approaches that give the appearance of a disjointed kaleidoscopic focus by a multiplicity of federal and state agencies developing different standards and compliance schemes based upon antiquated legislative mandates or authorities. Surely it's time for a change, time for a new look at the total problem using contemporary understandings on the interwoven role that animal health and human health considerations play in consumer protection. A complete plan is needed which both provides for public consumption of safe and wholesome products and results in better and more efficient livestock production techniques. One need only to look at the success of USDA in organizing and implementing cooperative programs in resource management and consumer protection to see what can be done given the industry perceived need and legislative mandate.

Lacking that philosophical recognition, about all that any of us in fishery science can do is to continue to use our good science to provide adequate answers to the information needs of our constituents, be they resource managers, public health authorities or seafood industry members attempting either to establish marketing strategies in a developing fishery or maintaining markets in an established fishery.

The question of a product's safety for human consumption is a primary determinant to its marketability. The lack of safety in a product is the result of any or all of four hazards: (1) environmental natural hazards, such as the presence of ciguatoxin in some reef fishes, (2) environmental manmade hazards, such as pesticides, heavy metals, and PCBs, (3) process-induced hazards, where the processing technology used is either inadequate itself, or is inadequately applied, such as the outgrowth of botulinum in canned fish, and (4) marketing/distribution induced hazards, such as improper handling practices, particulary inadequate storage temperatures, which can quickly render a product unsafe. Situations where products on the marketplace have been found to be unsafe are usually of disastrous consequence to the segment of the industry involved and frequently to the industry as a whole—witness the mercury scare of several years ago. Generally, the seafood industry does not have the expertise nor the resources to provide the research information or analytical capability necessary to avert or recoup from such situations, and necessarily relies on government to provide such. It is also important to recognize that the common property nature of the resource itself is a principal limiting factor on industry ability or desire to invest in such research.

The need for a new look in consumer protection in fishery products may be illustrated by discussing some recent foodborne outbreaks of disease. During the four year period of 1978-1981, there was a total of 2,114 foodborne outbreaks of disease reported to the Center for Disease Control. Of this, the vast majority (61 percent) was attributed to unknown vehicles, 8 percent to red meat, 4 percent to poultry, and 9 percent to fishery products (Center for Disease Control 1981-1983). The significance of these figures assumes added importance when we compare them to the 1983 per capita consumption rates for such products, i.e., red meat 179.2 lbs. (81.3kg), poultry 65.5 lbs. (29.7kg.), and fishery products 16 lbs. (7.2 kg) (National Marine Fisheries Service 1984).

In addition, analysis of the etiological agents associated with foodborne outbreaks of disease attributable to fishery products during the same 1978-81 time frame shows that of the 192 reported outbreaks, 73 percent are due to finfish, with 93 percent of those due to chemical causes (scombrotoxin or ciguatoxin) and 27 percent attributed to shellfish (most of it molluscan), with the vast majority being of bacterial or viral etiology. Simply, progressive fishery management techniques, which examine the cause of these diseases and prohibit the harvest of these affected resources where necessary can go a long way toward resolving public health issues dealing with fishery products.

Finally, the following is an attempt to end on a positive note. Since the mid-1960s, there have been numerous legislative proposals calling for the mandatory federal inspection of fish and fishery products, based upon the concepts employed by USDA for animal proteins. These proposals have failed primarily for two reasons: (1) they did not have industry support, and (2) their cost appeared prohibitive. The industry resistance is changing, and under our current administration the program cost may be switched to the users, with user acceptance.

Literature Cited

Center for Disease Control 1981-1983. Foodborne disease outbreaks annual summaries 1978-1981. Issued February 1981, April 1981, February 1983, and June 1983.

Fields, F. R. 1977. Public health constraints on food production from the sea. Presented at Fifth Food-Drugs from the Sea Conference, University of Oklahoma, Norman, OK. September, 1977. 7 pp.

National Marine Fisheries Service. National Fishery Statistics Program. 1984. Fisheries of the United States, 1983. Current Fishery Statistics No. 8320. NMFS, Washington, D.C. 121 pp.

National Marine Fisheries Service. Office of Utilization Research. 1985. The future direction of product quality and safety research in NOAA/NMFS. Washington, D.C. February, 1985. 12 pp.

Disease Organisms, Economics and the Management of Fisheries

Ivar E. Strand
University of Maryland
College Park, MD 20742

Douglas W. Lipton
National Marine Fisheries Service
Washington, D.C. 20235

Introduction

Disease organisms can dramatically alter economic conditions in food producing industries. Recent examples include dramatic fluctuations in egg prices caused by an outbreak of avian flu in Maryland's laying-hen flocks and in citrus prices due to a citrus canker outbreak in Florida. The seafood industry is no exception. One need only observe the recent situation in Maryland oyster production. Oyster spat fall in 1980 was nearly the highest on record, leading to expectations of a boom 1983-84 harvest. Emphasis in research was reoriented from harvest augmentation to marketing and promotion. A protozoan, MSX (*Haplosporidium nelsoni*), infected the oyster stock and destroyed those expectations. Instead of a boom, the 1983-84 Maryland oyster harvest fell below one million bushels, one of the lowest on record.

Increased mortality, as was experienced by the oyster resource, has the clearest impact on the fishing industry, but the subtlety of other impacts should not mask them from our view. Sindermann (1977) offers a pathologist's view of the range of potential economic influences:

> Economic effects of disease in marine fishes may be categorized as reduction in numbers of food fish available to the fishery; weight loss by diseased individuals; rejection of abnormal fish by consumers, and subsequent loss of interest in fishery products as food; (p. 315).

While the Sindermann categorization is quite useful, greater examination of producer and consumer behavior in the presence of disease organisms may prove beneficial.

In this paper, we will explore some of the ways that disease organisms can affect the economic welfare of the fishing industry and consumers of fish. For this study, disease organisms are defined very broadly to include parasites for which fish may act only as a passive host and microorganisms which alter the quality of fish. The first section is a theoretical discussion of how disease affects the supply-side of the market in a deterministic and then a stochastic framework. Examples of lost production and revenues are presented. We emphasize that lost revenues are not particularly useful measures of monetary losses to the industry. This is followed by an explanation of how economists derive monetary estimates of disease-related losses to the producers and consumers of fishery products. The MSX outbreak in the Virginia oyster fishery serves to illustrate our point. The next section deals with the effects of disease organisms on consumer demand. We follow with a discussion of how the understanding of waterborne organisms can improve the welfare of seafood producers and consumers. The final section contains a discussion of the implications of disease organisms for fisheries management.

Effects of Disease on Fish Supply

Fishermen are faced with a number of short and long-term decisions, which when totaled, result in an industry level of effort and harvest. These decisions include how much labor to apply within a season, and how much capital (e.g., vessel, gear, etc.) to invest or disinvest. There are also individuals who are determining whether to switch from another fishery or occupation, into the fishery of interest. The ultimate decisions depend on economic conditions, which themselves are affected by the population dynamics of the fishery in question. In this section, we explore how disease affects the population dynamics of a fishery and in turn, how this affects fishermen's behavior.

Disease is a direct and major cause of fish mortality. In the 1950s, MSX on planted oyster grounds resulted in 90-95 percent cumulative mortality in Delaware Bay (Ford and Haskin 1982). High oyster mortality from MSX was observed in the early 1960s in the Chesapeake Bay (Haven et al. 1978). *Ichthyophonus*, a disease common to finfish led to a cumulative mortality of 55 percent of plaice in Scottish waters (McVicar 1981), and 50 percent of Gulf of St. Lawrence herring (Tibbo and Graham 1963). Clearly, the presence of disease reduces fishery stocks and hence, production. Table 1 lists some estimated mortalities associated with fish diseases.

Disease organisms can also decrease fish stock size and growth from causes other than direct mortality. Whiting infected with copepod parasites, *Clavella uncinata* and *Lernaeocera branchialis,* experienced significant weight reduction when compared with non-parasitized fish (Van den Broek 1978). *Ichthyophonus* will also lead to emaciation (McVicar 1982). The resulting decreased muscle efficiency makes these fish more susceptible to predation mortality. This was demonstrated indirectly in a 1955-1956 *Ichthyophonus* outbreak in herring that was accompanied by an increase in cod growth, presumably due to the availability of infected herring as prey (Tibbo and Graham 1963). Haddock infected with a coccidian parasite (*Eimeria gadi*) affecting the swim bladder were more suceptible to predation mortality (Odense and Logan 1976). The dysfunction of the swim bladder also prevented the haddock from spawning.

Vaughn et al. (1984) demonstrate how to incorporate disease-related stress into deterministic fishery models. The models range from the simple aggregate surplus production function attributed to Schaefer (1957), to complex bioenergetic models. In the surplus production model, the intrinsic population growth rate parameter can serve to aggregate both the direct mortality and indirect effects of disease on all age classes of the population dynamic processes (i.e., growth, reproduction, etc.).

We will use this simple model to show the intertemporal effects of disease on the fishery. In addition to the biological model, we introduce a fishery investment sector following Smith (1968). The investment sector is characterized by open access. The bioeconomic model then includes a capital stock based on profits and a resource stock based on initial stock and net growth (growth-harvest). A steady-state equilibrium occurs where the level of fishing effort is such that there is no net population growth of fish and no net capital investment in the fishery. No net population growth requires that the harvest level be equal to the natural rate of growth of the

Table 1. Summary of prevalence and mortalities of selected fish diseases.

Disease	Species affected	Location	Prevalence[a]	Mortality Rate[a]	Years	Source
MSX	Oyster	Chesapeake Bay (VA)	0-80%	>50%	1964-1966	Andrews (1968)
		Chesapeake Bay (MD)	4-70%	2-55%	1961-1968	Farley (1975)
		Delaware Bay		37%	1958-1982	Haskin and Ford (1973)
Dermocystidium	Oyster	Chesapeake Bay (VA)	70-90%	17-22%	1952	Haven et al. (1978)
SSO (*Minchinia costalis)*	Oyster	VA Eastern Shore	NA[b]	12-44%	1959-1960	Andrews (1968)
Marteilia refringens & Bonamia ostreae	*Ostrea edulis* (Flat oysters)	Brittany	NA	70-90% 80-90%	1970-1976 1980-1982	Grizel (1983)
Ichthyophonus	Plaice	Scotland	2-12%;85%	NA	1976-1980	McVicar (1980)
	Haddock	Scotland	<25%	NA	1976-1980	
	Herring	Gulf of St. Lawrence	NA	50%	1954-1956	Tibbo & Graham (1963)
Blackmat syndrome	Tanner crab	Gulf of Alaska	0-60% (in males)	NA	1981-1982	Hicks (1982)
Eimeria gadi	Haddock	Nova Scotia	32%	NA	1973-1974	Odense and Logan (1976)
Lernaeocera branchiahs	Whiting	Medway estuary	40.4%	NA	1973-1975	Van den Broek (1978)
Vibriosis	Saithe	Norway	NA	NA	NA	Munro et al. (1983)

[a]See source for selected area sampled.
[b]NA = not available.

fish stock. No net investment in the fishery requires that profits resulting from additional investment in the fishery are zero. The bioeconomic equilibrium is denoted as point A in the phase diagram of Figure 1. In this diagram, X is stock size and K is the amount of capital in the industry. The parabola, $F(X,K) = O$, is the combination of X and K at which there is no net growth in the fish population. The function, $I(X,K) = O$, is the combination of X and K where there is no net investment in the fishery. The intersection of these curves at point A is the stable equilibrium point where both these conditions are satisfied. The point of intersection will vary depending on fish prices and fishing costs (Clark 1976).

Our diagram, although not unrealistic, represents a stylized analysis which must be adapted to the particulars of the fishery. Biological quirks, cultural inertia, and institutional anomalies are among the realities which must be recognized when examining a specific disease outbreak. Thus, most disease outbreaks will reduce the biological capacity of the fishery. The degree to which the disease influences the fishing sector depends, in part, on these other factors. With the simple model in hand, we move on to discuss typical variation of it.

Enzootics

Consider first an introduction of disease into the fishery which alters the biological growth characteristics in a constant intertemporal manner. The "long-run" biological effect is seen in Figure 1 as a shift in the biological equilibria from $F_o(X, K)$ to $F_l(X, K)$. The immediate effect of the disease is to reduce fish stock, causing profits to fall and reducing capital. The movement from equilibrium A to A' is

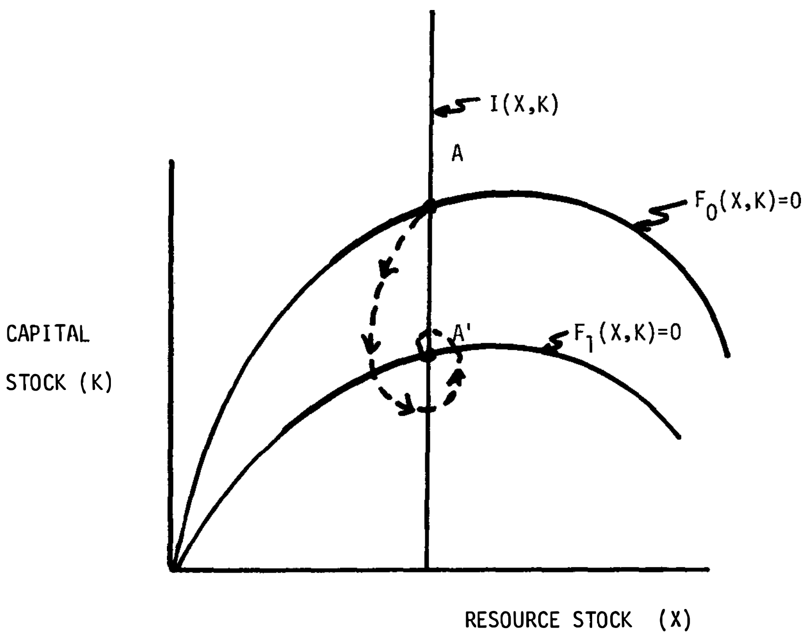


Figure 1. Capital and fish stock movements following permanent introduction of disease.

shown as the dashed line with arrows. The harvest (shown in Figure 2) drops from A to A' after cycling. The periodicity of the cycle is a function of reaction speed of the fish and investors. The quicker the reaction, the tighter is the dashed path and the shorter the period of the cycle.

The above analysis assumed that capital is perfectly malleable so that disinvestment can occur as easily as investment. Bockstael and Opaluch (1983) demonstrated that there may be non-monetary (e.g., cultural) costs in disinvesting from one fishery and investing in another, or out of fishing altogether. Thus, when the disease first occurs to reduce the population to point A', some fishermen may decide to "stick it out," and not disinvest or switch fisheries. If this occurs, the harvest rate may continue to exceed the population growth rate, so that the population declines even further. At the lower population size, profits will continue to decline, eventually below the threshold that was necessary to keep the fishermen in the fishery. Disinvestment finally occurs but, because the resource is so depleted, the time to reach a new equilibrium is lengthened.

Epizootics

Seldom is the disease introduction as simple as depicted above. Immunity, natural selection, and varying environmental conditions can cause diseases to occur during narrow windows of time and sporadically. The MSX and *Ichthyophonus* outbreaks discussed earlier represent such behavior. Sindermann (1956) found that since 1900, North Atlantic herring stocks had experienced six major 1-3 year epidemics of *Ichthyophonus*. The prevalence of the disease was 25 percent during the epidemics and 1 percent in intervening years. MSX in Delaware Bay appears to follow 6-8 year cycles of prevalence, but not in Chesapeake Bay (Ford and Haskin 1982).

Sporadic epidemics can be represented as a series of movements of the biological growth function. An outbreak is seen to shift the function downward (like $F_i(X,K)$ in Figure 1) for a period of time. Once the disease population has run its course, the growth function returns to its original potential, say $F_o(X, K)$. The time path of harvests now depends not only on the "natural" biology of the host and economic

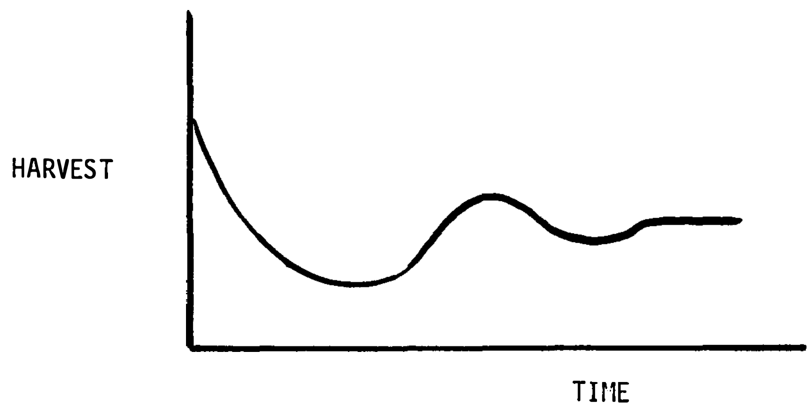


Figure 2. Time path of harvest following disease introduction.

response of the industry but also on the population dynamics of the disease organism. We offer a possible time path of harvest in Figure 3. The illustrated time path shows harvest rising above the initial harvest level. This can occur when the resource population is building rapidly and the investment has not yet responded to the favorable condition. Investment eventually catches up and returns stocks and harvests to the original levels.

Disease and Uncertainty

Thus far, the discussion has been couched in a world in which the investors make myopic decisions based on the level of profits received at one point in time. Clearly, this is a simplification (see Berck and Perloff [1983] for a more complex model). Most investment analysis suggests that investors not only consider the current level of profit but also the amount of fluctuation in profits over time. Investors are considered to be risk-averse, preferring low variation in profit to high variation.

In Figures 2 and 3, we see that the disease has introduced not only lower catches but also greater fluctuation in catches. Implicit in these harvest fluctuations are fluctuations in profit. Thus, the introduction of disease, at least in our model, introduces greater fluctuations in the economic environment.

Although it is difficult to obtain good cost/profit information, we believe disease organisms also introduce uncertainty in existing fisheries. A disease such as vibriosis, for example, may affect fish so rapidly that the disease is not detected, although significant mortalities have occurred (Munro et al. 1983). The sudden appearance of an unidentified fungal disease at high prevalence rates in some North Carolina and Virginia-caught menhaden is an excellent current example of disease-related uncertainty.[1] Lesions indicative of the disease have been found mainly on young-of-the year menhaden. The industry is unsure how this disease will affect recruitment to the offshore fishery one or two years hence. The industry would be in a better position to plan their investments if they had projections of recruitment. These examples demonstrate that, at least in some species, disease may be a significant contributor to the variability of the stock size, and the uncertainty of fishermen and investors.

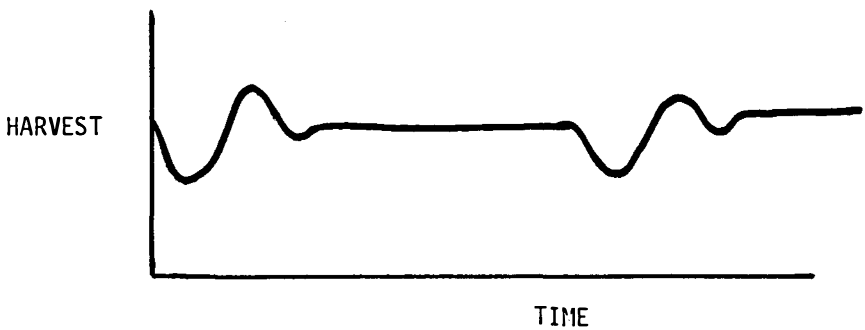


Figure 3. Harvest time path for an epizootic.

[1]Personal communication, Dr. J. V. Merriner, NMFS, Beaufort Lab., N.C.

The studies of fishing under uncertainty are extensions of the deterministic model presented earlier.[2] This model is modified to incorporate a stochastic element in stock growth over time. Assuming that fishermen and investors in fishing are risk-averse, they would be willing to invest more in a fishery where the stock size was known with certainty than another fishery with the same average stock size, but where the stock size varies from year to year due to disease.[3] Thus, the level of investment is less in the stock with disease. The corresponding harvest is smaller, providing harvest is not being exploited beyond maximum sustainable yield (MSY). If it is beyond MSV, then the presence of disease strangely enough increases the harvest level.

Another change in fishing behavior brought on by the presence of uncertainty in the stock size is that of risk-spreading. This is manifested by fishermen investing in the appropriate gear to allow them to switch to other fisheries when a disease outbreak occurs in the primary fishery. It is a characteristic of many inshore fisheries.

Disease in a Closed Access Fishery

The discussion of open access fishing is not always appropriate. Many capture fisheries and aquaculture have characteristics which alter some of our previous arguments. Whereas fishermen in open access have little incentive to defer production, those in a closed access fishery may actually allow or be forced to defer current harvest with the expectation of returns in future harvest. However, when the uncertainty of mortality from disease increases, these fishermen and managers have an incentive to allow more harvest, as well as catching smaller, faster growing fish. This behavior is demonstrated by the change in harvesting strategy of Delaware oystermen in response to MSX (Haskin and Ford 1983). These oystermen reduced the marketing age of oyster to allow only one summer's growth. This permits harvest before MSX related morality could occur. Plantings were also made in new areas where conditions resulted in poor growth, but were free of MSX. In France, shifting from the flat oyster (*Ostrea edulis*) to another variety (*Crassostrea Gigus*) occurred following disease outbreaks (Grizel 1983).

In many instances, the closed access fishery leads to greater problems of disease. If "farming" is practiced, greater density of stock is likely to occur. The increased density itself may lead to greater risk of disease and to its rapid transmission. Examples of outbreaks in closed access situations include salmon culture (Eklund et. al 1984), live lobster marketing (Stewart et at. 1975) and blue crab shedding operations (Newman and Ward 1973).

Another potential source of disease in closed access systems is the introduction of disease through "exotics." With open access, no one has an economic incentive to introduce new varieties. In closed access, there are potential returns from introducing new, high yielding varieties. Unfortunately, there are possible dramatic losses, especially in areas where newly introduced disease organisms can be easily transmitted (by the water column) among the "farmed" stocks. Oyster culture in Brittany,

[2]See for example: Smith (1980), Dudley and Waugh (1980), Andersen (1982), Bockstael and Opaluch (1983), Andersen and Sutinen (1984), Ploude and Bodell (1984), and Yohe(1984).

[3]It has been shown empirically that New England fishermen are on average risk averse (Bockstael and Opaluch 1983).

France, is reported to have introduced several disease organisms (Grizel 1983) from importation of a Japanese and North American oysters.

Revenue Losses

A few studies which discuss the economic effects of fish disease usually measure these effects by losses in total revenue. Sieling (1971) estimated that Delaware Bay losses due to MSX totaled $3 million per year in lost revenue. He showed, however, that in Virginia and Maryland, the lower production due to MSX was offset by higher dockside prices. Total revenues in Virginia were unaffected, while revenues in Maryland actually increased. Oyster disease in Brittany lowered revenues from *Ostrea edulis* culture from 131.6 million francs to 65.2 million francs (Grizel 1983). This loss was somewhat offset by increased culture of *Crassostrea angulatus*. The industry use of labor declined from 742 thousand man-hours to 492 thousand man-hours.

An Illustration of Profit Losses

While the lost revenues associated with disease outbreaks are somewhat indicative of the lost profits to producers, they are by no means a precise measure. As has been documented (Haskin and Ford 1983), producers can shift to production of other items to offset their losses. Moreover, many costs are directly related to production levels. As production and revenues fall, so do costs. Thus, lost revenues from harvest, at best, represent the worst possible losses to the harvesting sector. Most often these are not the only lost profits from the disease.

To illustrate this point, we explore the events surrounding the initial outbreak of MSX in the Chesapeake Bay. Beginning in Virginia's 1959-60 oyster season, MSX began causing mortality in adult oysters. Mortalities ranged from 20 percent in the first year to over 50 percent in later years (Andrews 1968). By the end of the 1966-67 season, mortality from MSX stabilized and in some areas of Chesapeake Bay, oysters showed signs of resistance (Farley 1975). Using commercial data provided in Haven et al. (1977), we derive estimates of lost profits and behavioral changes for this period. These numbers are provided mostly for illustration and should not be treated as complete estimates. A more intense research effort would be required to increase their accuracy. The process of estimation, however, is useful for illustration. Although profit losses by watermen are observed, our major concern is the losses to private growers from the MSX. Planters were most affected by MSX because the seed purchased by them suffered severe mortality from the protozoan invasion.

The planter makes profits by buying seed oysters, planting them, and then harvesting them several years later. The expected profected profit for a two year cropping pattern is given by:

$$(1) \qquad \underbrace{E\,[(f(Q_s)\,(P_{t+2}) - CH_{t+2})\,(1 + r)^{-2}]}_{\text{Discounted Expected Net Returns in } t+2} - \underbrace{(p_t + c_t)\,Q_s}_{\text{current costs}}$$

where:

$E[.]$ is the expected value operator;

$f(Q_s)$ is the output of marketable oysters (bushels from the planting of Q_s bushels of seed);

P_{t+2} is the market oyster price in year $t+2$;

CH_{t+2} is the harvest costs per bushel of marketable oyster in year $t+2$;

r is the rate of interest;

p_t is the price per bushel of seed in year t; and

c_t is the transportation and planting cost of seed in year t.

The epidemic associated with MSX reduced the marketable oysters produced from seed by an amount $(1 - \%MSX_{t+1})(1 - \%MSX_{t+2})$ where $\%MSX_{t+1}$ is the percent mortality associated with MSX during year $t + 1$. Thus, as the mortality rises, expected net revenues will fall, decreasing the damand for seed oysters. It is in the seed oyster market that we estimate the losses to growers. Following Just et al. (1982), changes in demand for an essential input (in this case oyster seed) can be used to estimate profit losses to individuals "up" the market chain. We calculate changes in profits for the period 1959 to 1974 that we can attribute to MSX. The "welfare" changes are shown for both the seed harvesters and the growers.

In order to make equation (1) operational, we assume the grower expects the market oyster price and harvest costs in subsequent years to be equal to the current values. We also make the assumption that the mortalities suffered in the contemporaneous season are expected for the subsequent growing seasons. Finally, we postulate that after 1966-1967 growing season, the growers required a "premium" above normal profits in order to absorb the newly acquired risk of subsequent MSX outbreaks in the industry. Our derived demand for oyster seed becomes:

$$(2) \qquad QD_t = g\,(P_t - CH_t)(1 + r)^{-2}(1 - \%MSX)^2, p_t + c_t, R_t)$$
$$= g\,(DNR_t, p_t, R_t)$$

where R_t is a binary variable, equal to one for all seasons following 1966-67.

To complete the seed oyster market, we specify that the quantity supplied is as follows:

$$(3) \qquad QS_t = k\,(P_t/p_t, Q_{t-1}).$$

This is the simple partial adjustment model (Maddala 1977). We assume seed tongers are responsive to the relative prices of market and seed oyster price (they can harvest either seed or market oysters) but that their responsiveness is not complete after one year. If the relative price of market to seed oysters rises, one expects less production of seed oyster. Fishermen direct effort to tonging market oysters. The partial adjustment model captures the possibility that not all of the movement to the market oyster is made immediately (in one season). Fishermen may slowly adjust. Data for MSX mortalities is provided by Andrews (1968).

An instrumental variable regression analysis produced the following estimated equations:

$$(4) \qquad Q_t = 4.24 - \underset{(-2.22)}{1.73\,p_t} + \underset{(1.26)}{0.24 DNR_t} - \underset{(2.10)}{0.91\,R_t}$$

$$(5) \qquad Q_t = 0.58 - \underset{(1.52)}{0.19\,(P_t/p_t)} + \underset{(10.74)}{0.97\,Q_{t-1}}$$

where the t - ratio is shown in parenthesis below coefficients. The signs of all coefficients are as expected, although the standard errors of coefficients associated with discounted net revenue and relative price variables are relatively high. The coefficient of 0.97 on lagged seed suggests that if tongers respond to price, they do it in a very slow fashion, about 3 percent per year. This is not too difficult to believe, however. The risk premium (*R*) for the additional MSX risk was approximately \$.50 per bushel of seed. In other words, planters after the 1966-67 season required an additional profit of \$.50 per bushel of seed to bear the additional risk of planting.

Using the coefficients in equation (4) and (5), we calculate tonger and planter losses from the MSX episode. For the seasons 1959-60 through 1974-75, the loss in profits to seed harvesters and planters averaged around \$2.2 million per year (1967 dollars). The high was around \$4 million and the low around \$1 million. The harvesters of the seed suffered about 40 percent of the losses whereas the planters suffered around 60 percent of the losses.

There are without doubt oversights and exigencies inherent in our analysis. For example, we chose to use an *ex ante* approach to the welfare change. By looking at the grower supply of market oysters, we may have been able to examine *ex post* losses. No consideration has been given to the welfare of marketing agents in the wholesale and retail trade. Finally, the consumer is ignored.

Effects on the Demand for Fish

Thus, far, the attention has been on the harvesting sector. There are, however, potential dramatic effects of disease organisms on consumers of fisheries products. Our guess is that consumer losses are of equal or greater magnitude with those of fishermen and processors. Unfortunately, data do not exist to substantiate this claim, though we can still discuss the manner in which consumers are affected by disease organisms in fish.

Price Effects

The most obvious manner in which consumers are affected is the lost production discussed in the previous section. Consider the effects of decreased production in a community which does not import seafood. Because one cannot consume a product which has not been produced, consumption cannot exceed production. Since production has fallen, consumption also must decrease. Clearly someone will go without the item and others will pay more to consume the same amount.

The dollar loss to the consumer can be measured by the change in household expenditures necessary to keep the household at the same standard of living given the higher price. While this might be small for each household, the total effect when all households are totaled may be considerable. The losses should be greatest for those items for which consumers do not easily substitute other goods. Outbreaks of gaffkemia (*Aerococcus viridans homari*) in the lobster industry likely will reduce consumer welfare more than an outbreak of similar proportion of *Ichthyophonus* in haddock. There are simply more substitutes for haddock than for lobster.

Quality Effects

In addition to higher prices, there can be other effects on consumers from quality changes which arise because of disease organisms. These effects can be divided according to whether the disease organism changes the taste/product form or consumers' health. Each will be considered separately.

Taste and Product Effects

Perceived Changes. The analysis of product quality has been a major research area for economists for the last twenty years. Early work on differentiated agricultural products (e.g., Waugh 1929) was generalized into a theory of consumer demand for quality (e.g., Lancaster 1966). The theme of the analysis is that consumers consider quality as well as price when they buy products. It is now commonplace in economic analysis to consider quality as well as product price in the demand for goods (e. g., Hanemann 1982).

The manner in which fish disease effects are perceived by consumers can be quite straightforward. The following excerpt is somewhat illustrative:

> *Ichthyophonus* infected haddock have been recorded from commercial landings in Scotland . . . resulting in [discard] . . . due to flecked appearance, rubbery texture and obnoxious smell. (McVicar 1980, p. 3).

These particular quality differences are so overwhelming that the fish is immediately discarded by the merchants. They know consumers will not buy spoiled fish. In this case, the haddock suffer from economic mortality rather than physical mortality. Similarly, processors are reluctant to accept tanner crab infected with a fungal disease known as black mat syndrome (Sparks 1982, Hicks 1982). Black tar-like material on the crab's exoskeleton can break into the crabmeat resulting in an inferior product. The effect of discard culling on consumers is the same as with physical mortality increase: lower consumption and higher prices.

Unperceived Changes. Not always is the consumer able to make accurate quality judgements on their fish purchases-and their learning experience may actually be more troublesome than higher prices. Take, for example, a homemaker who purchases an infected fish that has escaped culling. They prepare it and find during the meal that the fish is rancid. Not only is the preparation time lost, but there is no easy alternative for the meal. Having seen the situation, the authors are aware the higher prices may not be the most costly effect to the consumer of disease organisms in fish and shellfish.

Scenarios such as the above, form our "experience" (Nelson 1970) about fishery products. After enough time, the consumer has an expectation of the quality of the product. One or two rancid fish expereinces lower expectations of quality and therefore reduce demand. These reactions lead to lower welfare to the consumers from the unstandard quality. Exactly how the experience is formed and how many bad experiences are required before demand is affected is not well understood.

It is understood, however, that the absence of enforceable minimum quality standards in fish may contribute to losses suffered by consumers and the industry (Bockstael 1984). The reason derives from the rational strategy for a fish monger. If each producer's output is not differentiated (i.e, a fish from Giant is the same as one from Safeway), then the producers do not receive monetary incentives from maintaining quality. The average quality of fish is not as high as when the consumer knows the difference between products. The welfare of consumers and producers is lower because of the undifferentiated quality. While it is not always true that products are undifferentiated—consumers often remember that Store X has good fish and Store Y does not, the fact remains that because Store Y has poor quality fish, consumers who go to Store Z where the quality is unknown, are less likely to buy fish than a Perdue chicken. Greater quality standards and enforcement of existing ones can potentially improve both the welfare of consumers and producers in this case.

Do disease organisms in fish lower the quality of fish/shellfish in a manner which cannot be perceived by the consumer? The answer is yes, although the extent of the problem is not clear. *Icthyophonus* is considered responsible in part for the undesireability of slowly marketed fish. "Proteolytic enzymes released during the growth of *Itchyophonus*. . . contributed to the rapid decay in the muscle." (McVicar 1982). The disease organisms can also spread into uninfected fillets, even at temperatures as low as 8 degrees Centrigrade (McVicar 1982). Herring exhibits similar degeneration if infected with *Itchyophonus*. On the West Coast, Pacific whiting, milky halibut, sole, flounder, and salmon all potentially have their quality affected by myxosporidian spores. Upon harvest of the fish, the parasite releases an enzyme which diffuses away from the cysts. The texture of the flesh softens and the quality of the product diminishes. (Patashnik and Groninger 1964, Patashnik et. al. 1982).

Probably more disconcerting to consumers, however, is the potential for nematodes (worms) in seafood. Not always can they be perceived:

> A cod, caught on ocean side of Cape Breton Island, Nova Scotia, was filleted and purchased from a fisherman at Ingonish Beach, Nova Scotia on 5 August 1972. Within an hour, one of the fillets was cooked outdoors over a gasoline campstove. While consuming the fish, one of the structures taken for "veins" was seen to move; it was recognized as a worm, and since other such "veins" had been ingested, this specimen was kept in charcoal transport medium intended by one of the party for bacteriological sampling. Enquiry of local residents revealed that pollack was considered to be of good quality although cod was recognized to be wormy during the summer. During the evening of 11 August the 22-year-old woman who had eaten the infected cod (filleted 6 days earlier) felt a "tingling" sensation in her throat and extricated the apparent cause—a live nematode. (Kates et. al.).

The incident suggests nematodes (in this case *Phocanema*) are perceived by some and not perceived by others. Without some rules of thumb (e. g., Nova Scotian cod is wormy in the summertime), the consumer is left to question the quality of the product. Evidence that the roundworm problem for consumers is not specific to Nova Scotia/Gulf of Maine comes from reports of similar incidents throughout the country (e.g., Juels, et al. 1975, Dailey et al. 1981). Research during 1976 has shown that roundworms occurred in 10-20 percent of the fish (edible portions) caught in Washington, Oregon, and California waters during 1975. West Coast shellfish did not show the presence of roundworms (Myers 1979).

To believe roundworms reside only in finfish, however, would be a mistake. Scallops, shrimp, and surf clams are among the commercially valuable shellfish hosts of nematodes (Norris and Overstreet 1976, Sawyer et al. 1983). An interesting episode occurred in the surf clam industry during 1975. Dark roundworms *Sulcascaris sulcata)* suddenly began appearing in surf clams. These were noticeable to processors who were quite concerned about the impact on their market from the obvious presence of worms. As it turned out, the worms may have been present in surf clams for some period and only became obvious when a haplosporidan protozoa *(Urosporidum spisuli)* also invaded the clam, discoloring the worms. Since then, it has been claimed that this nematode "may parasitize a wide range of molluscan hosts" (Sawyer et al 1983).

Human Health Effects

Although the unpercieved quality change may reduce demand and consumer welfare, a far more serious problem arises when the unperceived quality is linked with human disease. The distinction between whether or not human health is involved has important economic as well as public safety ramifications.

There appears to be growing concern about the human health effects of fish consumption. Myers (1979) explains:

> The anisakine nematodes attracted attention during the early 1960s because their presence reduced the commercial value of fish (8). Large anisakines, such as *Phocanema* sp. larvae, were easy to detect in both the edible and nonedible muscle of a large variety of fish, especially the cod. Extensive studies were conducted in Canada on this so-called "codworm" but the parasite was thought to be merely unappetizing. Work was directed toward removing it or reducing the number of nematodes visible in fish fillets (8). That this anisakine could be a human pathogen was not considered. During the past 10 years, however, there have been an increasing number of reports that these nematodes can infect humans (6).

In essence, what was believed to be a taste/form effect has been linked to human health. The nematodes are just one of numerous potential causes of human disease/ reaction arising from consumption of fish and shellfish.

Outbreaks of typhoid fever, for example, have been related to U. S. oyster consumption since an outbreak in Connecticut in 1893. In 1910, the annual report of Virginia's Board of Fisheries claimed "The scare of 'polluted oysters' has cost the workers of Virginia three to four million dollars a year for three or four years." (Capper et al. 1983). A 1924-25 typhoid epidemic in Chicago and several eastern cities caused around 150 deaths and was linked to indigestion of raw oysters harvested from Raritan Bay in New Jersey. Over the years, however, better sanitation facilities and water quality requirements of oyster harvesting areas have largely eliminated problems of health hazard caused by bacteria.

Viral infection has not been as easily addressed. The reason, according to Metcalf (1979), is that the water quality criteria for closure of shellfish areas is based on fecal or total coliform count. While these may be reasonable indicator organisms for bacteria, they are shown to have little relation to the presence of viruses (Goyal et al. 1979). Enteroviruses, reoviruses, adenoviruses, and heptatitus A are common viruses which are likely to be transmitted by shellfish. The shellfish apparently act as passive hosts for the virus (Chang et al. 1971) and enter humans through consumption of raw seafood.

Numerous examples of gastroenteritis outbreaks exist but the one following a meeting of a Northeast shellfish sanitation association highlights the problem. The meeting, held in New Haven, Connecticut, featured a social hour during which raw clams were served. Seventeen of the 19 persons who consumed the raw clams developed gastroenteritis, symptoms of which included nausea, vomiting, fever, and diarrhea. The possible cause of the clam contamination was a power failure in Norwalk, Conn. The outage resulted in partially treated sewage overflow into waters upstream of clam beds. The beds were subsequently closed to shellfish harvest, (*J. of Infectious Disease,* 1969, pp. 265-66).

Ciguatera is slightly different in causing human reaction to seafood consumption.

It is a toxin found in certain fishes in the Caribbean and around Hawaii. It apparently arises when fish consume dinoflagellates and humans consume the fish, even cooked. There is no way to identify these hazardous fish, but individuals who eat them experience nausea, vomiting, severe diarrhea, and abdominal cramps. It has even been known to cause death *(San Jose Star Magazine,* October 4, 1981, p. 3-6). Deaths are also known to be caused by botulism in smoked fish.

The wide range of health hazards resulting from fish/shellfish consumption ultimately influences the fishing industry and other users of the water. We first discuss the consumer reaction and then examine the fishing industry and related industries.

Consumer Response. Consumer response to human disease organisms in fish is conceptually similar to the quality changes discussed previously. The main difference, however, might be a substantially greater response. Disliking or throwing away a dinner is not as traumatic as vomiting, stomach cramps, hospitalization, or death. Risk averse people will likely avoid fish more if their health is involved. Weighing against this argument is the fact that most human disease organisms can be eliminated by a thorough cooking. People can avoid the nuisance by changing the form in which the seafood is consumed. Thus, if cooked seafood is nearly as preferred as raw seafood, there may be little consumer reaction to the disease organism.

To the authors knowledge, little is known about consumers preference between raw and cooked seafood. Data normally are not collected on prices and quantities consumed of different product forms. Our best guess is that cooked seafood is not a perfect substitute for raw seafood. Behavior to avoid the nuisance (Shulstad and Stoevener 1978, Swartz and Strand 1981) would result in a loss to the consumer from human disease organisms and lower demand for seafood.

Because the data are not available to study this problem empirically, we can only present results from related research and speculate on potential losses. It is known that consumers respond to quality characteristics of seafood. Bockstael (1977), for example, found that, for New England groundfish, "The relative price of fresh and frozen fish has been such that only in relative gluts, or when existing fresh fish channels were full, would it be worthwhile to divert domestic catch to the frozen market" (p. 38). Consumers are generally willing to pay a higher price for fresh fish. Moreover, it has been shown that consumers of shucked oysters were unusually responsive to potential health effects arising during the Kepone closure of Virginia's James River (Swartz and Strand 1981). Although there is not overwhelming evidence, we conclude that consumer reaction to disease-related quality in fish is a serious problem for the industry.

Because there is so little information on consumer response, it is impossible to obtain estimates of consumer welfare losses from disease-realated organisms. Nevertheless, figures regarding the medical treatment expenses associated with botulism from canned salmon cost are revealing. Treatment of one individual cost approximately $65,000. This offers some guidance as to the medical expenses for an individual who eats diseased fish.

Theoretically, there is a difficulty in measuring welfare losses when human health is involved. Typical welfare measures [such as those previously used] only offer reliable guidance if large changes in the individuals' state of welfare are not involved. They, in some manner, are based on a compensation to offset a change in an indiviudual's state (situation). When dramatic changes in an individual's state are involved, the measures sometimes cannot be used. The extreme example is the case in which no amount of money can compensate the individual for the change of state. Death might be the clearest example but surely one has heard the expression " I wouldn't go through that again for anything." In these cases, typical welfare measures might not be very useful and one is left in an unsatisfactory position regarding loss estimation.

*Production Losses.*Perhaps as a result of the potentially extreme losses when human health is involved, federal and state governments have interceded in an attempt to reduce the potential for human health effects from fish with disease organisms. The apparent expression of policy comes in the prohibition of harvest from particular waters. Because there is an available resource in these areas which is prohibited from use, the possibility exists for a negative impact on producer and consumer welfare. But, because the disease organisms are present, harvest is not undertaken and production is lost.

Shellfish production is an obvious example of production losses. In 1980, nearly 15 percent of the Nation's estuarine water were classified as prohibiting shellfish harvest (Verber 1981). Atlantic Coast estuaries had 96 percent of all U. S. waters under shellfish harvest prohibition.

Unfortunately, it is not possible to determine the value of the lost production. First, is is often possible to harvest shellfish from prohibited areas if the purpose is replanting. Here, the industry does not lose production, prohibition merely raises the costs of harvest. Secondly, it is never clear whether stocks from a closed area would be harvested if the prohibition was not in place. The presence of shellfish is not sufficient for their harvest. Costs and prices must be considered. Finally, these prohibited areas may act as sanctuaries for the shellfish. Because of their existence, reproduction might be enhanced.

Ending on a positive note, the shellfish prohibition figures show that acreage with shellfish prohibition has begun to decrease. National prohibited acreage went from 3.79 million acres (1.53 million ha) in 1974 to 2.89 million acres (1.17 million ha) in 1980, a 25 percent decrease. Some of the improvement is due to water quality improvements and some to alternate methods of regulation.

Other Related Losses

The issue of improved water quality brings up an important component of loss from disease, the opportunity costs incurred to assure populations of disease organisms are held "reasonably" in check. Historical review notes that the reason Baltimore built a state-of-the-art sewage treatment plant in 1912 was primarily to protect the good name of Maryland oysters (Capper et al. 1983). The increased expense to Baltimore citizens for the purity of wastewater discharge was due solely to the disease potential of oysters. These expenses, then, convey income losses to Baltimore citizens from the existence of the organisms.

The Back River Disposal Plant in Baltimore is representative of the technologies we use to avoid greater presence of disease organism in our waters. Between 1973 and 1984, the federal government awarded $32 billion in construction grants for sewage disposal. Obviously not all of this money was directed to suppressing disease organisms in seafood. However, our society allocates a substantial portion of resources each year to assuring the cleanliness of our estaurine systems. A fair portion of that allocation is undoubtedly attributed to the presence of disease organisms in fish and shellfish.

Management Implications

In this paper, fisheries management is not considered synonymous with harvest restriction. National Marine Fisheries Service and other fisheries agencies have broad responsibilities beyond the direct control of harvest. In what follows, we examine the implications of the previous discussion on several of these missions, combining them under the general label of management. In particular we consider research direction, input controls (prophylaxis), and harvest management.

Research Direction

Much of the literature cited in this paper primarily addresses the life history as well as etiology of enzootic and epizootic occurences. In this role, the biological researcher is like an historian of the microscopic world, recording and interpreting events. The value of the biological research derives not only from the information itself but also from how it is used. The research on MSX, for example, may have provided planters with valuable information on expected mortality. Armed with this, planters may have made better decisions and not sunk valuable time and resources into dying oysters.

Government sponsorship of the research is important because no one planter is likely to have the incentive or capital to obtain the information. Moreover, when the information is publicly supplied, it is available to all, including future generations. Its potential for pay-off therefore may be high. It might even provide a classic circumstance from which valuable insight can be drawn.

To measure the "social returns" from the provision of this information is difficult if not impossible. One would have to determine the circumstances (e.g., industry profits) without the information and then determine the conditions with the information. The difference would reflect social returns. The impact of information, however, might be far-reaching. In their pursuit of generalization, scientists often require an understanding of many cases before a pattern emerges. Thus, beside the more direct gains from information, the research can have a long-lasting effect on science in general. Typical methodology to account for the more general is not likely to yield measures of the returns that are above reproach.

One area for which research might provide valuable information is in the area of consumer preferences for raw seafood. Our review noted little to no knowledge of the consumer preferences for raw fish. Yet this is a critical piece of information both for the industry and for the government. Without an understanding of the consumer trade-offs between raw and cooked fish, there are only indirect methods for determining losses to consumers from the disease organisms. A directed research effort along these lines could be quite valuable. If one found out, for example, that consumers were largely indifferent between raw and cooked fish, efforts could be directed to telling/requiring people to cook the fish. On the other hand, if they preferred raw fish to cooked fish strongly, efforts might be directed to assuring that products were free of parasites.

Input Control (Prophylaxis)

Another important use of basic research is in the prevention of disease outbreak. It may be possible to restrict the spread of disease through intervention. The literature suggest three methods for input control:

1. Direct protection-measures which alter the host so that infection can not occur;
2. Eradication—measures which eliminate the pathogen after it is introduced;
3. Exclusion—measures which prevent the introduction of pathogens into an area.

Sindermann (1985) has discussed the relevance of these methods for extensive (in a common water column) aquaculture and intensive (in private water column) aquaculture. We would like to discuss the role of government in the two settings.

With extensive marine aquaculture, there is a serious potential for entire industry effects from one producer. That is, if one aquaculturist introduces disease into a common water body, then many aquaculturists are affected. There is a strong tradition, even in our free market, to reduce or eliminate these external effects. The obvious way is through control of transfer or exclusion. Here, the role of government is regulation.

On the other hand, the government's role in intensive aquaculture may be substantially less. If an individual wishes to risk his entire enterprise by using an exotic, he is only going to affect himself. In a free market, he should have this freedom without government regulation. There may be a research role for the government, however. Just as the U. S. Department of Agriculture provides research on agricultural production and marketing, so too is it appropriate in aquaculture. The public good nature of information provides a high potential pay-off from centralized research.

Harvest Management

Rational fisheries management should make allowances for the existence of disease organisms in fish and shellfish. The traditional goal of fisheries management is a suppression of current harvest so that future harvests are improved. Because disease organisms can either directly or indirectly influence harvest, the clever manager will understand their effects and use them to an advantage. Without the understanding, the manager's policies can be enhanced or shunted in an apparent whimsical fashion. A general picture of disease/harvest interaction currently is unavailable, and worthwhile effort would be to expand the first section of this paper into a complete model. We offer only a sketch, the portrait remains unfinished.

There are two observations which might indicate the complexities of the general model. First, it is entirely possible that disease organisms in fish can improve future production while limiting current production—a manager's delight. The mechanism making this possible is consumer demand. Deaths from typhoid fever in the 1920s, for example, probably drove down the price of oysters and "economically" restricted their output. Here, the harvest reduction probably led to greater stocks and greater subsequent production. This is, at least, informed speculation and supported by some circumstantial evidence.

More troublesome, however, is that we do not even know whether disease induced mortality will and *should* lead to greater or lesser current harvest. One could argue that harvest should increase because the infected specimens will just die anyway. On the other hand, one could argue that the increased mortality endangers the stocks, and reduced catch is necessary to prevent a complete collapse of the fishery. Our guess is that the correct answer depends on the parameters of the system and that circumstances dictate the appropriateness of the policies. Which particular parameters and circumstances result in recommendations for greater or lesser current harvest is the question. Greater understanding of these might prove valuable to fisheries managers.

Conclusions

Our intention in this paper is to explore the relationship between fish disease organisms and economics and then relate it to fisheries management. We had no predispositions before the effort. We found, to our surprise, that problems of fish disease were ubiquitous, significant, and possibly increasing. They existed for numerous species and for most types of fishermen. Moreover, the economic impacts of disease organisms were wide-ranging—from altering producer expectation to reducing demand for products. We document many cases and attempt to show how one would measure losses from existence of disease organisms.

We also begin to explore why the situtation is important to managers of fish. Admittedly, our efforts are restricted. While there is a long history of government intervention to prevent the spread of disease in agriculture, the role of government in relationship to fish diseases is relatively new. We hope that it could be eliminated but, in fact, believe it may become far more important in the future. If we are right, research along the lines developed in this paper may prove valuable.

Literature Cited

Andersen, P. 1982. Commercial fisheries under price uncertainty. J. Env. Econ. and Manage. 9:11-28.

_____, and J. G. Sutinen. 1984. Stochastic bioeconomics: a review of basic methods and results. Mar. Res. Econ. 1(2):117-136.

Andrews, J. D. 1968. Oyster mortality studies in Virginia. VII. Review of epizootiology and origin of *Minchinia nelsoni.* Proc. Nat. Shellfish Assoc. 58:23-36.

Berck, P., and J. M. Perloff. 1983. The rational expectations, open-access fishery. Econometrica 52(2):489-506.

Bockstael, N. E. 1977. A market model for New England groundfish industry. URI Agr. Exper. Sta. Bull. No. 422. 56 pp.

_____. 1984. Uncertainty about consumption and consumer uncertainty. Mar. Res. Econ. 9(1):67-76.

_____, and J. J. Opaluch. 1983. Discrete modelling of supply response under uncertainty: the case of the fishery. J. Env. Econ. and Manage. 10:125-137.

Capper, J., G. Power, and F. R. Shivers, Jr. 1983. Chesapeake waters: pollution, public health and public opinion, 1607-1972. Tidewater Publishers, Centerville, Maryland.

Chang, P. W., O. C. Liv, L. T. Miller, and S. M. Li. 1971. Multiplication of human enterovisuses in northern quahogs. Proc. Soc. Exp. Biol. Med. 136:1380-1384.

Clark, C. W. 1976. Mathematical bioeconomics: the optimal management of renewable resources. John Wiley and Sons, New York. 352 pp.

Dailey, M. D., L. A. Jensen, and B. W. Hill. 1981 Larval anisakine roundworms of marine fishes from southern and central California with comments on public health significance. Calif. Fish and Game 67(4): 240-245.

Dudley, N., and G. Waugh. 1980 Exploitation of a single cohort fishery under risk: a simulation optimization approach. J. Env. Econ. and Manage. 7:234-255.

Eklund, M. W., F. T. Poysky, M. E. Peterson, L. W. Peck, andW. D. Brunson. 1984. Type E botulism in salmonids and conditions contributing to outbreaks. Aquaculture 41:293-309.

Farley, C. A. 1975. Epizootic and enzootic aspects of *minchinia nelsoni* (Haplosporida) disease in Maryland oysters. J. Protozool. 22(3):418-427.

Ford, S. E., and H. H. Haskin. 1982. History and epizootiology of *Haplosporidium nelsoni* (MSX), and oyster pathogen in Delaware Bay, 1957-1980. J. Inv. Path. 40:118-141.

Goyal, S. M., C. P. Gerba, and J. L. Melnick. 1979. Human enteroviruses in oysters and their overlying waters. Appl. Envir. Microbiol. 37:572-581.

Grizel, H. 1983. Impact of *Marteilia refringens* and *Bonamia ostreae* on Breton oyster culture. ICES C.M. 1983. 22 pp.

Hanemann, W. M. 1982. Quality and demand analysis. *In* G. C. Rausser, ed. New directions in econometric modeling and forescasting in U.S. Agriculture. Elsevier/North Holland Publ. Co., New York.

Haskin, H. H., and S. E. Ford. 1983. Quantitative effects of MSX disease *(Haplosporidium nelsoni)* on production of the New Jersey oyster beds in Delaware Bay, U.S.A. ICES C.M. 1983. 21 pp.

Haven, D. S., W. J. Hargis, and P. C. Kendall. 1978. The oyster industry of Virginia: its status, problems and promise. VIMS Specal Papers in Mar. Sci. No. 4. 1024 pp.

Hicks, D. M. 1982. Abundance and distribution of black mat syndrome on stocks of tanner crabs, *Chionoecetes bairdi,* in the northwestern gulf of Alaska. Proc. Intnl. Symp. on genus *Chionoecetes*:563-579.

Juels, C. W., W. Butler, J. W. Bier, and G. J. Jackson. 1975. Temporary human infection with a *Phocanema* sp. larva. Amer. J. Trop. Med. Hyg. 24(6):942-944.

Just, R. E., D. L. Hueth, and A. Schmitz. 1982. Applied welfare economics and public policy. Prentice-Hall, Inc., Englewood Cliffs, NJ. 491 pp.

Kates, S., K. A. Wright, and R. Wright. 1973. A case of human infection with the cod nematode *Phocanema* sp. Amer. J. Trop. Med. Hyg. 22(5):606-608.

Lancaster, K. J. 1966. A new approach to consumer theory. J. Pol. Econ. 74:132-157.

Maddala, G. S. 1977. Econometrics. McGraw-Hill Book Company, New York. 516 pp.

McVicar, A. H. 1980. The effects of *Ichthyophonous* infection in haddock *Melanogrammus aeglefinus* and plaice *Pleuronectes platessa* in Scottish waters. ICES 1980/16. 16 pp.

______. 1981. An assessment of *Icthyophonous* disease as a component of natural mortality in plaice populations in Scottish waters. ICES CM 1981/G:49 8 pp.

____. 1982. *Ichthyophonous* infections of fish. Pages 243-268 in R. J Roberts, ed. Microbial diseases of fish. Academic Press, New York.

Metcalf, T. G. 1979. Indication of viruses in shellfish growing waters. Amer. J. Pub. Health 69(11):1093-1094 (editorial).

Munro, A. L. S., A. H. McVicar, and R. Jones. 1983. The epidemiology of infectious disease in commercially important wild marine fish. Rapp. P.-V. Reun. Cons. Int. Explor. Mes. 182:32.

Myers, B. J. 1979. Anisakine nematodes in fresh commerical fish from waters along the Washington, Oregon and California coasts. J. Food Protect. 42(5):380-384.

Nelson, P. 1970. Information and consumer behavior. J. Pol. Econ. 78:311-329.

Newman, M. W., and G. E. Ward, Jr. 1973. An epizootic of bluecrabs, *Callinectes sapidus* caused by *Paramoeba perniciosa.* J. Inv. Path. 22:329-334.

Norris, D. E., and R. M. Oversteet. 1976. The public health implications of larval *Thynnascaris* nematodes from shellfish. J. Milk Food Techn. 39(1):47-54.

Odense, P. H., and V. H. Logan. 1976. Prevalence and morphology of *Eimeria gadi* in the haddock. J. Protozool. 23(4):564-571.

Patashnik, M., and H. S. Groninger. 1964. Observations on the milky condition in some Pacific coast fishes. J. Fish. Res. Board Can. 21:335-346.

Patashnik, M., H. Groninger, H. Barnett, G. Kundo, and B. Koury. 1982. Pacific whiting, *Merluccius productus:* Abnormal muscle texture casued by Myxo-sporidian-induced proteolysis. Marine Fisheries Rev. 44(5):1-12.

Ploude, C., and R. Bodell. 1984. Uncertainty in fisheries economics: the role of the discount rate. Mar. Res. Econ. 1(2):155-170.

Sawyer, T. K., A. Rosenfield, F. O. Perkins, D. E. Zwerner, R. K. Dias, J. R. Lichtenfels, P. A. Madden, G. J. Jackson, J. W. Bier, W. L. Payne and G. C. Miller. 1983. Identification of parasitic nemotode larvae, *Sulcascaris sulcata,* in the calico scallop. *Argopecten gibbus* (Linnaeus), and the surf clam, *Spisula solidissima.* Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 182:140-143.

Schaefer, M. B. 1957. Some considerations of population dynamics and economics in relation to the management of marine fisheries. J. Fish. Res. Bd. Canada 14:669-681.

Shulstad, R., and H. Stoevener 1978. The effects of mercury contamination in pheasants on the value of pheasant hunting in Oregon. Land Econ. 54(1):39-49.

Sieling, F. W. 1971. Economic value of research in resources management from research. Proc. Nat. Shellfish. Assoc. 61:15-19.

Sindermann, C. J. 1956. An epizootic in Gulf of St. Lawrence Fishes. Trans. N. Amer. Wildl. Conf. 23:349-360.

______, ed. 1977. Disease diagnosis and control in North American aquaculture. Elsevier, New York.

______. 1985. The role of disease in management of cultivated marine fish and shellfish populations. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 50:641-648.

Smith, J. B. 1980. Replenishable resource management under uncertainty: a reexamination of the U.S. northern fishery. J. Envir. Econ. Manage. 7:209-219.

Smith, V. L. 1968. Economics of production from natural resources. Amer. Econ. Rev. 58:409-431.

Sparks, A. K. 1982. The histopathology and possible role in the population dynamics of tanner crab, *Chionoecetes bairdi,* of the fungus disease (black mat syndrome) caused by *Trichomaris invadens.* Proc. Int. Symp. on the Gensus *Chionoecetes:* 539-545.

Stewart, J. E., B. M. Zwicker, and B. Arie. 1975. Status report on gaffkemia in lobsters in Atlantic Canada. ICES C.M. 1975/K:20. 5 pp.

Swartz, D. G., and I. E. Strand, Jr. 1981. Avoidance costs associated with imperfect information: the case of kepone. Land Econ. 57(2):139-150.

Tibbo, S. N., and T. R. Graham. 1963. Biological changes in herring stocks following an epizootic. J. Fish. Res. Bd. Canada 20(2):435-449.

Van den Broek, W. L. F. 1978. The effects of *Lernaeocera branchialis* on the *Merlangius merlangus* population in the Medway estuary. J. Fish Biol. 13:709-715.

Vaughn, D. S., R. M. Yoshiyama, J. E. Breck, and D. L. DeAngelis. 1984. Modeling approaches for assessing the effects of stress on fish populations. Pages 259-278 in V. W. Cairns and P. V. Hodson, eds. Contaminant effects of fisheries. John Wiley and Sons, New York.

Verber, J. L. 1981. National shellfish register of classified estuarine waters, 1980. Northeast Technical Services Unit, Davisville, R.I.

Waugh, F. V. 1928. Quality factors affecting vegetable prices. J. Farm Econ. 10:185-196.

Yohe, G. W. 1984. Regulation under uncertainty: an intuitive survey and application to fisheries. Mar. Res. Econ. 1(2):171-192.

Registered Attendance

ALABAMA
Guy Baldassarre, Eileen Baldassarre, Theodore T. Buerger, Keith Causey, James R. Davis, Carolyn Marn, Joseph M. Meyers, Ralph E. Mirarchi, Donna Jo Painter, John Pritchett, John Thompson, Rich Turnbull

ALASKA
Michael A. Barton, Greg Clevenger, Win Green Phil Janik, Jerome Montague, John A. Sandor, John F. Martin, Richard J. Vernimen

ARIZONA
Michael E. Berger, Bud Bristow, Carole Hamilton, Paul R. Krausman, Carol Krausman, Bruce D. Leopold, R. William Mannan, Tony Melchiors, W. Linn Montgomery, Carlton N. Owen, Jerome J. Pratt, Kurt R. Rautenstrauch, Alister R. Shanks, William W. Shaw, Darcy Shaw, David Smith, Norman S. Smith, A. Heaton Underhill, Mark C. Wallace, Harry R. Woodward

ARKANSAS
William Brewer, Steven Cole, Rebecca Field, Scott Henderson, Junior D. Kerns, Duncan Martin, Larry Martin, Allan M. Strong, John C. Sunderland, Billy White, Steve Wilson, Scott C. Yaich

CALIFORNIA
Judge Anderson, Blair A. Csuti, Robyn Darwin, Lewis R. Davis, E. Lee Fitzhugh, Wendy S. Fitzgerald, Michael T. Hanson, Joseph H. Harn, Jim Holeman, Walter E. Howard, Janet F. Hurley, Huey D. Johnson, John G. Kie, Don Lollock, Wayne E. Long, Julie Moore, Dennis G. Raveling, Joan Reutinger, Otto Reutinger, Kent Smith, Deane Swickard, Janie Swickard, William C. Unkel, Ellen Yeoman

COLORADO
Bill Alldredge, David R. Anderson, Spencer R. Amend, Clait E. Braun, Galen Buterbaugh, Jack Capp, Len H. Carpenter, David E. Chalk, Cheryl Charles, Robert S. Cook, Allen Cooperrider, Eugene Decker, Mel DePra, Ronald P. Desilet, Charlette A. Desilet, Gordon P. East, Janet S. East, Jack R. Grieb, Retha Grieb, Don Henne, N. Thompson Hobbs, Thomas W. Hoekstra, Charles A. Hughlett, Shirley Ann Hughlett, C. Eugene Knoder, John Loomis, Melanie Malespin, Harvey W. Miller, John W. Mumma, James B. Ruch, Sandi Ruch, Hal Salwasser, V. B. Sawarkar, Edward H. Seely, William Seitz, Tim Schultz, Fred D. Theurer, Jean K. Tool, Carole L. Tool, Robert K. Turner, Lee Upham, Paul A. Vohs, George H. Wallen, Thomas W. Warren, Gary C. White

CONNECTICUT
Jeffrey L. Diehl, William B. Hull, Jack F. Kamman, Barbara Kamman, Stephen R. Kellert, Kathy Patey, Thomas J. Steinke

DELAWARE
Lloyd Alexander, Bill Allegretti, Michael K. Brown, Rod Harmic, Wayne C. Lehman, Kevin B. McCormack, Kenneth Reynolds, Bill Wagner

DISTRICT OF COLUMBIA
Andrew Ajemian, Jocelyn Alexander, David J. Allen, Jeannette E. Allen, Irwin M. Alperin, Guy Baier, Malcolm F. Baldwin, Jack H. Berryman, Gyongyver "Kitty" Beuchert, Charles L. Boothby, Hugh Black, Ben Bolusky, John R. Botzum, Carmen J. Blondin, Paul Brouha, E. Carl Brown, John D. Buffington, Charles H. Callison, Henry Clepper, Keith W. Cline, John Crawford, Rodman P. Cupka, James P. Daniel, Edward L. Davis, Robert Davison, Amy Donovan, Dennis G. Eggers, J. Erwin, J. Scott Feierabend, Elliott Gimble, Patsy Goodman, Nancy Green, Bette S. Gutierrez, Keith Hay, Hazel Groman, Victoria C. Guerrero, John Hadidian, Jay D. Hair, D. Heyward Hamilton, John E. Hansel, Kirk Horn, Ray Housley, Constance Hunt, Robert F. Hutton, Laurence R. Jahn, Helen Jahn, Robert A. Jantzen, Paul P. Johnson, Ronald G. Kelsey, Alan Kesterke, Carolyn Kirby, Joseph H. Kutkuhn, Linda Langner, Thomas C. Lankenau, Maurice LeFranc, Robin Levenstein, Randy Long, Laura Loomis, Holly Lown, Albert Manville, Richard E. McCabe, Margaret McCabe, Neil Middlebrook, Doug Miller, Jim Miller, Mark R. Millikin, Brian A. Millsap, Neil Morck, Robert D. Nelson, Midge Nelson, Thomas C. Nelson, James R. Norine, Hal O'Connor, David H. Pardoe, Carol J. Peddicord, Edwin D. Pentecost, Robert Peters, Doug Pifer, Keith C. Pitchford, Howard W. Pollock, Daniel A. Poole, Dorothy Poole, Carol Porter, Gil Radonski, William Radtkey, Christina U. Ramsey, Dick Randall, Christine Reid, Nobby Riedy, Ron Rinaldo, Edward F. Rivinus, Elizabeth Roberts, Kenneth R. Roberts, Larry M. Roberts, Matt Roberts, John G. Rogers, Margaret Rostker, Mark Rugaber, Alison B. Russell, Debra Forthman Quick, Kenneth J. Sabol, Cathy Sabol, Neil Sampson, Charles Savitt, Napier Shelton, Sharon Shutler, Karl Siderits, Allen E. Smith, Carol Smith, Rollin Sparrowe, Bettina Sparrowe, Dottie Taylor, Craig Tufts, Ed Verburg, Anne Wakeford, Rolf Wallenstrom, Bob Wardwell, W. Alan Wentz, Jan Wentz, Lamar White, Lonnie L. Williamson, Patsy Williamson

FLORIDA
Mark E. Berrigan, Robert M. Brantly, Allan L. Egbert, Robin H. Fields, Barbara Gianikas, Juanita Greene, Ronald F. Labisky, Wayne R. Marion, Dave McElveen, Joan Scott, Joseph Ward

GEORGIA
E. L. Cheatum, Oscar Dewberry, Bobbie Dewberry, Jeffrey J. Jackson, James H. Jenkins, Jerry McIlwain, Victor F. Nettles, Chester F. Phelps, James W. Pulliam

IDAHO
Ernest D. Ables, Bill Burnham, Jerry M. Conley, James R. Fazio, Craig R. Groves, Maurice Hornocker, Lewis Nelson, Jr.

ILLINOIS
Frank Bellrose, Paul A. Brewer, George V. Burger, Jeannine W. Burger, Jack M. Cohlmeyer, Matthew Conley, Mike Conlin, Matthew B. Connolly, Jr., James Dudas, Stan Etter, Warren Garst, John Husar, Dave Kennedy, W. D. Klimstra, Miriam Klimstra, Gregory T. Koeln, Edward L. Kozicky, Richard W. Lutz, T. Miller, John Roseberry, Glen C. Sanderson, J. Henry Sather, Shirley Sather, James M. Shepard, Louisa Squires, John R. Strieter, Gloria Strieter, Donald W. Thompson, Dennis Thornburg, Richard E. Warner, John E. Warnock, Mary R. Warnock, David E. Wesley, Dale E. Whitesell, Michael B. Witte

INDIANA
Durward L. Allen, Mason C. Carter, John S. Castrale, Wayne C. Faatz, Edward L. Hansen, Bob Kern, Laura Kern, Harmon P. Weeks

IOWA
Louis B. Best, Richard A. Bishop, Allen L. Farris, Robert B. Moorman, Larry J. Wilson, Dee Ann Wilson

KANSAS
David J. Gabriel, George Halazon, Kay Halazon, Kent Jackson

KENTUCKY
Stephen A. Bonney, Wayne L. Davis, Bill Graves, Bill Hanzlick, Janette Hanzlick, Bill McComb, R. J. Robel, Anice Robel, Elizabeth E. Thach

LOUISIANA
John M. Anderson, Hugh Bateman, Mary Courville, Jim Dyer, Mrs. Jim Dyer, Joe L. Herring, Dick Lynch, Zoe S. Lynch, David M. Soileau, Richard K. Yancey, Philip J. Zwank

MAINE
John A. Bissonette, Gregory N. Brown, Jan C. Brown, Patrick W. Brown, Malcolm W. Coulter, Vera Hoffmann, Alan Hutchinson, W. N. Johnson, Dennis G. Jorde, Glenn H. Manuel, Howard L. Mendall, Emma Mendall, Ray B. Owen, Paul Strong, Robert J. Wengrzynek, Susan Woodward

MARYLAND
Larry Adams, Lowell W. Adams, Mark Albaugh, Peter H. Albers, Michelle Arrington, Paul A. Billeter, Ron Bowman, C. Richard Bozek, Shirley A. Briggs, Carl R. Brunori, Cathy Carlson, Mark C. Conner, Michael Conny, Robert K. Davis, Bradley D. Dorf, William J. Duddleson, Judy Duddleson, Fish & Wildlife Reference Service, Thomas M. Franklin, E. Hugh Galbreath, Marshall J. Garrett, J. Edward Gates, William R. Gates, William K. Geiger, Rob Gibbs, Richard E. Griffiths, John Helm, John E. Hench, Clare Hendee, Maria Hille, Herb Hille, Clarence R. Hickey, Harry E. Hodgdon, Earl H. Hodil, Michael Hollins, Daniel L. Leedy, Barbara Leedy, Stephen Lewis, Thomas E. Lewis, Roland J. Limpert, Anne M. Lynn, James R. Lyons, Donald R. Maclean, Donald E. MacLauchlan, Denise P. Meridith, W. Edward Montz, Coowe Moss, Bill Osburn, Oliver H. Pattee, Robert Perry, Martha Perry, Jamie W. Rappaport, Deborah Richardson, Deborah D. Rudis, Irene Sacilotto, Lynette Scaffidi, John E. Schaeffer, Courtland L. Smith, Edward C. Soutiere, Ronald T. Speers, Tyrone Stinson, Kenneth L. Stromborg, Carl Sullivan, Glenn D. Therres, David L. Trauger, Geoffrey A. Yeadon

MASSACHUSETTS
William C. Ashe, Abigail D. Avery, Carl A. Carlozzi, Richard Cronin, Steven L. Garman, Fred Greeley, Curt Griffin, Perry R. Hagenstein, Cathy Kap, Joseph S. Larson, Scott M. Melvin, Lawrence B. Morris, Donald R. Progulske, Eunice Progulske, David S. Wilkie

MICHIGAN
John G. Bruggink, Dan Groebner, Jonathan Haufler, Robert Hess, Larry C. Holcomb, Jerrilyn Holcomb, Niles R. Kevern, Patmarie Maher, Anna B. McPherson, Edward J. Mikula, Richard Moran, Connie G. Myers, Thomas Nederveld, Rolf O. Peterson, Merrill L. Petoskey, Jean Petoskey, Bill Robinson, Raymond D. Schofield, Jeanne Schofield, Ronald O. Skoog, Tobi K. Stork, Rosemary Kay Thiebaut, Reuben E. Trippensee, Louis J. Verme, David K. Woodward

MINNESOTA
Ira R. Adelman, Forrest Carpenter, Dan Frenzel, Todd K. Fuller, Gordon W. Gullion, Mrs. Gordon W. Gullion, Carrol Henderson, Roger Holmes, James Jack, Edward L. Lindquist, Harvey K. Nelson, Gene M. Nelson, Collin Peterson, Dale L. Rabe, Larry R. Shannon, Bill Stevens, Gustav A. Swanson, Evadene B. Swanson, Walter H. White

MISSOURI
Kenneth M. Babcock, Allen Brohn, Amy Callison, Brenda S. Carter, Bill T. Crawford, Midge Crawford, Charles Davidson, F. E. Eyman, Leigh H. Fredrickson, Erik K. Fritzell, Larry R. Gale, Edwin H. Glaser, Timothy L. Haithcoat, Kellie Haithcoat, Diana L. Hallet, Leroy Heman, Dale D. Humburg, Sherman Kelly, Chris Kelly, Robert B. King, Robert D. Miller, Charles A. Purkett, Cheryl K. Riley, Ed Stegner, Ollie Torgerson, Eric S. Wilson, John E. Wylie

MISSISSIPPI
Dale H. Arner, Julia B. Arner, Lewis W. Bays, Ellis J. Clairain, Billy J. Cross, Stephen W. Forsythe, James I. Jones, Chester O. Martin, L. Jean O'Neil, Thomas H. Roberts, Ross Shelton, Gwen Shelton, Hanley K. Smith, Lon Strong, Bill Tomlinson

MONTANA
Andrew C. Dana, Robert L. Eng, Patrick Graham, Spencer Hegstad, Barbara Holder, Ron Marcoux, Daryle R. Murphy, Arnold Olsen, Leonard Sargent, James M. Sweeney, Kathi Sweeney, Dale Witt, Philip L. Wright

NEBRASKA
Keith W. Harmon, Jane Johnson, Ken Johnson

NEVADA
Donald J. Armentrout, Phillip B. Davis, Donald A. Molde, William A. Molini, Jim Yoakum

NEW HAMPSHIRE
Richard Griffith, Bill Mautz, Donald R. Miller, Linda O'Bara, Ronald O'Bara, Scot J. Williamson, Rawson L. Wood

NEW JERSEY
James E. Applegate, Herb Blackwell, Ann Cali, Ben Callaway, Russell A. Cookingham, Kenneth C. Davis, Helen C. Fenske, Joseph Fischl, Jo Ann Frier-Murza, Paulette Garron, Howard Geduldig, Christina Holstrom, George P. Howard, Marianne Manzuk, Tony Petrongolo, Dennis Slate, Leonard J. Wolgast

NEW MEXICO
Roger Bumstead, Carol Cochran, Bill Huey, H. Stevan Logsdon, Harold F. Olson, James M. Ramakka, Kurt Sandoval, Sanford D. Schemnitz, Mike Spear, Daniel Sutcliffe, Tom Watts, Clarence R. West, Bo West, William D. Zeedyk

NEW YORK
Gordon R. Batcheller, Donald F. Behrend, Angie Berchielli, Marc A. Breslav, Harlan B. Brumsted, Evelyn C. Brumsted, John L. Buckley, Robert L. Burgess, Catherine Campbell, Ralph F. Campbell, Kevin Church, Phyllis Dague, Daniel J. Decker, Herbert E. Doig, Mark Ellingwood, Sherman Gray, William R. Hilts, Sylvia Hilts, Arthur M. Johnsen, J. Edward Kautz, Marie Kautz, Tracy Kay, Robert Kent, Gaut-Lian C. Kreamer, Richard Martyr, Michael J. Matthews, Jay McAninch, Judith McIntyre, Aaron N. Moen, Ron Moen, Charles Nilon, Karl Parker, Bill Porter, Ken G. Purdy, Gordon C. Robertson, Patricia Riexinger, James P. Rod, Peter Roemer, William Sarbello, William I. Spencer, Laura E. Tessier, Thomas N. Tomsa, James D. Weaver, Ray Winchcombe, Ed Zern

NORTH CAROLINA
John M. Beland, W. Vernon Bevill, Dick Brame, Peter Campbell, Elizabeth Creech, Phillip D. Doerr, Manley Fuller, Joe Freeman, Brad B. Gunn, Isaac Harrold, Jess Hawkins, William Hester, Judy Hinkley, Laura E. Jackson, Richard A. Lancia, Tim Lemon, Leon L. Lineberry, James R. Linville, Edward M. Lunk, Gary L. Miller, Richard L. Noble, Tina M. Odenbaugh, Deborah S. Paul, Kenneth G. Rice, Gary L. San Julian, Byran J. Taylor, William E. Towell, Virginia Towell, Melinda Welton, Jim Wetherill, Andrew R. Wood, Sandra D. Wood

NORTH DAKOTA
Richard D. Crawford, Bob Hoffman, Ernest D. Husmann, Bob Meeks, Charles H. Schroeder

OHIO
Jonathan Bart, Karl E. Bednarik, Theodore A. Bookhout, Max E. Duckworth, James H. Glass, James W. Goodrich, Billie Jagers, Dennis L. Krusac, Chuck Olson, Tony J. Peterle, Robert Priddy, Joseph R. Robb, Janet Roth, Thomas W. Seamans

OKLAHOMA
Steven A. Lewis, Jay Mitchell, Phil Schneider, Lib Selman, Gene Stout

OREGON
Craig Bienz, Hugh Black, Cliff Hamilton, John E. Cornely, Robert W. Harris, John P. Harville, David B. Marshall, Betty Marshall, Laura Mason, E. Charles Meslow, William B. Morse, Richard J. Myshak, Judie Neilson, Jack W. Thomas

PENNSYLVANIA
Ralph W. Abele, Peggy Abele, Sylvia G. Bashline, Robert S. Bond, Ron Brenneman, Doris Brenneman, Robert P. Brooks, Robert Carline, Douglas Cottam, Peter S. Duncan, Paula Ford, Robert W. Franzen, William H. Goudy, Hitch Goudy, Joe Greenday, Tom Greenlee, Richard W. Gross, Kathleen Gross, Fred E. Hartman, Charles M. Harvey, Janice B. Hill, Jim Hudgins, James C. Hyde, Bryce Jordan, Jonelle Jordan, Ed Kuni, Steve Liscinsky, Jack Payne, Samuel R. Pursglove, Kent M. Reasons, Harvey A. Roberts, Dale E. Sheffer, Bryon P. Shissler, Gerald L. Storm, Tim Storm, Lee Stribling, James A. Thompson, Nancy G. Tilghman, James S. Wakeley, Thomas C. Walker

RHODE ISLAND
Thomas P. Husband

SOUTH CAROLINA
Dan Dobbins, John Frampton, G. P. Friday, Robert G. Hooper, Lisa C. Huff, Susan D. Jewell, Fred Kinard, Thomas S. Kohslaat, Rob Keck, Olin E. Rhodes, D. Lamar Robinette, Kim Scribner, Michael A. Smith, John R. Sweeney, James A. Timmerman, Gene W. Wood

SOUTH DAKOTA
K. L. Cool, Lester D. Flake, Tom McCabe, Terry Riley, James W. Salyer, Charles G. Scalet, Jeff Stingley

TENNESSEE
Ken Arney, Charles D. Buffington, Sharon Coe, John P. Doyal, Daryl Durham, Dan Eagar, Ronald J. Field, Ron Fox, Roberta E. Hylton, Roy L. Lassiter, Patricia S. Martin, Chester A. McConnell, Gary T. Myers, Ellen M. Rasch, David Woodward

TEXAS
Charles E. Allen, John T. Baccus, Sam L. Beasom, Deborah Blank, Lytle H. Blankenship, Eric G. Bolen, Ted L. Clark, Charles A. DeYoung, Jim Dickson, Dan Fagre, Paul N. Gray, Lowell K. Halls, Jane Halls, Howard Hunt, Wallace Klussmann, David M. Knotts, Michael Knotts, Brandt Mannchen, William I. Morrill, Freddie Morrill, C. R. Palmer, Nova Silvy, R. Douglas Slack, Brenda H. Smith, Loren M. Smith, Don Steinbach, Wendell Swank, James G. Teer, William Tietje, David A. Tilton, Murray T. Walton, Felixia Walton, Milton W. Weller, Walter J. Wenzel, Michael Zagata

UTAH
Bill Burbridge, Joseph A. Chapman, Keith E. Evans, William H. Geer, Norman V. Hancock, F. Claire Jensen, Sandra Jensen, Derris Jones, Jess Low, Bud Phelps, Homer D. Stapley, Stan Tixier, Gar W. Workman

VERMONT
David E. Capen, Rebecca A. Herbig, Howard E. Woodin

VIRGINIA
Keith A. Argow, Theordore B. Bampton, Evelyn W. Bampton, Richard C. Banks, Chris Bolgiano, Stephen S. Boynton, Pete Bromley, Beth Buehler, David Buehler, Edward P. Cliff, John S. Coleman, Joan M. Comanor, Lawrence V. Compton, Erminie Compton, Dick Cross, Josie Cross, Gerald H. Cross, Carol Dana, James D. Felkel, Herbert A. Foster, Jim Fraser, Nathan P. Garner, Barrett A. Garrison, Andrea Gaski, Mary T. Gaudette, Roy A. Geiger, Theodore N. Gianoutsos, Francoise T. Gianoutsos, Donald S. Girton, Ellen J. Goetz, John S. Gottschalk, C. R. Gutermuth, Marian Gutermuth, Wes Hayden, Eric C. Hellgren, F. Eugene Hester, Kirk Horn, Dale A. Jones, Roy L. Kirkpatrick, Barbara A. Knuth, Virgil Kopf, Jack Lorenz, Gene Ludlow, Dave Luukkonen, Linda A. Lyon, Sandra L. MacPherson, Carol A. Marchione-Heiser, Gary A. Marchione-Heiser, Raymond W. Matheny, Pamela K. McClelland, Leigh McDougal, Jai N. Mehta, Roger Milio, Conley L. Moffett, John M. Morton, Mary B. Moss, Charles E. Most, William F. Murphy, Carol M. Natella, Marcus C. Nelson, Wm. Harold Nesbitt, Richard M. Parsons, Steven Parsons, Larry Pettinger, Jack Reneau, George Rieger, Francis N. Satterlee, Frederick A. Servello, Thomas N. Shiflet, Robert F. Soots, W. M. Spaulding, Dean F. Stauffer, Bennie Stauffer, Fred A. Stormer, Michael Stuwe, Lloyd W. Swift, Rose Swift, Lee Talbot, Carl H. Thomas, David A. Tice, Barbara A. Tulip, Donna D. Turgeon, Michael R. Vaughan, Lynn Vaughan, Rolf Wollenstrom, Yvonne B. Weber, Gene Whitaker

WASHINGTON
Carl N. Crouse, Gloria Crouse, Lorin Hicks, Frank R. Lockard, Jim O'Donnell, Constance Perenyi, Rich Poelker, John F. Ratti, James A. Rochelle, L. F. Ruggiero, Jack Wayland

WEST VIRGINIA
Kathleen Carothers, Robert J. Cooper, Jenny M. Dickson, Kevin M. Dodge, Christopher C. Foster, Lynn Miller, Ralph F. Mumme, David Samuel, Shari L. Stevens, Donald Weber

WISCONSIN
Tim Andryk, George Archibald, C. D. Besadny, John Cary, Scott R. Craven, James W. Hardin, Mary Ellen Hardin, George Harrison, Kit Harrison, Hilda Harwood, Thomas A. Heberlein, Joseph J. Hickey, Lola G. Hickey, James Huntoon, Robert M. Jackson, Mrs. Robert M. Jackson, Kent E. Klepinger, Harry Libby, Kevin F. McCabe, Robert A. McCabe, Marie S. McCabe, Shirley Miller, Steven W. Miller, Dennis L. Olson, Robert Radtke, Orrin J. Rongstad, Robert Ruff, Don Rusch, Michael D. Samuel, Dennis A. Schenborn

WYOMING
Ted Baker, David Belitsky, Douglas M. Crowe, Timothea M. Crowe, Donald W. Dexter, John P. Ernst, William Oelklaus, Donald J. Seibert, Dale Strickland

CANADA
Michael G. Anderson, Robert O. Bailey, Dale Caswell, Wayne Cowan, Donald G. Dodds, Mrs. Donald G. Dodds, Donald L. Eldridge, George Finney, Henry L. Frew, G. L. Martin, George J. Mitchell, D. S. Morrison, Graham R. P. Mutch, Rick Page, D. F. W. Pollard, Merrill Prime, Don Simkin

MEXICO
Emilio R. Woodyard

FOREIGN
Bertrand des Clers de Beaumets, Sally DePra, Anna Loy, David Nellis, David Saltz

Banquet Invocation

O Lord God, when you created man and woman, you put them in a garden of Eden, enjoining them to till it and keep it. And so it is that we rejoice in the 50-year stewardship of the men and women who have gathered for this conference to take stock of this garden and their management of it. As have they, let us all care for your earth, that it may produce good fruit and plenty. Keep us, the people of this nation, from a preoccupation with convenience and our own gain, so that we will not despoil this garden and deprive others of its enjoyment. And so it is, Lord God, as we break bread here tonight we would be mindful of the hungry, and of the fact that they need not be so. So may we dedicate ourselves to making your earth a place of justice as well as of beauty and plenty, to the end that when we are through in our time and space we may leave in the world a little more beauty, a little more grace, a little more justice than would have been here had we not labored long and hard in it for what it is not but could be. We pray in the name of Jesus of Nazareth who loved even the lilies of the field and the fish of the sea, and commanded us to break bread with everybody. Amen.

The Rev. Henry A. Baumann
Fairfax Presbyterian Church
Fairfax, Virginia

Index