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Edited by

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Chair
WILLIAM P. HYTCHE
University of Maryland Eastern Shore
Princess Anne, Maryland

Cochair
STEVE N. WILSON
International Association of Fish and Wildlife Agencies
and Arkansas Game and Fish Commission
Little Rock, Arkansas

Opening Remarks

Rollin D. Sparrowe
Wildlife Management Institute
Washington, D.C.

Welcome to the 58th North American Wildlife and Natural Resources Conference. A diverse program will focus our attention on scientific developments, management experience and resultant policy in addressing critical problems ranging from human overpopulation to migratory bird management. The purpose of this Conference, since its beginning in 1915, has been to serve as a forum for a wide array of interests and expertise to address ways to make our natural world more productive. This objective is needed now more than ever, as competing interests vie for future management direction of our forests, rangelands, wetlands, farmlands, and associated fish and wildlife.

We all are aware that powerful transitions in thinking, values and application to resource management are underway in North America. Not the least of these is an abrupt and forceful change in direction by the new administration in Washington. Since the election great oscillations in philosophy have emerged on the U.S. conservation scene Many who feel they have been ''outside the system'' for more than a decade are prepared to assure quantum leaps in new directions in every arena of natural resource management. Individuals have been exhorting resource management agency staffs to ignore internal agency direction, to change their use of staff and dollars without regard to designated purposes, to make biological diversity the main goal in everything they do. Whether this is a responsible way to make reasonable and needed change is questionable.

Natural resource management in the '90s is hazardous business. Pressures are as great to maintain the viability of local economies dependent on public resources as they are to maintain the viability of wildlife or fish that depend on those same natural resources. Agency managers are subject to pressures from local constituencies that mistrust them, bring political pressure to bear on them, speak out against actual and perceived government interference, and yet demand sustainability of life-styles dependent on the resources the agencies are charged to protect and manage. These agencies receive the oversight of elected representatives and executive branch appointees who often enter office on a basis of campaigning against government.

Professional resource managers across the United States are aware of potential significant changes in agencies in the Interior and Agriculture departments. The desire for changes raises important questions. Do we provide a better framework for professionally trained agency managers to manage, and hold them accountable, or do we enforce our personal or organizational views on issues by imposing more rules and legislation, and by tampering with the inner working of agencies? Sessions at this Conference focus on ways to improve agency functions and avoid such intrusions.

Nowhere has more controversy arisen over these topics than in the dispute over the northern spotted owl. Allegations of misuse of science by agencies has focused attention on the scientific basis of resource management decisions. Recent contacts with principals involved in the spotted owl debate, in and out of the agencies involved, reveal that there were few true differences between the scientists' viewpoints. The differences were in the actions of managers—some politically appointed and some career—who second-guessed the science to provide answers they thought were desired by industry, politicians or even environmental organizations. Resolution of this issue appears mired in the courts. This is a clear failure of agency management systems to handle significant problems.

During the past year, conservationists held out hope that the USDA Forest Service, U.S. Fish and Wildlife Service and other agencies in the Southwest would collaborate to change directions in forest management and avoid having to list the Mexican spotted owl. Apparently, management, in this instance, again has not done its job and listing is in progress. By contrast, the Forest Service can take credit for the bold step of radical changes in timber management to avoid a crisis over spotted owls in California. Of course, the action is under attack through litigation and appeals, and the outcome is far from clear.

The spotted owl examples illustrate the imperative need for science within the agencies, strongly applied to reasonable actions on behalf of the resource by management leadership dedicated to following law, and mindful always of the agencies' prescribed public trust missions.

Questions of credibility, then, are not really questions of science to be solved by isolating and insulating scientists, but rather are produced by actions taken in response to what scientists do. Such a problem can only be fixed by leadership. The single greatest problem is agonizing decisions over management and policy issues—such as with endangered species, timber harvest, wetlands and grazing public lands—has been lack of leadership from the top down, from the Executive Office to field managers of agencies.

Progress since the 1930s in wildlife and fishery management at the state, provincial and federal levels has been founded on the strong introduction of biological science into agency programs. In the United States, the Cooperative Fish and Wildlife Research Unit program started more than 50 years ago to provide well-trained individuals to staff the agencies. Those programs have brought together dollars and scientific expertise from cooperating agencies and universities to satisfy the needs of each of the cooperators, and fish and wildlife resources. The flow of trained personnel into management positions in the agencies has had a powerful and positive impact on the capability of those agencies to apply science to daily management decisions. This flow must continue.

In the United States, federal land-management agencies need a consistent supply of new information from research. The U.S. Fish and Wildlife Service has special needs for research data to carry out its trust responsibilities outside of federal lands. Research is integral to the daily operations of the Service. There are parallel needs in the National Park Service, Bureau of Land Management and Forest Service, and certainly in Mexico and Canada. Information must be developed regularly with full input and direction from the users who will employ the information on the ground. In addition to the federal agencies' administration of federal lands, states and provinces have the primary job of implementing resource management where it counts. They must continue to be strong partners in setting priorities and directions for research in the progressive, scientifically based management of public resources.

These examples also illustrate the need for management to look at ecosystems, watersheds and other broad frameworks for sustaining of fish and wildlife resources and their habitats. After years of litigation and public pressure on the Ouachita National Forest in Arkansas and Oklahoma, the Forest Service has underway a major redirection in forest management. By top-down policy and local implementation, the Service has dramatically reduced reliance on even-age cutting trees from the bottoms to the tops of ridge lines. The Service has mapped long-term rotations of forest habitats that will meet both endangered species and forest management goals, and will provide for diversity of fish, wildlife, invertebrates and their habitats. Management of this forest presents an optimistic picture for the future and can serve as a model for many other locations and resource programs in North America.

Many will ask whether Ouachita managers go far enough in meeting goals for biological diversity or "native" ecosystems. Some of those who helped affect change from outside the agency still object to every timber cut, controlled burn and most other management actions on the forest. They don't realize that they have won. For the long run, the Ouachita is on the right track. Achieving a balance in pushing for change, measuring the result and accepting strong progress as a measure of victory must be applied to many areas of natural resource management that will be faced during the tenure of the current Administration.

Programs at this Conference again will focus on actions taken through the North American Waterfowl Management Plan, its joint ventures and the North American Wetlands Conservation Act. These programs have fostered unprecedented land protection and management partnerships in Canada, the United States and Mexico. The efforts still are not uniformly supported by some groups because the initial and primary energy and most of the private dollars have come from people interested in waterfowl and wetlands. Critics say the focus is too much on ducks. On the ground, the expanding joint ventures continue to benefit a growing array of species, habitats and ecosystems. They increasingly address water quality, responsible agriculture, watershed management, endangered species and much more.

Perhaps a solution is to bring together the joint venture boards from the waterfowl plan, the agencies and other groups with broad visions for our landscape. Together, they might expand attention of conservation efforts to the major watershed level. Groups who want broader things, in the name of biological diversity or some other goal, can present specific recommendations for action, funding and accomplishment that match the resources that have been committed by the "duck people." The need is to build on successes in this broadening program to reach common goals on a large scale, and to bring in more actively contributing partners. The spotting community—long committed to land and wetland protection—has provided initial leadership and needs help to incorporate and achieve the larger goals.

Agricultural programs offer a major opportunity to redirect huge sums of money into conservation programs on private lands. The Conservation Reserve, Swampbuster and other conservation measures have enhanced fish and wildlife habitats on 40 million acres of the American landscape. As subsidies are reduced, there will be strong interest in keeping funds in the farm community. Farmers are more likely to be persuaded to conserve soil, water, and habitats for fish and wildlife than to preserve biological diversity. Great gains for fish and wildlife over millions of acres can be made as a significant step toward restoring functioning ecosystems.

The Wetlands Reserve Program last year enrolled almost 50,000 acres under permanent easements to restore wetlands and adjacent uplands by removing marginal croplands from production. Farmers voluntarily entered in this pilot program in nine states. Protection of farmers' rights and interests, environmental benefits to taxpayers and enhanced public support have been the results. Conservationists are hopeful that strong steps are underway by the new Administration to enroll 1 million acres by 1995.

There will be renewed attention to improving management of national wildlife refuges. Personal and organizational visions for federal refuges range from recreational playpens to inviolate reserves. The history, original purposes and the law provide for something in between. How the problems with refuges are addressed can be a bellwether for responsible management of fish and wildlife and their habitats in North America. Legislation may be needed to solve real problems of inappropriate pressures on refuge resources. Such legislation can be widely supported if it sticks to addressing and solving specific problems.

The overall direction of refuge management is newly described in a draft environmental impact statement. Effective work through the public comment process can outline management direction for the refuge system to provide greater focus on ecosystems and biological diversity, without changing many traditional refuge purposes and the attendant, significant benefits. To foster these concepts in management, a program to work on surrounding private lands has been started by the U.S. Fish and Wildlife Service. While the initial focus is wetland restoration, work can expand to ecosystems and watersheds from this base. It must be approached a a joint state/federal partnership. Goals for biological diversity cannot be achieved without a strong private lands program that encompasses much more than what lies within refuge boundaries.

We convene this Conference and entertain a new Administration with expectation of significant change in programs that affect natural resources and their management. The need for leadership from top to bottom in agencies is clear. The need for support and delivery of virtually all these programs at the field level will require effective consultation, dialogue and on-the-ground collaboration to affect responsible changes.

In any transition in government, there must be careful treatment of valuable existing programs and cooperative relationships that have existed for decades. They have achieved much. Those in this audience who attended this Conference in prior decades will know what newcomers need to know—that meaningful and enduring change requires time and comes in small increments. New, even radical ideas can accelerate positive action, but all the players must have equal and timely input before radical changes are made.

Restoring Conservation Leadership at the U.S. Department of Agriculture

The Honorable Mike Espy
Secretary of the U.S. Department of Agriculture
Washington, D.C.

I am honored to be here to join you for the 58th North American Wildlife and Natural Resources Conference. I am particularly pleased to appear with my colleague and friend, Secretary of the Interior Bruce Babbitt.

As Bruce already has indicated, there is a new spirit in Washington, D.C., and a new philosophy when it comes to government, and natural resource and environmental issues. Part of that comes form a renewed commitment on the part of the U.S. Department of Agriculture (USDA) and the Department of the Interior to work together to solve resource management problems instead of create new ones. Bruce and I are committed to that purpose. Government can be part of the solution to the natural resource problems we face.

This morning, I want to discuss the role that USDA can and will play in promoting conservation and stewardship of the forest, range and croplands of the United States. In addition, I'll elaborate on the subject of coordination and cooperation among natural resource agencies—in USDA and with other government departments' agencies. Finally, I'd like to discuss, in greater detail, improvements I intend to make in how USDA goes about its business in conservation and forestry.

USDA Leadership in Conservation

The U.S. Department of Agriculture has a long and proud tradition of leadership in conservation and forestry. The Soil Conservation Service and the USDA Forest Service have played significant roles in protecting soils, water quality, fish and wildlife habitat, and forests and rangelands. In addition, the natural resource program of the Extension Service and the conservation programs of the Agricultural Stabilization and Conservation Service (ASCS) also have had an important hand in shaping the conservation landscape.

The USDA Forest Service manages 191 million acres of forests, rangelands and grasslands in the National Forest System. These public lands play an essential role in meeting the timber and non-timber resource needs of the nation. Fully half of the nation's softwood timber and half of the nation's big game and cold water fisheries are on national forest lands. In addition, 75 percent of the water in the West originates in the national forests.

The Forest Service's State and Private Forestry Program provides protection from fire, insects and disease for millions more acres of state and private forests. Its urban and cooperative forestry programs are the principle source of information and technical assistance for guiding management decisions affecting private, non-industrial and municipal forests across the nation. The Forest Service Research Program is the premier natural resource research program in the world, providing the scientific support and guidance affecting all aspects of resource management. The International Forestry Program is rapidly becoming the world leader in providing scientific and technical support for International resource management programs.

The Soil Conservation Service (SCS) shares similar notoriety as a world leader in conservation. As a source of technical support to farmers, ranchers and others, SCS provides outstanding leadership in tackling tough issues like non-point source pollution, wetland protection, and watershed restoration and management.

The ASCS administers cost-share programs to aid farmers in making conservation investments. It also directs implementation of the Conservation Reserve and Wetland Reserve Programs. The former has proven to be a highly successful tool for preventing erosion of highly erodible and environmentally sensitive farmland. The latter holds great promise to aid in restoring agricultural wetlands.

Finally, the natural resource program of the USDA Extension Service has provided valuable information and assistance to thousands of farmers, ranchers and woodland owners to guide them in making environmentally sound management decisions.

Unfortunately, however, these agencies and their programs have suffered in recent years. The Forest Service, for example, has been maligned for too narrow a focus on timber and too little attention to the non-timber resources it is entrusted to manage. The Soil Conservation Service has been accused of carding too much for the concerns of the farmer and too little for the needs of the soil and water resources in its care. Both agencies have suffered from a lack of clear direction, a clear signal of where they are to head in fulfilling their conservation and stewardship roles. It's time for a change.

We recognize that today's conservation challenges are significant. Issues like the conflict over protection and management of old-growth forests, reducing agriculture's impacts on water quality, and protecting wetlands are complex and controversial. However, with these challenges come important opportunities to affect changes in the conservation and stewardship of our forests, fields and waters.

The U.S. Department of Agriculture has the people, the expertise and the responsibility to provide the leadership in conservation that has been lacking in recent years. We look forward to fulfilling that role.

Coordination and Cooperation in Conservation

Our greatest challenge in USDA is to get the many agencies and programs of the Department which can affect natural resources and the environment working together to promote stewardship of these resources for present and future generations. In a Department consisting of 42 agencies and 124,000 employees, with representatives operating in every country of the nation, it is not unusual to find that programs and priorities can, at times, operate at cross purposes. This must come to an end. Instead, we must work together—with a common vision—to ensure that the resource and conservation implications of all programs in the Department are understood.

I have given considerable thought to reorganizing USDA to improve the coordination of key programs and to improve the visibility of the Department in dealing with critical agriculture issues. One area in which this coordination and visibility is crucial is in natural resources and environment.

It is critically important that American agriculture—and USDA—step up to the task of dealing with the environmental problems that agriculture can create. Clearly, many farmers have done so. Others, with the right information, and proper assistance, will be the same. However, USDA must continue to provide needed leadership to achieve these goals. I am certain if we do so, that the conservation record of American agriculture will continue to improve.

Cooperation and coordination with our sister agencies in the Department of the Interior and with the Environmental Protection Agency, are essential if improvements in conservation and land stewardship are to occur.

It is inconceivable to me that different agencies of the federal government can operate on the basis of different policies in dealing with common natural resources problems. It's inappropriate, it's inefficient and it sends the wrong message to the people we serve as stewards of their natural resources.

Of course, the best example of the failure of this kind of management is the situation now confronting the Pacific Northwest region as it affects old-communities who rely on these resources. The Forest Service, Bureau of Land Management, and Fish and Wildlife Service share responsibility for the public land resources of the region. Yet, at time during the past four years, it often appeared that they were headed in opposite—or at least strongly divergent—directions in terms of policy and management direction. This must change.

As I noted earlier, Bruce Babbit and I are committed to working together to address issues of common concern. We will do so in identifying issues, in assessing options, and in implementing programs and policies on the ground—where it matters. As President Clinton has made clear, government can be a part of the solution. But only, I would add, when government is smart, efficient and working together.

Improving USDA's Conservation and Forestry Programs

I am committed to making needed improvements in the ways that USDA fulfills its conservation mission and stewardship role. Several concepts will guide our efforts to make these improvements.

First, at USDA we will emphasize the need to serve our customers better. During the campaign, Governor Clinton emphasized his desire to make USDA more farmer friendly. I intend to follow up on that commitment.

But USDA has many customers, in addition to farmers and ranchers. All of you here this morning are customers of USDA. And not simply because you eat. Those of you who care about a clean and healthy environment—whether you're a rural resident or from a city or suburb—are USDA customers as well. We intend to serve you, too.

Second, I believe that sound policy must be based on sound science. USDA has the capability—more than any other entity—to do the research needed to establish the factual basis for making informed policy and program decisions. We must strengthen the link between research and management so that our policies have this strong scientific foundation.

Third, we must look beyond the immediate effects of management decisions to be sure that we understand the ramifications on both a special and temporal basis. Simply stated, we need to see the forest for the trees and be sure that today's fix does not create tomorrow's problem.

This concept has immediate application in dealing with the old-growth issue. But it also has ramifications for how we deal with conservation and water quality concerns.

Last year, Forest Service Chief Dale Robertson announced the agency's commitment to ecosystem management. Similarly, the Soil Conservation Service has pioneered efforts to promote watershed-based planning for conservation strategies. We must strengthen these efforts and develop the information base to fully implement these strategies. But, as a part of this effort, we must also commit the resources needed to monitor our actions, to measure our progress over time. Strategies like ecosystem management and watershed planning are for the long term. We must establish the capability to be certain that we are accomplishing what we set out to do, and to take corrective measures when it appears that we have strayed off course.

A fourth concept that should guide our conservation and forestry programs is the concept of sustainability. Management strategies—be they for agricultural lands or forests—can only be effective if they lead to sustainable production of the goods and services which the land provides. Sustainable production, in turn, can provide the basis for sustaining the economies of rural communities and provide them with a more certain future.

Fifth, I strongly believe that management is an effective tool for dealing with the nation's natural resource problems. Too often, advocates propose to limit management options as a way of solving problems. Too often, debate over forestry issues has focussed simply on which lands to manage and which to preserve. The problem with this approach is that as our land base shrinks, the conflicts over management of remaining lands intensifies. Management strategies that include the preservation of environmentally sensitive or ecologically significant lands should be part of the solution, but not the only solution. Sixth, management strategies must be adaptive. That is, with the research and monitoring to back it up, management should respond to changing conditions and be sufficiently flexible. For example, it wasn't too long ago that standard management practice was to eliminate downed timber and woody debris from streams as a fishery management practice. Subsequent research showed that it was better to leave this material in streams to provide needed habitat. Current management reflects that viewpoint—i.e., changes were made to adapt a new information.

A seventh criteria that will guide all our natural resource and conservation programs and policies is that they simply comply with existing law.

Number eight, I intend to ensure that we take full advantage of opportunities to develop partnerships, where appropriate, with the private sector. For example, the wetland acquisition program of Ducks Unlimited, Inc. and the federal Wetland Reserve Program could work jointly to protect important wetland resources. Additionally, the land-protection activities of The Nature Conservancy and other state and local conservation groups could aid the Forest Service in acquiring important and desirable forest tracts.

While representing the 2nd Congressional district of Mississippi, I worked closely with The Nature Conservancy to establish the Dahomey National Wildlife Refuge. Past efforts like this demonstrate the benefit of public/private partnerships. I will seek to expand these efforts to help promote an effective and efficient strategy for land acquisitions.

Ninth, I will seek to ensure that common sense guides us in the development and implementation of our conservation programs. By this, I mean that rules and regulations should be customer-oriented, "user-friendly," and guided by common sense. This is critically important if we expect farmers and ranchers to take the initiative to address agricultural conservation concerns.

Finally, we must restore public faith in resource management professionals and their ability to serve as stewards of the land. USDA is blessed to have two agencies with the expertise and experience that SCS and the Forest Service bring to natural resource and conservation issues. We must reestablish the credibility of these agencies and empower these professionals to use their knowledge and skills in dealing with these issues. If so, I am convinced that the nation's natural resources will benefit and the public's faith will be restored.

Summary

In closing, let me say that I believe USDA has the capability to move aggressively to deal with many of the natural resource and environmental problems facing our nation. We have the resource and environmental problems facing our nation. We have the resources, the professional expertise and the will to get the job done. I look forward to serving you and the people of this great nation in leading USDA to achieve this important goal.

Marine Fisheries: Our National Resource, Our National Responsibility

Nancy Foster
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Washington, D.C.

Introduction

Our past Assistant Administrator for Fisheries distributed an "all hands" memorandum summarizing his views on major issues facing marine fisheries and the National Marine Fisheries Service (NMFS) when he first assumed the position. In that memorandum, he stated his belief that over the long term, the loss of nearshore ocean and estuarine fishery habitat probably is the greatest threat to United States marine fishery productivity. Today, I am even more convinced that this is true. The challenge is to help materially to turn back this threat.

U.S. commercial and recreational fisheries contribute about $30 billion annually to the U.S. Gross National Product (commercial fisheries, $17 billion and saltwater recreational fisheries, $13.5 billion). More than 70 percent of U.S. commercial and recreational fishery landings are composed of species that are associated with estuaries during some life-history stage.

Each year we are losing marine and estuarine fish habitats due to intentional and accidental physical alteration and other human impacts. The capacity of our habitats to produce continued high levels of living marine resources is diminishing, while pressures for their conversion to other uses are continuing. Despite our regulatory programs and coastal zone plans, human population growth and increasing development continue to result in a net loss of habitats. The U.S. coastal population has risen by 40 million people since 1960. Today, about half the population lives within 50 miles of the shoreline; this population continues to grow at four times the national average. It is inevitable that this growth will alter the marine, estuarine and anadromous habitats essential to the production and health of fishery resources. These losses are not unique to marine and estuarine resources.

Nearly all agencies, institutions and individuals represented at this Conference have some interest, if not responsibility, in the protection of fish and wildlife habitats. Many of our are involved with preservation of endangered and threatened species, the designation of important habitat areas as sanctuaries and refuges, and restoration of already degraded habitats. In the case of NMFS, Federal fishery management plans and regulations will be moot if habitat loss and degradation destroy the very fish and shellfish populations for which they are prepared.

My central message today is that the protection of fish and wildlife habitats is a national problem in critical need of attention. This Conference is an excellent forum to discuss the strengths and weaknesses of our habitat protection laws, policies and programs. Why are we losing the war against fish and wildlife habitat loss? What steps are needed to stop and offset the losses? Are the federal and state fish and wildlife agencies meeting their responsibilities? I hope that by sharing our habitat protection experiences, we may leave here with a better understanding of what will be needed in years to come.

Let's talk about my agency, the National Marine Fisheries Service (NMFS). There are four general approaches that I believe are critical in NMFS's contribution to our national agenda for conservation of marine and estuarine habitats. I hope that you will find some of these provocative and perhaps applicable in your own programs.

Approach I. Habitat Protection—The Highest Priority

I would like to emphasize the high priority afforded habitat protection programs with a reference to restoration. During September 25–26, 1990, the National Oceanic and Atmospheric Administration (NOAA) sponsored the first national restoration symposium in Washington, D.C., "Restoring the Nation's Marine Environment." Selected panelists included 15 eminent scientists and researchers, experts in such field as ecology, marine science, fisheries biology, and physical and chemical oceanography. The members of the audience, any of whom were deeply concerned with habitat restoration, filled the Commerce Department auditorium. One important point was raised repeatedly: first priority should always be placed on *protection* of habitats. While restoration is an important option to be considered, successful protection will preclude the need for restoration solutions. A small amount of protection can decrease the need for a great deal of restoration.

The assignment of endangered and threatened status to many species is symptomatic of the cumulative, ongoing nature of broad-based habitat deterioration. Conservation of fish and wildlife habitats must start with habitat protection. While perhaps in vogue at this time, it is not enough to focus our greatest energies only on maintaining the existence of endangered and threatened, and otherwise protected species. Habitat loss and degradation are the major factors contributing to endangerment and extinction. Success in preserving biological diversity will depend on the effectiveness of our collective habitat protection programs. Over the long term, the highest priority should be placed on getting the most out of our existing habitat protection authorities and resources.

I believe the most effective habitat conservation role for agencies like ours is advocacy at the local level. This advocacy should be carried out by influencing the many individual federal permits, licenses and construction projects, and conducting related habitat research and public education. Much protection is possible under existing provisions of the Fish and Wildlife Coordination Act, the Federal Power Act, the National Environmental Policy Act and other laws. Federal, state and local fish and wildlife agencies should be committed to influencing habitat-altering decisions of permitting and licensing agencies. Each permitting and licensing decision that damages or destroys marshes and wetlands should occur only after fish and wildlife agencies have exhausted available protection alternatives within our resources. Within NMFS we take this responsibility seriously. It is the cornerstone of our Habitat Protection Program.

Success of the NMFS program depends upon timely, effective and scientifically sound recommendations to protect habitat. It is true that federal regulatory agencies are not required to accept our recommendations. However, real benefits occur from our ability to provide high-quality scientific advice and to convince the action agency to accept our habitat conservation recommendations. Numerous examples have shown that our recommendations do make a difference and have substantial benefits for our nation's fisheries.

Other benefits also come from our local habitat conservation involvement. Our activities generate increased awareness within the Corps of Engineers and other federal construction and permit-granting agencies, as well as within state and local agencies and public interest groups. Developers often realize savings of cost and time when NMFS staff advise them during early stages of permit and license design. Finally, because of their routine "hands-on" experience, NMFS Habitat Protection staffs are requested frequently to assist other NOAA programs, such as Superfund Program activities, Regional Response Teams for releases of oil and hazardous substances, Regional Outer Continental Shelf Technical Working Groups, and the Environmental Protection Agency's National Estuary Program committees.

Some people dismiss Fish and Wildlife Coordination Act (FWCA) consultative powers, referring to them as "merely advisory" in nature. They reason that because federal permitting and licensing agencies do not have to accept fish and wildlife recommendations, consultation activities do not accomplish much. These persons view FWCA programs as ineffective or as a useless exercise. At best, this attitude is internally divisive. At worst, it undermines our protection efforts.

Dismissing an "advisory" program on its face as ineffective is simplistic reasoning, since actual program effectiveness is the key issue. How an agency plays the consultation game has a significant influence on how its "advisory" recommendations get treated. HIghly credible recommendations are more likely to be accepted by the consulting federal development agency. Credibility rests on: (1) sufficient staff and resources to conduct competent evaluations; (2) adequate technical expertise; (3) negotiating skills; (4) the timeliness of recommendations; and (5) and the effectiveness of the recommendations' delivery. To the extent any of these ingredients are missing, the program's effectiveness is weakened.

"Consultative powers" can be very effective when properly used. However, their effectiveness can be compromised. I would like to remind detractors of the FWCA that it remains the most powerful overall habitat protection mandate available to us. It can be very effective when properly implemented. Often the FWCA is the only administrative recourse between a wetland's health and its loss. Those who advise that we should wait for "laws with more teeth" actually can undermine our agencies' will and effectiveness to protect habitats.

Having said that, it also is true that our effectiveness could be increased by improved federal laws. I'm referring specifically to legislation that would improve participation in individual grass roots decisions on water resource permits, licenses and construction projects. I'm not recommending a "veto" authority for fish and wildlife agencies, which I believe would be unrealistic and unworkable. However, I am in favor of legislation that would give general and state fish and wildlife agencies a stronger role in the permitting and licensing processes. Such legislation also should expand currently limited fish and wildlife staffing and funding dedicated to habitat protection. For these reasons, we are following with interest the proposed Wetlands Reform Act (i.e., Edwards Wetlands Bill).

Also, we are considering with our Fishery Management Councils possibly proposing legislation that which would parallel Section 7 of the Endangered Species Act. Under Section 7, federal permitting and licensing agencies must consult with NMFS or the U.S. Fish and Wildlife Service (FWS) to assure that proposed permits and licenses will not adversely affect endangered species. Such an amendment would require consultation by federal regulatory and construction agencies with NMFS, FWS, and state fish and wildlife agencies to assure that proposed federal permits and licenses will not adversely affect the productivity of fish and wildlife habitats.

Finally, enacting the strongest laws would be of little value if agencies lack the resources and the will to implement them. To address the latter half of this problem, we have over the past four years within NMFS created an Office of Habitat Protection and, within it, the Chesapeake Bay Office. As part of our National Habitat Protection Program, these offices exist to protect and conserve fish and shell fish habitats. However, these offices in themselves are not enough and I personally will continue to seek additional resources to further supplement the presence and effectiveness of our program.

Approach II. Habitat Restoration

In 1985, NMFS undertook a three-year cooperative pilot study with the U.S. Army Corps of Engineers (Corps) to restore fish habitats. Participation in this program was partially based on the conclusion that habitat protection and preservation programs, while vital and in need of expansion, are only part of the answer. The final report concluded that we must either acquiesce to the inevitable habitat losses or pursue alternatives that will routinely restore fishery productivity as it is lost.

In order to address this need, the NOAA Restoration Center was established in 1991 within the NMFS. The Center is a broadly based, cross-cutting program to lead the development and application of restoration science across the entire agency, and to participate in discharging NOAA's responsibilities as a federal trustee for marine resources in natural resource damage litigation.

Since its origin, the Restoration Center has taken its place as an integral part of the Damage Assessment and Restoration Program (DARP)—an interdisciplinary team of NOAA attorneys, scientists and economists. The DARP carries out NOAA's responsibilities as a federal trustee for natural resources under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); the Federal Water Pollution Control Act (Clean Water Act); and the Oil Pollution Act of 1990 (OPA). The DARP assesses the injury resulting to trust resources from releases of oil and other hazardous substances in the marine environment, seeks monetary awards from responsible parties for injuries and assessment costs and applies recoveries to restore, replace or acquire the equivalent of injured resources. The RC plays a central role in this process. It is responsible for restoration planing, both as a component of the damage assessment process (pre-settlement) and following the settlement of damage claims. After settlement, the RC's focus shifts to finalizing and implementing approved restoration plans and monitoring resulting progress.

The Restoration Center simultaneously is implementing a research and development program focused on improving NOAA's operational capabilities to undertake the restoration of fisheries habitats. Two initiatives in this regard relate to a Memorandum of Agreement (MOA) between NOAA and the U.S. Army Corps of Engineers for the restoration of fisheries habitats (established in 1991), and restoration efforts conducted in Louisiana by NMFS in association with the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990.

The NOAA/Corps MOA is a follow-on to the pilot study mentioned earlier. The pilot study resulted in developing a nursery for blue crabs and shallow-water fish and expansion of an existing oyster reef in the Maryland waters of the Chesapeake Bay, revegetating three sites atop existing disposal areas to stabilize sediments and restore habitats for shrimp, flounder, other fish and their food sources in North Carolina, salt marsh creation in Texas, and constructing an artificial reef along the California coast, resulting in mature plant and kelp production. In 1992, the Restoration Center initiated an additional five projects under the NOAA/Corps MOA.

The Restoration Center was awarded funding for two CWPPRA projects in FY 1992 and three additional projects in FY 1993. The implementation of all five NMFS-sponsored projects will benefit approximately 15,000 acres of wetlands in Louisiana's coastal zone. These restorations are being conducted with close cooperation from the NMFS Southeast Regional Office in Baton Rouge, Louisiana and the NMFS Southeast Fisheries Science Center laboratories in Beaufort, North Carolina, and Galveston, Texas. NMFS is likely to take on additional CWPPRA sites in FY 1994.

Finally, the Restoration Center presently is developing a Habitat Restoration Research Program within the NMFS. The aim of the program is to expand the tools and in-house capabilities for accomplishing and overseeing restoration, creation or acquisition of habitat for the benefit of living marine resources.

Approach III. Cooperative Programs

Cooperative interagency programs can provide opportunities that cut across all of the above-mentioned approaches. Effectiveness can be leveraged through cooperative efforts among federal, state and local agencies, conservation organizations, and user groups which also have authority and/or interest in the long-range quality of coastal ocean habitats. This approach is even more critical as agency budgets have been level-funded or reduced in recent years. It is my experience that many agencies are willing to work cooperatively to solve mutual problems. Such interagency networking among federal, state and local agencies may prove to have immense positive impacts. I encourage the exploration of areas of mutual concern.

An excellent example is the interagency Chesapeake Bay Program. Made up of state and federal agencies, this program has been a national success. It has been used as the primary model for the Environmental Protection Agency's national Estuary Program, the Gulf of Mexico Program and others. As with other estuaries, Chesapeake Bay issues and solutions are not controlled by any one jurisdiction or by any one federal, state or local agency. Interjurisdictional, multi-agency cooperation has proven to be a hallmark for tackling enormous water-quality problems related to excessive nutrient loadings to Chesapeake Bay. This Program's success has stemmed from the it's ability to forge regional consensus on potentially divisive issues that require costly solutions, either in terms of public expenditures or societal tradeoffs, e.g., limiting private property rights or limiting access to public resources.

To coordinate and take maximum advantage of NOAA's expertise in the Chesapeake Bay Program, the NOAA Chesapeake Bay Office, Annapolis, Maryland, was created during 1992 and placed in the NMFS Office of Habitat Protection. The Office's objectives are to improve cooperation among NOAA elements, the Environmental Protection Agency, and other Chesapeake Bay federal and state partners with staff in Annapolis, and strengthen and expand our research studies in areas in which NOAA has particular expertise. To achieve these objectives, the Office will continue its cooperative research on Bay fisheries stock dynamics, oyster diseases, effects of toxicants and nutrients on estuarine structure and function, atmospheric disposition of nitrogen, etc. It also will cooperate with other state and federal partners in the Chesapeake Bay Program to restore key habitats, such as oyster bars, wetlands, Bay grasses and anadromous spawning runs. In addition, the Office will work with NOAA's Office of Coastal Zone Management to integrate the Maryland and Virginia coastal zone management programs into the Chesapeake Bay Program, especially with respect to nonpoint source control and growth management.

Unique within NOAA, the Office seeks to focus the agency's energy in a single geographic region. It works cooperatively with a regional estuarine management organization to protect and restore living resources and the habitats they depend upon. Program benefits are value-added. Not only is the office funding applied Bay research, but it is ensuring that this research meets local management needs and that results are distributed to the appropriate users. Also, NMFS is able to leverage its expertise in habitat restoration and protection with considerable resources from other agencies. The close interaction between NOAA and the management, scientific and public communities of the Bay region will make certain the funds are well spent. The long-term benefits of the Office will be improved information for better management, protection and restoration of the Bay's living resources.

Nor should we constrain ourselves to searching for cooperating with agencies and groups solely interested in fisheries. Much more than fish habitat is adversely affected by pollution and degradation; other user groups have strong concerns about the quality of our rivers, lakes, and marine areas:

(1) the public is turned away from beaches closed for public health reasons;
(2) whitewater sporting interests are adversely affected by hydroelectric development;
(3) private property values and esthetics are affected by trash and degraded water;
(4) hotels and marinas are impacted by oil spills; and
(5) potential business losses occur to industries engaged in the development and manufacture of light-weight boats, campers, sports equipment and other recreational gear.

Thus, we should exploit opportunities to marshall our efforts with these impacted groups.

Approach IV. Research and Development

In too many instances, there are data deficiencies in all three major groups of information required for decision making—biological, economic and social. There seems never to be enough information or it is not translated into a format usable by managers. Rather than attempting to express specific types of research and development that are needed, let me instead deal with two underlying principles that should accompany habitat research programs:

(1) to formulate credible agency positions on habitat issues, state-of-the-art scientific results must form the basis for development of positions and recommendations; and
(2) to achieve an agency's full habitat conservation program potential, integration of habitat management and research programs is critical. Researchers should be involved in providing technical information which will insure the highest-quality agency positions. Research program priorities should be directed to producing information of this type.

Research priorities should be determined through iterative processes that include programmed inputs from the managers who will be using the information. For example, the NMFS Southeast Fisheries Center's Beaufort and Galveston laboratories are conducting research into the functional equivalency of created versus natural marshes. This work may show that the design criteria for mitigation need only be improved to approach productivity levels of natural habitats. On the other hand, results may show that such ends will be achieved more slowly or be more costly than anticipated. The answer may have major ramifications on federal mitigation policy and regulations.

Conclusion

Make no mistake. The nation's war to conserve fish and wildlife habitats is being lost. The need to promote protection of fish and wildlife habitats is a national priority. Fish and wildlife agency habitat protection programs are in need of expansion and revitalization.

Major inroads will require heavy commitment and teamwork by many public and private sector parties. Once an agenda is established, difficult decisions will be needed within each agency and organization in selecting the most effective approaches for implementation. Legislators should recognize that enactment of the strongest laws would have little value if government is not provided adequate resources to implement them.

(1) We should squeeze every bit of effectiveness from existing habitat protection laws and programs. These laws include the Fish and Wildlife Coordination Act, the Federal Power Act, the National Environmental Policy Act and others.

(2) NMFS believes that the most effective habitat protection role is advocacy at the local level in the many individual federal permits, licenses and construction projects

(3) Those who advise that we should await "laws with teeth" should reassess the fact that such laws may not come soon, if ever. Meanwhile, such a "wait and see" attitude actually undermines our collective will to protect habitats.

(4) We should attempt to improve our effectiveness by supporting legislation that would give federal and state fish and wildlife agencies a stronger role in the permitting and licensing processes. Dedicated staffing and funding for habitat protection should be expanded.

(5) With respect to habitat restoration, we must apply available technology to slow and reverse the present pattern of habitat loss. Simultaneously, we must direct research and development programs to improve the tools and technologies to restore, enhance and create fish habitats. Only through research and development efforts will restoration be made more efficient and less costly.

(6) Seeking out cooperative actions, such as the interagency Chesapeake Bay Program or the CWPPRA, provides opportunities to leverage our effectiveness by working cooperatively with agencies and third parties.

(7) We should seek out opportunities to marshall with other impacted groups, including swimmers, whitewater sporting interests, private property owners, hotels, marinas and sports equipment manufacturers.

And only with collective momentum in pursing the agenda can federal and state fish and wildlife agencies make important inroads in conserving habitats.

The Myth of Nature's Constancy— Preservation, Protection and Ecosystem Management

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Introduction

Two recent essays by noted ecologists Daniel Botkin and Jared Diamond throw light on certain issues in natural resource conservation today. Botkin (1992), in *A Natural Myth*, relates his experience with the Hutcheson Memorial Forest, an oak forest reserve on the New Jersey Piedmont. The forest had been set aside with private funds in the 1950s to preserve the "state of harmonious balance" that would perpetuate itself for centuries if left undisturbed. Within two decades, however, it became obvious that the oaks were not regenerating and a dense maple understory had developed. So much for harmonious balance. Later studies revealed that fires, probably set by Indians, had occurred at about 10–year intervals prior to, but not after, European settlement in 1701. Fires removed the understudy and favored oaks, creating the tall, open forest which naturalists in the 1950s and 1960s thought to be original and unaffected by human influence.

Jared Diamond (1992), in *Must We Shoot Deer to Save Nature?*, describes changes in Fontenelle Forest, a mature oak/hickory reserve on the floodplain of the Missouri River near Omaha. A 1,300–acre fragment of the once vast floodplain forests of the Missouri drainage, Fontenelle Forest was privately set aside to preserve it in its natural state—all plant and animal life is protected, no hunting is allowed. The philosophy for operating the reserve is one of no management, no human interference.

After describing the beauty of the place, Diamond recounts his dismay after a closer look: no oak or hickory seedlings, few acorns and nuts. The few understory stems were of ironwood and hackberry, plants of disturbed areas which disperse by wind-blown seeds or tiny fruits. Herbs such as snakeroot and stinging nettle had replaced oak and hickory seedlings on the forest floor. The forest was undergoing reverse succession. White-tailed deer (*Odocoileus virginianus*) were the culprits and heavy browsing indirectly affected understory birds, butterflies and wintering jays. The rules of non-interference had frustrated the goal of preserving the forest "in its natural state," i.e., the way it looked when the decision was made to preserve it.

Botkin and diamond have pointed out the paradox that the goals of non-interference with nature and preservation of natural habitats can be incompatible. Examples ranging from elephant damage to Kenya's Tsavo National Park to deer overbrowsing the Gettysburg National Historical Monument show that nature reserves probably can't be left to nature to manage. The same largely is true for designated wilderness areas, where it is becoming evident that fire suppression, changes in surrounding landscapes and environmental contaminants have profound effects on the wilderness itself. For example, many wilderness areas were not designated with ecosystem or biodiversity goals in mind, and, while the intent is for management by natural forces, normal natural disturbance patterns are rarely achieved.

Why does simple preservation often fail to achieve our expectations for ecosystems protection? We suggest that it is the set of relevant ecosystem processes rather than a given stage of development that must be preserved. We will emphasize the importance of regional differences in disturbance regimes and ecosystem processes, and the potential values of active management in preserving ecosystems based on our experiences in New England.

Preservation—States or Processes?

The idea of preserving a landscape in its natural state flows logically from the idea of natural succession to a climax community. Given enough time, ecosystems will tend toward a steady state of dynamic equilibrium (Bormann and Likens 1979). Consequently, the obvious strategy for achieving or preserving a climax state would seem to be to leave things alone.

Recent evidence, however, suggests the climax model may be inappropriate and that constant change is the rule for North American ecosystems (Botkin 1990, Pielou 1991). Furthermore, there is ample evidence that forests in eastern North America are still responding to the last glacial cycle (for a summary, *see* Davis 1976). If natural systems change constantly, preservation alone will rarely, if ever, maintain a particular ecosystem condition. Instead of preserving certain ecosystem states, we need to think in terms of maintaining ecosystem processes that are within our control. This entails taking the long view, realizing that plant and animal communities at a given site will change, sometimes dramatically, over time.

Eliminating human activity from a landscape may not produce a climax state, but it may protect the ecosystem if enough of it can be reserved. Presumably, if a reserve encompassed an entire ecosystem type, no management would be necessary because the full range of natural disturbance regimes, successional stages and species would be included. Few, if any, reserves or management areas encompass an entire ecosystem type; most include only a small fraction of the ecosystem type. While entire ecosystems need not necessarily be preserved to have the full range of disturbance regimes, stages and species, the extent does depend on the types of disturbance that characterize the ecosystem and the area requirements of particular species. Most reserves are too small to have disturbances that are frequent or large enough to maintain viable populations of early successional species. The smaller the portion of an ecosystem type that is protected, the more likely that native species, including key species such as top predators and large herbivores, will be missing, and natural processes will be interrupted and exotic species will be present. When only part of an ecosystem type is under protection, it is likely that management will be necessary to maintain the disturbance regimes, species and processes that shaped the original ecosystem.

Regional Differences

It follows that management must be conducted in a regional context that recognizes the disturbance and climatic regimes and geological factors that shaped the ecosystem in the recent past. Forces that shaped the presettlement forests of the Atlantic coastal plain, the Ohio River valley and New England are very different (Figure 1). Yet, concerns founded in one region often influence public opinion and management decisions in another, sometimes with little biological justification. For example, concerns about clear-cutting and brown-headed cowbird (*Molothrus ater*) parasitism voiced in mid-western woodlots, where gaps are the major forest disturbance, are echoed in northern New England where forests are extensive, big blowdowns are a major forest disturbance and cowbirds are uncommon. Obviously, management that would be appropriate in one region may not be in another.

Much of the concern about forest management in the eastern United States has focused on migratory birds since it became obvious that many of these species had undergone severe population declines at several widely scattered locations. Precipitous population declines occurred in the 1960s and 1970s at particular sites in the Middle Atlantic area (Briggs and Criswell 1978, Robbins 1979), New Jersey (Leck et al. 1988), upstate New York (Litwin and Smith 1992), Connecticut (Butcher et al. 1981) and Wisconsin (Ambuel

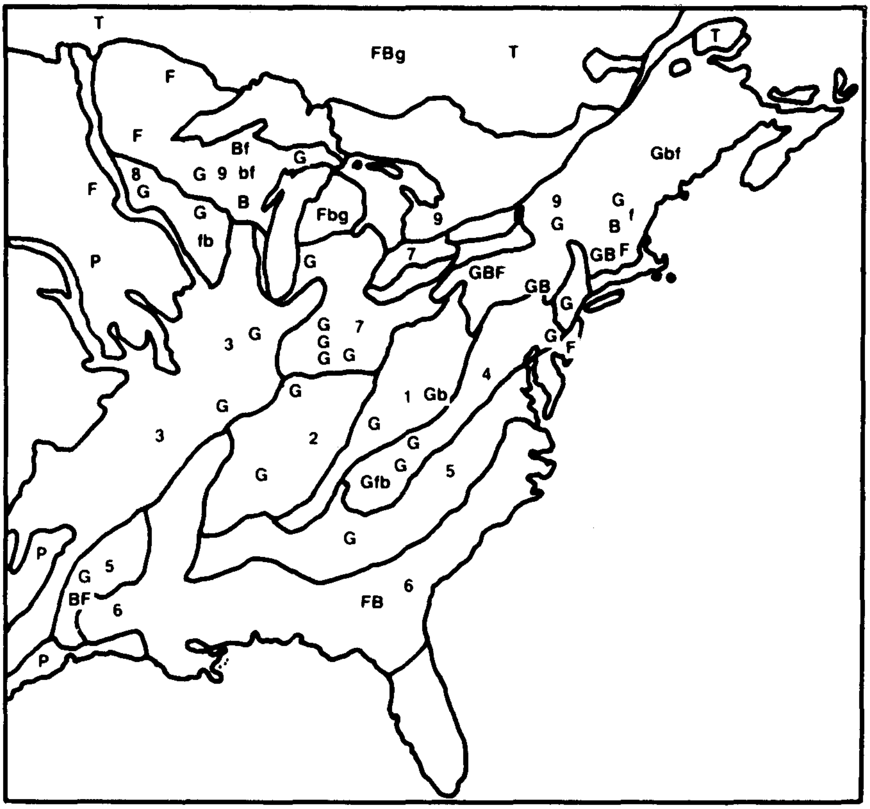

Figure 1. Geography of disturbance for the eastern deciduous forest (from Runkle 1990). F. and *f* locations indicate where fire was a major and minor importance, respectively; B and *b*, where big blowdowns were of major or minor importance, respectively; G and *g*, where gaps were of major or minor importance, respectively. The literature on which this figure is based and the names of the forest regions numbered on the figure, are given in Braun (1950).

and Temple 1982). Most of the species involved are so-called forest interior birds, species not usually found in open or early successional habitats. Furthermore, most are neotropical migrants. These declines have been hypothesized to have resulted from the fragmentation of forest near the study sites, resulting in the increasing isolation of the small patches (generally <100 ha) due to rapid suburbanization since 1950 (Askins et al. 1990).

It is well established that many species of forest migrants have low reproductive rates in small isolated forest fragments (Wilcove 1985, Robinson 1988, Small and Hunter 1988). In Missouri, male ovenbirds in small forest patches were less likely to be mated than males in large forests (Gibbs and Faaborg 1990). In small woodlots in Illinois, Robinson (1988) estimated that 80 percent of cup nests were destroyed by predation and 65 percent were parasitized by cowbirds. In large and small forests in the eastern U.S., the overall bird abundance and species richness are similar, but species composition is different: more forest interior migrant species occur in large forests and more generalist species occur in small forests (Whitcomb et al. 1981, Lynch and Whigham 1984, Freemark and Merriam 1986).

The brown-headed cowbird has long been known to parasitize nests of neotropical migratory birds, especially in the Midwest where the eastern deciduous forest gives way to the Great Plains (Leopold 1924, Gates and Gysel 1978). The Midwest is a farm/woodlot landscape (Whitcomb et al. 1981), where cowbirds penetrate to the interiors of forest islands and parasitize nests of forest-breeding birds (Brittingham and Temple 1983, Freemark and Merriam 1986).

Rates of nest predation and cowbird parasitism probably are higher in small isolated forest patches because even the center of a small fragment is close to the forest edge. Edges of forests in agricultural landscapes have higher densities of generalist mammalian predators (Wilcove 1985, Andren and Angelstam 1988) and nesting success has been shown to be lower at the forest edge than in the interior (Gates and Gysel 1978, Temple and Cary 1988).

In contrast to many parts of the Midwest, New England, since the 1840s, has experienced a steady, inexorable decline in agriculture that started with the opening of the Erie Canal and has continued to the present day. Once covered by the primeval forest, New England was cleared for family farms after European settlement in the seventeenth century. By 1840, 75 percent of the landscape was in crops and pasturage (Raup 1966). However, New England today is at least 75 percent forested and northern New England is more than 90 percent forested (Frieswyk and Malley 1985, Brooks and Birch 1988). The reversion of farmland to forest has resulted in extensive, mature forest cover, although species composition is different from that prior to European settlement (Foster et al. 1992). The pileated woodpecker (*Dryocopus pileatus*), as revealed by the Breeding Bird Survey, has shown a significant increase for the period 1982–1991 in eastern North America; the brown-headed cowbird has shown a significant decline for the same period. New England's forests become older and more extensive every year (Waddell et al. 1989), but miles of stone fences and thousands of old cellar holes give mute testimony to a history of intensive land use.

Most woodlands in New England are privately owned. Would the aging, extensive forests of New England, particularly northern New England, be fragmented by even-age management, specifically clear-cut harvesting? Two lines of evidence from managed public lands suggest that they would not. First, regeneration occurs rapidly and closed canopy sapling stands form within 7–10 years after clearcutting. The interfaces between even-aged stands (internal edges) are ephemeral and do not support distinct bird communities as do field/forest edges (DeGraaf 1992). We have found no evidence for increased rates of predation on artificial nests along these internal edges (DeGraaf unpublished). Predation rates on artificial nests, which are elevated in fragmented forests (Wilcove 1985, Angelstam 1986), were not elevated in seedling/sapling or poletimber stands compared to rates in mature northern hardwood stands in extensive forest (DeGraaf and Angelstam in press).

Second, all species of birds found in old-growth or virgin northern hardwood stands also are found in mature managed stands (DeGraaf 1987, Absalom 1988). In New England northern hardwood forests, four distinct breeding avifaunas occur in seedling, sapling, poletimber and mature stands; no species are unique to old-growth stands, nor are there differences in breeding bird composition among even-aged sawtimber, old growth or uneven-aged stands (DeGraaf 1987). Furthermore, a distribution of size classes ranging from regenerating to mature stands provides breeding habitat for approximately twice as many bird species as does an extensive, uneven-aged hardwood forest (DeGraaf 1987). Among small mammal communities, all species found in mature stands also are found in younger stands (Healy and Brooks 1988, DeGraaf et al. 1992). In our opinion, the main negative impact of logging probably is the resultant haul roads that are large enough to create permanent corridors or promote human access rather than the logging itself. In Maine, marten (*Martes americana*) occupy logged as well as mature conifer forest, but are taken in disproportionally high numbers in logged stands due to trapper access via the logging roads (D. Harrison personal communication). Megafaunal species that have shown declines or avoidance of habitats as road densities increased include black bear (*Ursus americanus*) in the Adirondacks (Brocke et al. 1990), wolf (*Canis lupus*) in Minnesota and Wisconsin (Theil 1985, Mech et al. 1988), and mountain lion (*Felis concolor*) in Utah (Van Dyke et al. 1986). Increased vulnerability to hunter harvest has been related to road density for moose (*Alces alces*) in Canada (Fraser 1976, Crete et al. 1981) and white-tailed deer (Sage et al. 1983).

The less-frequent once or twice per century stand entry associated with even-aged management may result in fewer roads, or roads that grow over more quickly than roads needed for the frequent entry (every 10–15 years) under uneven-aged management. As many roads as possible should be closed after logging, especially to vehicular traffic (Brocke et al. 1990).

Multiple Use and Old Growth

Can multiple-use management also accommodate the need for old-growth forest? We think it can. First, and most directly, large blocks can be managed for old-growth by excluding most vegetation management practices. This is the approach used in New England's national forests, where about half the forest area has been designated for old-growth. Even with intensive timber management in the remaining forest, mature and old-growth forest forms a contiguous block with patch size nearly equal to the total forest area. Seedling/sapling stands will be ephemeral islands in the forest landscape.

We also are optimistic that some old-growth values can be provided in stands and forests managed for other values. In northern hardwoods, it is possible to achieve an old-growth age structure (*sensu* Hayward 1991) and harvest some timber using uneven-age silvicultural systems. We also think even-aged and two-aged silvicultural systems can be used to provide some old-growth values, provided we can define the desired age and stand structures. Modifying silvicultural systems to provide commodities and old-growth values deserves more attention; it will require a clear definition of old growth for eastern forest types.

Much concern has been expressed about forest birds, but that concern should not be limited to any one species, guild or habitat type. We need to save all the pieces of the regional mosaic—early successional, late successional and everything in between. We need to provide these components at spatial and temporal scales that meet the needs of wildlife and reflect the natural patterns of disturbance.

Seral Communities

Declines of grassland and shrubland birds in eastern North America are more alarming and more consistent than those reported for forest migrants (Askins 1992). Many species of grassland birds have declined significantly since 1966 and these declines have occurred in the Midwest as well as the Northeast (Robbins et al. 1986, Bollinger and Gavin 1992). Compared with birds of mature forests, which, in the East, have been shown to be quite tolerant of disturbance and successional changes beyond the poletimber stage (e.g., Webb et al. 1977, Maurer et al. 1981, DeGraaf 1987), grassland birds are specialists that quickly disappear from a site as the vegetation changes. For example, grasshopper sparrows (*Ammodramus sauannarum*) need grassland interspersed with bare ground (Smith 1963, Whitmore 1981); Henslow's sparrows (*A. henslowii*) need fields with a deep litter layer, standing dead forbs and tall, dense grass (Zimmerman 1988), and bobolinks (*Dolichonyx oryzivorus*) need hayfields with low proportions of alfalfa (Kantrud 1981, Bollinger and Gavin 1992).

As grasslands and abandoned fields are invaded by shrubs and small trees, grassland specialists are replaced by shrubland specialists, which, like the grassland species, are dependent on transitory, even ephemeral habitats. Shrublands quickly become unsuitable habitat for species such as golden-winged warblers (*Vermivora chrysoptera*) (Confer and Knapp 1981) or yellow-breasted chats (*Icteria virens*) (Shugart and James 1973, Thompson 1977, Andrle and Carroll 1988). A shrubland/forest edge generalist, the rufous-sided towhee (*Pipilo erythropthalmus*), has declined steadily 8–10 percent per year in New England since 1966 (John Hagan personal communication).

Grasslands and Shrublands as Natural Habitats

Do the declines of grassland and shrubland birds (and possibly other species) in eastern North America reflect a return to presettlement conditions? Clearly, some species spread eastward from the Great Plains as the East was cleared for farmland—horned lark (*Eremophila alpestris*), dickcissel (*Spiza americana*), western meadowlark (*Sturnella neglecta*) and brown-headed cowbird are examples (Lanyon 1956, Hurley and Franks 1976). But there is ample evidence that grasslands and other open habitats were common in eastern North America before Europeans arrived. Large natural prairies occurred on Long Island (Niering and Dreyer 1989); open habitats occurred in southern New England, possibly maintained by Indian burns (Bromley 1935). In the period 500–1000 AD, Indians shifted from food gathering to food production and storage—maize, beans and pumpkins were planted in fields (Likens 1972). The interior of the eastern deciduous forest biome (present-day Ohio River Valley) was primarily influenced by small-scale disturbances, i.e., gaps, but large-scale disturbances occur throughout the biome. Hurricanes affect coastal areas primarily (Nelson and Zillgitt 1969; Foster 1988a, 1988b).

Fires are major sources of disturbance at the edges of the biome, probably for different reasons in different locations (Runkle 1990). In the Southeast, sandy soils and high temperatures make fires more likely (Nelson and Zillgitt 1969); toward the Great Plains, low precipitation increases fire frequency. In northern forests, fire frequency may be related to increased proportions of flammable conifers such as pine and spruce (Whitney 1986). Low-intensity fires have maintained open habitats in Maine for at least the past 900 years (Winne 1988). The health hen, an extinct subspecies of the greater prairie chicken (*Tympanuchus cupido*), restricted to grassland and other open habitats (Forbush 1927), was abundant in the 17th century from Massachusetts to Maryland (Gross 1932), indicating that there were extensive grasslands, but most East Coast grasslands were destroyed long before their bird communities were described (Askins in press).

The nomadic habits of grassland birds (Wiens 1969, Fretwell 1986, Whitmore and Hall 1978) and the tolerance to disturbance of mature forest birds (Webb et al. 1977, Maurer et al. 1981, DeGraaf 1987) likely reflect avian responses to disturbance regimes in eastern North America.

Clearly, grassland and other early successional habitats were historically present in presettlement New England, and it is reasonable to maintain and manage grasslands using fire, mowing and grazing to prevent invasion by forest vegetation. Shrublands can be maintained by applying methods used to produce stable shrub communities on powerline rights-of-way (Niering and Goodwin 1974, Bramble et al. 1990).

Management to provide early successional habitats is necessary in view of recent declines of such habitats. In 1950, about 30 percent of the New England forest was in the seedling or sapling stage (Black 1950); by the 1970s, these stages represented 14 percent; and by the 1980s, 8 percent of the forest cover (Brooks and Birch 1988). Hay crop acreage has declined 46 percent in New England since 1966 (U.S. Department of Agriculture 1967, 1987). The decline of early successional habitats and the aging of forests in the Northeast have implications for all wildlife species.

In sum, concerns about forest migrants are valid, but their breeding habitats are increasing in parts of the Northeast. Early successional species and habitats are declining acutely in New England and in eastern North America in general (Askins 1992). Natural disturbance regimes vary regionally. Wildlife communities reflect these disturbance patterns and management practices should acknowledge, if not mimic, these regimes.

Habitat Relationships—Effects of Scale

Increasingly, natural resource management is being viewed in a landscape or ecosystem context (Forman and Godron 1986, Rodiek and Bolen 1991, DeGraaf et al. 1992). Most forest management activities are applied at the stand level, but many species have territories or home ranges that are much larger and also include nonforest habitats: red-tailed hawk (*Buteo jamaicensis*), wild turkey (*Meleagris gallopavo*), black bear (*Ursus americanus*) and moose (*Alces alces*) are examples. Traditional wildlife habitat management has focused on single or featured species approaches to providing and manipulating the target species' habitat requirements of food, water, cover and their spatial distribution in a given area (Schemnitz 1980). Incorporating the needs of all wildlife species in a management plan requires a hierarchical approach to habitat relationships. Such an approach has been proposed for management of New England wildlife associated with forest habitats (DeGraaf et al. 1992).

Today, resource management professionals are faced with several new philosophical outlooks, described as "new forestry" and "ecosystem management." New habitat management approaches are concerned with addressing the complexity of natural and managed systems and the task of managing lands for biological diversity (Trauger and Hall 1992). Much greater emphasis is being placed on spatial distribution of habitats and changing habitat patterns across landscapes and over time. Basic ecological approaches to forest land management must consider forest area, species diversity related to habitat scales, predictable patterns of vegetative structure, natural disturbance patterns and human impacts (DeGraaf et al. 1992, Hunter 1990). No single management system on any one scale will meet the needs of all wildlife at any given time or place. It is important to have a suite of ecologically based management strategies to address all species needs in view of the changing cultural demands placed on forests today.

In new England, extensive forests of uniform age or vegetative structure provide habitat for relatively few species. When a variety of upland openings and aquatic habitats are present, the number of species increases dramatically. For example: landscapes of unbroken mature forests have approximately 100 vertebrates; forests and early successional habitats, about 200; and forests with early successional and aquatic habitats, more than 300 vertebrates.

Conclusions

Management for both societal and biological goals must be planned and conducted in a regional context. Forest products vary regionally in economic importance. Natural disturbance regimes, to which endemic communities are adapted, also vary regionally.

Human activities dominate the landscape; we are "managing" vegetation and wildlife whether we are aware of it or not. The forests have returned after extensive clearing started in the 18th century, but introduced pests have altered the forests forever. The introduction of the chestnut blight (*Endothia parasitica*) and gypsy moth (*Lymantria dispar*) probably had a greater impact on forests and wildlife in the eastern deciduous forest than any other event since land clearing in the 17th and 18th centuries.

In eastern North America, forest management and wildlife management are not at biological odds. Many vertebrate species depend on early successional habitats, while none are unique to old-growth forests. Early successional habitats and species are declining, while forests are becoming older and more extensive.

We emphasize the need to reach a middle ground between protecting ecosystems and producing goods and services. These activities are not mutually exclusive and, as professionals, we need to continue to seek ways to accommodate both protection and production. We will be able to preserve only small parts of ecosystems. Most of the landscape will be used but that fact does not diminish our responsibility to protect the land by preserving ecosystem processes. That requires management and would produce commodities as a by-product. We think the idea that commodities are by-products of the ecosystem ought to prevail in resource management.

We can consciously manage landscapes to provide habitat for endemic communities or let nature be and accept the consequences. In the heavily altered landscapes of the 20th century, nature is what we make it.

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4-H Wildlife and Fisheries Recognition Awards, 1992

Introducing Remarks

John F. Turner, Director, *U.S. Fish and Wildlife Service, Washington, D.C.*

Many of you here this morning had the opportunity—as I did—to meet the six National 4-H Wildlife and Fisheries Adult Volunteer Leader winners for 1992 at the reception ceremony held last evening. These truly are outstanding, generous people giving freely of their time and energies, leading some of our nation's finest young people. I am please to have this time to publicly recognize and thank these people—winners who represent thousands of other 4-H adult volunteer leaders—for their very essential contribution, inspiring 4-Hers to become life-long stewards of our fish and wildlife resources.

I am pleased to continue this U.S. Fish and Wildlife Service tradition: this is the 13th consecutive year we have worked in partnership with USDAs Cooperative Extension Service, to recognize six outstanding volunteer leaders for their significant contributions to our young people and their understanding of fish and wildlife resources.

Myron Johnsrud, Administrator for Extension, *U.S. Department of Agriculture, Washington, D.C.*

I, too, am pleased to participate in this program to honor these six 4-H Wildlife and Fisheries Volunteer Leaders, winners for 1992.

Once again, on behalf of the Cooperative Extension System and the U.S. Department of Agriculture, thanks to the U.S. Fish and Wildlife Service for their continuing support of this annual program, and to these outstanding volunteer leaders for their personal commitment and exemplary contributions to wildlife and fisheries 4-H youth education programs.

Award Recipients

Rod Chalmers, *Dripping Springs, Texas*

Rod Chalmers is a game warden training officer. He has been a 4-H volunteer for th past eight years and has served as Crockett County's 4-H field and stream program coordinator, 4-H shooting sports coordinator and as an instructor at adult leader training sessions for the hunting portions of field and stream workshops. Mr. Chalmers was named "Conservation Officer of the Year," by the Texas Parks and Wildlife Department in 1991, and was recognized for his emphasis on the use of educational programs to achieve natural resource conservation goals. He plans to continue his efforts to educate the youth of America for their role as future stewards of our nation's natural resources.

David G. Gabbard, *Lexington, Tennessee*

David Gabbard has been a 4-H volunteer leader for nine years. He also is a wildlife enforcement officer for the state of Tennessee. He and his wife Rosa have a twelve year-old son, Jon, and a seven year-old daughter, Sara. As a 4-H Wildlife and Fisheries leader, David has had the opportunity to introduce 4-H youngsters to activities as diverse as planting wildlife food plots to showing the how to trap and relocate wildlife using a rocket net. He has been deeply involved in the Tennessee 4-H shooting sports program, introducing 4-Hers to various shooting disciplines like archery, rifle and shotgun. The shooting sports program also includes outdoor skills like map reading and orienteering.

Mr. Gabbard points out that 4-H has given him "the opportunity to have a part in training our next generation to preserve and appreciate the great outdoors."

Catherine L. Munson, *Zackery, Louisiana*

Catherine Munson is the wife of Charles Munson and the mother of Scott, who is in the eleventh grade, and Vicky, now a seventh grader. Her family is a 4-H family and she has been a 4-H volunteer leader for the past 11 years. Catherine assisted in training four members of the Wildlife Habitat Evaluation Judging Team that placed 4th in the nation in 1991. She and her club helped organize two fishing trips for blind students, led many tours of Sabine National Wildlife Refuge, coached 4-H members for the junior judging contest, and will coach forestry and wildlife contestants and accompany them to national contests in the future.

Catherine continues to work hard to instill in her children and club members an understanding and appreciation of good wildlife habitat management and its contributions to our environment. Hunting, trapping and fishing activities are encouraged by Catherine as one of the best ways to keep kids from watching too much television. She encourages hands-on, experimental learning activities conducted outdoors as much as possible.

James H. Newquist, *Flanders, New Jersey*

James Newquist is a career educator and has been a 4-H volunteer leader for the past 15 years. He became a 4-H leader while his son, Kenneth, now a college student, was in elementary school. His wife Karen and daughter Kristen, also a college student, share his interest in the outdoors and in natural resource conservation in general. Jim has been the president of Essex County 4-H Leaders Association and serves as the county representative for the New Jersey 4-H Association. He has helped his 4-H members learn to interpret wildlife habitats and different species requirements, how to fish and to maintain quality streams.

Jim says that 4-H has influenced his life by providing opportunities to work with professionals and volunteers who have the same goals and have a genuine interest in helping youth realize that education will enrich their lives.

Irene S. Vansandt, *DeWitt, Arkansas*

Irene Vansandt is a nurse at Stuttgart Memorial Hospital. She has been a 4-H volunteer leader for 34 years and has provided leadership for teaching members in many areas of fish and wildlife conservation and management. She has led 4-H club competitive activities related to fish and wildlife, participated in Project Wild, built and erected nesting boxes for wood ducks and set up bird houses and feeders in parks and nursing homes.

Irene says she is a 4-H leader who fell in love with 4-H at first sight. She said, "There are not enough words for me to describe the Arkansas 4-H program and how wonderful it is."

Bonnie E. VanSpronsen, *Lowell, Michigan*

Bonnie VanSpronsen has been a 4-H volunteer leader for the past six years. She became a 4-H leader when her three sons, Ken, Joshua and Christopher were old enough to join 4-H. Bonnie and her husband, Karl thought that fisheries and wildlife was a field that was of interest to the whole family, especially since their ten acres outside Lowell contains a small pond, woods and a wetland. Bonnie started three school and two community 4-H clubs and coached three teams in the state fisheries and wildlife contest. She serves as the president of the 4-H Council in Kent County.

Bonnie says she never considered herself to be a teacher, but by virtue of being a parent, we all are teachers. She points out that we all desire to live in a better world, and to do so we must be willing to learn about it, respect it and work to make it better.

Concluding Remarks

John F. Turner, Director, *U.S. Fish and Wildlife Service*

Ladies and gentlemen, the value of the kind of work these six volunteer 4-H leaders do cannot be measured in traditional ways. Nevertheless, their positive impact in our nation's natural resources by helping youngsters learn to appreciate and understand the value of wise natural resource stewardship surely will be substantial for many years into the future. No wonder the 4-H Fisheries and Wildlife Program is growing—and so successful.

These six outstanding volunteers do not just talk about natural resources, they invest their time and energy guiding, inspiring and encouraging a large, key audience of youngsters. My sincere appreciation to these six winners and to the thousands of other volunteer 4-H wildlife and fisheries leaders they represent.

Myron Johnsrud, Administrator for Extension, *U.S. Department of Agriculture*

It is an honor and pleasure to co-present these awards this morning with Director John Turner, and to recognize briefly the significant contributions of these six outstanding 4-H Wildlife and Fisheries Volunteer Leader Winners for 1992. These dedicated volunteers have given freely of their time, resources and talent to help young people become better stewards of our natural resources. They are outstanding representatives of the hundreds of thousands of volunteer leaders across the nation who give of themselves to guide our young people of the present who will be better prepared to become our leaders for the future.

Thanks to you, John, and to the U.S. Fish and Wildlife Service for the continuing support and cooperation, and to these wonderful leaders for their past and future contributions.

The 1993 Guy Bradley Award

Whitney Tilt
National Fish and Wildlife Foundation
Washington, D.C.

Recognizing the vital role law enforcement plays in fish and wildlife conservation, the National Fish and Wildlife Foundation established an award to recognize excellence in wildlife law enforcement. Together with the biologists, habitat managers, and a host of other state and federal land-management professions, law enforcement represents a ''thin green line'' dedicated to conserving this nation's fish, wildlife and plant resources for future generations.

The Guy Bradley Award was established by the Foundation in 1988 to recognize the contribution of the law enforcement community to conservation. The award is to be given annually to that person, or persons, whose dedication and service to the protection of the country's natural resources provides outstanding leadership, extended excellence and lifetime commitment to the field of wildlife law enforcement, and whose actions advance the cause of wildlife conservation. The award is given in the spirit of Guy Bradley, an Audubon game warden killed in the line of duty in July 1905, while protecting a Florida rookery from plume hunters. Guy Bradley is believed to have been the first warden to give his life in the line of wildlife law enforcement.

In the past, the Foundation has recognized state and federal law conservation officers. Last year, the Foundation presented the award to Ronald D. Lahners, the United States Attorney in Omaha, Nebraska in recognition of the vital role the Department of Justice and state and federal judicial systems play in successful law enforcement. This year, the Foundation is pleased to recognize two individuals: Tom Moore, Forensic Scientist for the Wyoming Game and Fish Department and Richard Moulton, Special Agent for the U.S. Fish and Wildlife Service.

These two men were picked from a field of outstanding nominees by a volunteer panel of judges comprised of representatives from federal and state wildlife agencies and conservation organizations.

Tom Moore, Forensic Scientist, Wyoming Game and Fish Department

Tom Moore serves as the Senior Forensic Analyst for the Wyoming Game and Fish Laboratory in Laramie, Wyoming. Tom is a nationally recognized wildlife forensic scientist who, for more than 25 years, has made and continues to make outstanding contributions to the field of wildlife forensics and in the development of new techniques to aid wildlife law enforcement in the field. Tom's accomplishments are numerous. He has been instrumental in initiating and conducting research in the development of pioneering forensics tests, including the matching of meat and hair to specific individual animals using DNA probes. He also is an authority on animal hair identification, game animal blood and tissue identification. Further, he has helped advance the ability to identify the species of origin of cooked meats. Tom has recently coauthored the *Wildlife Forensic Field Manual*—an indispensable guide for the use of conservation officer in the field.

The hard work of dedicated field agents would mean nothing if the science were not there to back them up. The work of Tom Moore and many others like him has allowed law enforcement to become increasingly effective in tracking down wildlife violators. The poacher who kills an elk in Yellowstone National Park can no longer rest easy once he has the meat at home in the freezer. Now the forensics scientist can effectively trace an animal's remains left in Yellowstone to the violators home, thereby enabling a conviction to stand up in court.

Richard A. Moulton, Special Agent, U.S. Fish and Wildlife Service

Richard Moulton currently serves as a Special Agent for the U.S. Fish and Wildlife Service in Hartford, Connecticut. Richard is recognized here today for his invaluable contributions toward the protection of the world's endangered species. His efforts as case agent and covert operative in an international wildlife smuggling investigation, dubbed *Operation Wiseguy*, uncovered an elaborate network of illegal smuggling between the United States and South Africa.

Operating in a covert capacity, Richard effectively penetrated and made a case against a well-established international network for illegally selling endangered wildlife from Africa. Rhinoceros, cheetahs and leopards were illegally killed in Angola, Namibia, South Africa and Zimbabwe and sold to the United States. As the case developed, Richard discovered that illegal weapons, including AK-47 assault rifles and handgrenades, also were part of the smuggling network.

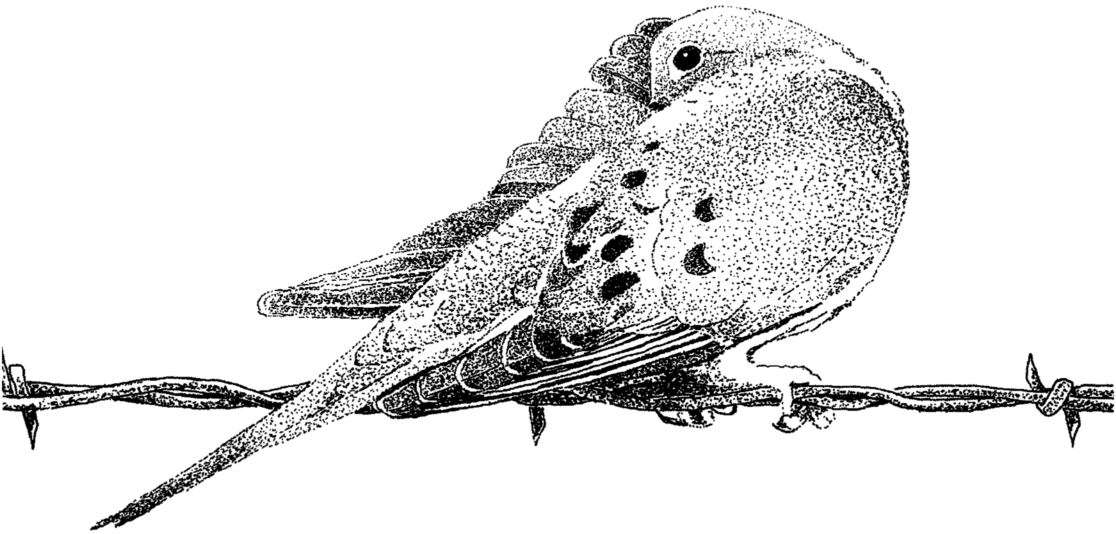
Richard's investigation led to the arrest and extradition of the two principal co-conspirators. The case marked the first international extradition involving crimes against wildlife. Noting the importance of *Operation Wiseguy*, John Turner, Director of the U.S. Fish and Wildlife Service, concluded: "The extradition is a sure sign that the world is becoming a riskier place for those who smuggle endangered species and other protected wildlife."

The success and significance of *Operation Wiseguy* exemplifies Special Agent Moulton's dedication to the enforcement of international laws to protect wildlife.

The Award

In recognition of Tom and Richard's efforts on behalf of wildlife conservation, the National Fish and Wildlife Foundation is pleased to present them each with the Foundation's 1993 Conservation Print and commemorative plaque, together with a check for $1,000.

The Foundation recognizes that Tom and Richard are only two of the hundreds of dedicated individuals in the law enforcement community who also deserve this recognition. The Foundation would like to thank John Doggett, Terry Crawforth, Jim Timmerman, Ken Goddard, Terry Grosz, Rollie Sparrowe, and Max Peterson for their willingness to serve as Guy Bradley Award judges. Finally, our thanks to the Wildlife Management Institute for its help in this presentation.



Special Session 1. *Ecology and Wildlife Management of Urban Habitats*

Chair
LOWELL W. ADAMS
National Institute for Urban Wildlife
Columbia, Maryland

Cochair
JOHN M. HADIDIAN
National Park Service
Washington, D.C.

Predicting the Distribution of Breeding Forest Birds in a Fragmented Landscape

Deanna K. Dawson
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel

Lonnie J. Darr
Maryland-National Capital Park and Planning Commission
Natural Resources Division
Upper Marlboro

Chandler S. Robbins
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Patuxent Wildlife Research Center
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Introduction

In recent years, concerns over the loss of biological diversity have created a critical need for guidelines on preservation and enhancement of habitat for birds and other wildlife. Before specific management actions can be recommended, knowledge first must be acquired of the extent and spatial distribution of habitats in the area of interest, and then of the distribution of species within them. Gap Analysis has been developed (Scott et al. 1993) to assess the conservation value of large geographic areas and to identify vegetation types or centers of species richness not protected in biological reserves. In this method, maps of existing vegetation are incorporated into a Geographic Information System (GIS), and published information on species' habitat associations is used to predict the presence of species in mapped vegetation types (Scott et al. 1993).

In landscapes where habitats have been fragmented by competing land uses, habitat area may be needed to successfully predict the occurrence of species within a vegetation type. Studies of forest birds in the eastern United States (e.g., Whitcomb et al. 1981, Robbins et al. 1989) have documented that species are not randomly distributed across forest areas, and have identified "area-sensitive" species, those unlikely to occur in small tracts of forest. The bird species composition of forests in Maryland and adjacent states, sampled from 1979 to 1983 (Robbins et al. 1989), was used to develop models that predict probability of occurrence for species as a function of forest area.

In this paper, we test the forest area models of Robbins et al. (1989), using data on bird distribution collected in forests of Prince George's County, Maryland, a rapidly developing county within the Washington, D.C. Metropolitan Area. We also demonstrate how these models can be used in conjunction with a GIS to assist land planners and managers in programs to conserve breeding habitat for forest birds.

Study Area

The study was conducted in Prince George's County, Maryland, located immediately to the east and south of Washington, D.C., between the Potomac and Patuxent rivers. The county lies almost entirely within the Coastal Plain physiographic province and the Oak-Pine Forest Region (Braun 1950, Stewart and Robbins 1958). Although a relatively high percentage of the county is still forested (≈46 percent in 1990), the forest occurs in more than 4,000 tracts, resulting in a highly fragmented landscape. Non-forested habitats include urbanized areas (adjacent to Washington, D.C.); suburbs with high-density and low-density residential, commercial and industrial areas; gravel-mining operations; and active and fallow agricultural lands.

A Woodland Conservation and Tree Preservation Ordinance was enacted by the County in 1989 to reduce the loss of its forest resources. Proposals for development of forested properties must include provisions to set aside a specified proportion (15–50 percent, depending on zoning status) of the site as woodland preservation area. Currently designated as priorities for preservation are forested 100-year floodplains, forested non-tidal wetlands, forested stream corridors, forested slopes, large contiguous forested areas and critical woodland habitats, and specimen and historic trees (Prince George's County 1992). Those who destroy forests without or contrary to an approved Conservation Plan are assessed a mitigation fee, to be used for land acquisition or for afforestation or reforestation on- or off-site. In April 1991, the State Forest Conservation Act, modeled after the Prince George's County ordinance, was signed into law in Maryland.

The location, area and spatial distribution of forests within Prince George's County were digitized from aerial photography taken in 1990, and stored in an ARC/INFO GIS (Environmental Systems Research Institute, Inc., 380 New York Street, Redlands, California 92373) by the Maryland-National Capital Park and Planning Commission. These data will serve as a baseline from which effectiveness of the Woodland Conservation Program can be assessed. In the GIS, a forest was considered to be a discrete patch if a canopy break discernible from the aerial photos separated it from other forest. All forests larger than 0.23 acres (0.09 ha), the smallest area subject to the Woodland Conservation ordinance, are represented in the GIS as polygons; the largest forest polygon in the county is 3,714.6 acres (1,503.3 ha).

Methods

Selection of Study Sites

We used the GIS as a sampling frame from which to select study sites. Forests were grouped into seven area classes (1.2–4.9 acres [0.5–2 ha], 4.9–14.8 acres [2–6 ha], 14.8–

49.4 acres [6–20 ha], 49.4–123.6 acres [20–50 ha], 123.6–370.6 acres [50–150 ha], 370.6–1,235.5 acres [150–500 ha], 1,235.5 acres [500 ha]), and within each class a random sample of sites was selected. Because of the interest of land-use planners in the value to wildlife of the small forests in the county, more sites were selected and sampled in the three smallest area classes. Selected sites were rejected from the sample only if landowner permission for access was denied or if the site was no longer forested.

In all area classes except the largest, a single sampling point was established at the approximate centroid of each site. One or more additional points were randomly located in forests larger than 500 hectares to increase the sample of large tracts, few of which are available in the county. In all, 224 points were sampled, distributed among the area classes as follows: class 1, 40 points; class 2, 45 points; class 3, 53 points; class 4, 29 points; class 5, 23 points; class 6, 19 points; and class 7, 15 points.

Bird Sampling

We used point counts to sample the bird populations at each study site, following the methodology of Robbins et al. (1989). Each point was visited on three mornings during late May through early July of 1992, within four hours of sunrise. In order to equalize the coverage of points, the visits to a point were made by different observers, and were scheduled at least one week apart at different times of the morning. On each visit, the observer counted birds heard or seen during a 20–minute period. For each species, separate counts were made of birds that at any time during the observation period moved within 50 meters of the point and birds that were beyond 50 meters throughout the observation period. In addition, we documented, both during the count and while walking to and from the point, any evidence that a species was nesting in the forest, including observations of male/female interactions, nests or fledglings.

Data Analysis

Models describing the relationship between forest area and probability of occurrence for bird species were developed by Robbins et al. (1989) using logistic regression (Cox and Snell 1989). In this analysis, the response variable, y, is binary, and assumes a value of 1 if the species was detected on any of the visits to a point and 0 if it was not detected on any visit. In the linear-logistic model, a species' predicted probability of occurrence within a forest of area x (the probability of detecting the species on at least one of three 20–minute visits to a randomly selected point) can be calculated as:

$$P(y=1) = \frac{\exp(\alpha + \beta x)}{1} + \exp(\alpha + \beta x),$$

where α is the estimated intercept parameter and β is the slope parameter.

For each of 34 bird species for which Robbins et al. (1989 and unpublished data) found a significant relationship between the response variable and forest area, we calculated the predicted probabilities of occurrence for the forests sampled in Prince George's County, using their estimated regression coefficients. We used these predicted probabilities to calculate the expected number of occurrences in forests in each of the seven area classes, and conducted chi-square tests to assess the fit of the Prince George's County data to the models developed from the broader geographic area.

We then used logistic regression (SAS Institute Inc. 1989) to characterize the relationship between occurrence and forest area in the Prince George's County dataset. For all species for which the slope term was significant and positive, we calculated the areas of forest at which the predicted probability is 0.1, 0.5 and 0.9. We view these areas as preliminary thresholds for identifying, on the basis of area alone, the sets of forests within the county, respectively, that would not be expected to provide suitable breeding habitat for a species, that would likely provide breeding habitat, and in which the presence of breeding populations would virtually be assured. To demonstrate the potential applicability of these models to land-use planning, we integrated the predicted probabilities into the GIS so that the spatial distribution of forests within the county within different probability categories could be displayed.

Results

Chi-square goodness-of-fit tests indicated that for 17 of 34 species the forest area models developed by Robbins et al. (1989) adequately described the data from Prince George's County (Table 1). For the other 17 species, the distribution of occurrences among area classes differed significantly in the Prince George's County dataset (Table 1). Of these, 10 species were observed in more sites than predicted by the models in all area classes: red-shouldered hawk, red-bellied woodpecker, hairy woodpecker, Acadian flycatcher, tufted titmouse, Carolina wren, blue-gray gnatcatcher, American robin, northern parula and hooded warbler. Two species, yellow-billed cuckoo and great crested flycatcher, were observed in fewer sites than predicted in all area classes. These differences reflect the differences between the two datasets in the overall proportion of sites in which species were detected, and explain in part their lack-of-fit. However, differences in the shapes of the distributions also could cause significant test results. To identify this component of lack-of-fit, we examined the logistic regression analyses for these species. We constructed 95 percent confidence limits for the estimated slope parameters for each species in the two datasets. There was no overlap in the confidence intervals for yellow-billed cuckoo, Acadian flycatcher, American robin, common yellowthroat and hooded warbler, indicating that the shapes of their distributions differed between the datasets. Except for common yellowthroat, the absolute values of the slopes for these species were higher in Prince George's County, indicating a stronger response to forest area. Although the chi-square test results were significant for European starling, yellow-throated vireo, Louisiana waterthrush and Kentucky warbler, neither the shapes nor the levels of the distributions differed significantly between the two datasets, suggesting the combined influence of these criteria on the tests.

For five species—blue jay, American crow, tufted titmouse, Carolina wren and common yellowthroat—area was not significant in the Prince George's County analysis (Table 1), contrasting with the statewide results of Robbins et al. (1989, unpublished data). The linear-logistic model was significant for the other 29 Prince George's County species for which we conducted analyses (Table 1). Of these, 21 species had significant positive slope terms, indicating that probability of occurrence increases with forest area. Calculations of the areas at which the probabilities of occurrence are predicted to be 0.1, 0.5, and 0.9 revealed differences among these species in their sensitivities to area (Table 2). When area is the only forest attribute being considered, there are only seven species for which there exist in the county forests large enough for the predicted probability of occurrence to exceed 0.9. There are no forests in which the predicted probabilities of occurrence for black-and-white warbler, worm-eating warbler and summer tanager would reach even 0.2 (Table 2); the number of county forests for which the predicted probability exceeds 0.1 for these species, respectively, is 125, 61, and less than 30. We illustrate for one "area-sensitive" species, ovenbird, the spatial distribution of county forests within three categories of predicted probabilities: $0.1 \leq P < 0.5$, $0.5 \leq P < 0.9$, and $P \geq 0.9$ (Figure 1).

Discussion

Among species for which the Prince George's County. data did not fit the forest area models of Robbins et al. (1989), two, American robin and European starling, were ob-

Table 1. Number of points at which 34 bird species were detected in Prince George's County, Maryland—their chi-square values from goodness-of-fit test of predictions of models of Robbins et al. (1989), and slope estimates from a logistic regression analysis. A significant chi-square value indicates that data do not fit the model; a significant slope indicates a significant relationship between probability of occurrence and forest area.

Species	Latin	Number points	Chi-square	Slope
Red-shouldered hawk	*Buteo lineatus*	38	68.59***	0.503*
Yellow-billed cuckoo	*Coccyzus americanus*	52	46.72***	0.904***
Red-bellied woodpecker	*Melanerpes carolinus*	170	27.54***	0.723***
Hairy woodpecker	*Picoides villosus*	84	71.44***	0.782***
Northern flicker	*Colaptes auratus*	142	10.11***	−0.461**
Pileated woodpecker	*Dryocopus pileatus*	40	11.80	1.215***
Acadian flycatcher	*Empidonax virescens*	140	93.69***	1.578***
Great crested flycatcher	*Myiarchus crinitus*	68	34.81***	0.514**
Blue jay	*Cyanocitta cristata*	167	11.67	−0.246
American crow	*Corvus brachyrhynchos*	220	1.20	−0.167
Carolina chickadee	*Parus carolinensis*	200	1.85	−0.522*
Tufted titmouse	*Parus bicolor*	215	18.22**	0.444
White-breasted nuthatch	*Sitta carolinensis*	75	6.87	0.746***
Carolina wren	*Thryothorus ludovicianus*	220	86.25***	−0.393
House wren	*Troglodytes aedon*	48	12.16	−1.052***
Blue-gray gnatcatcher	*Polioptila caerulea*	92	67.09***	0.641***
Wood thrush	*Hylocichla mustelina*	175	6.36	1.072***
American robin	*Turdus migratorius*	166	54.60***	−1.471***
Gray catbird	*Dumetella carolinensis*	90	9.98	−1.311***
European starling	*Sturnus vulgaris*	102	67.20***	−1.832***
Yellow-throated vireo	*Vireo flavifrons*	34	37.01***	1.41***
Red-eyed vireo	*Vireo olivaceus*	185	9.59	1.568***
Northern parula	*Parula americana*	68	637.06***	1.203***
Black-and-white warbler	*Mniotilta varia*	15	7.63	0.605*
Worm-eating warbler	*Helmitheros vermivorus*	11	10.32	0.840*
Ovenbird	*Seiurus aurocapillus*	103	5.74	1.842***
Louisiana waterthrush	*Seiurus motacilla*	29	34.77***	0.858***
Kentucky warbler	*Oporornis formosus*	57	40.90***	1.905***
Common yellowthroat	*Geothlypis trichas*	41	19.65***	0.041
Hooded warbler	*Wilsonia citrina*	79	121.45***	1.352***
Summer tanager	*Piranga rubra*	9	10.37	0.812*
Scarlet tanager	*Piranga olivacea*	135	8.34	1.770***
Northern cardinal	*Cardinalis cardinalis*	221	8.04	−2.137*
Indigo bunting	*Passerina cyanea*	101	4.43	−0.382*

* $P \leq 0.05$.
** $P \leq 0.01$.
*** $P \leq 0.001$.

served in many more forests smaller than 20 hectares than expected, reflecting in part the urban/suburban matrix in which many of these sites were located. The lack-of-fit of data for Carolina wren may reflect the temporal difference in the two studies. During the years of the Robbins et al. (1989) study (1979–1983), this species was likely recovering from the population decline associated with severe winter weather in 1976 through 1978 (Robbins et al. 1986); in our Prince George's County survey in 1992, Carolina wrens were detected in 220 of 224 sites. Another set of species that differed are those commonly associated with streams, swamps or floodplain forest in the Coastal Plain (Stewart and Robbins 1958), including red-shouldered hawk, Acadian flycatcher, blue-gray gnatcatcher, northern parula, Louisiana waterthrush, and Kentucky and hooded warblers. In Prince George's County, many of the existing forests are bisected by streams, which precluded their development for other uses. Because we sampled forests at their centroids, many of our points were located in the streamside habitats most frequently used by these species.

Our results indicate that forest area models will need some adjustment to fit the conditions in a specific locale. However, the fact that data for half of the species we tested did fit the predictions of Robbins et al. (1989) offers encouragement for the use of probabilistic models for predicting species distributions. With refinement and in combination with the mapping capabilities of GIS software, they have the potential to become extremely useful tools for land planners and managers interested in the conservation of birds and their habitats. If the goal is to ensure the protection of breeding habitat for all

Table 2. Maximum predicted probability of occurrence and forest area at which predicted probability of occurrence is 0.1, 0.5 and 0.9 for 21 bird species with significant positive slopes in logistic regression analyses. Missing values indicate that no forests of these areas exist in Prince George's County, Maryland.

Species	Maximum probability of occurrence	Forest area (ha) at which		
		P=0.10	P=0.50	P=0.90
Red-shouldered hawk	0.348	1.14		
Yellow-billed cuckoo	0.620	1.59	429.25	
Red-bellied woodpecker	0.938	0.00	0.27	290.88
Hairy woodpecker	0.737	0.11	71.81	
Pileated woodpecker	0.650	7.22	464.45	
Acadian flycatcher	0.981	0.19	4.70	116.16
Great crested flycatcher	0.544	0.04	673.26	
White-breasted nuthatch	0.684	0.16	139.27	
Blue-gray gnatcatcher	0.715	0.02	55.03	
Wood thrush	0.975	0.01	0.56	63.22
Yellow-throated vireo	0.569	10.15	854.89	
Red-eyed vireo	0.995	0.03	0.69	17.28
Northern Parula	0.809	1.41	94.66	
Black-and-white warbler	0.179	116.38		
Worm-eating warbler	0.182	222.02		
Ovenbird	0.973	1.09	17.07	266.17
Louisiana waterthrush	0.411	10.90		
Kentucky warbler	0.909	6.51	92.69	1320.29
Hooded warbler	0.881	1.18	49.91	
Summer tanager	0.147	430.92		
Scarlet tanager	0.986	0.34	5.86	102.17

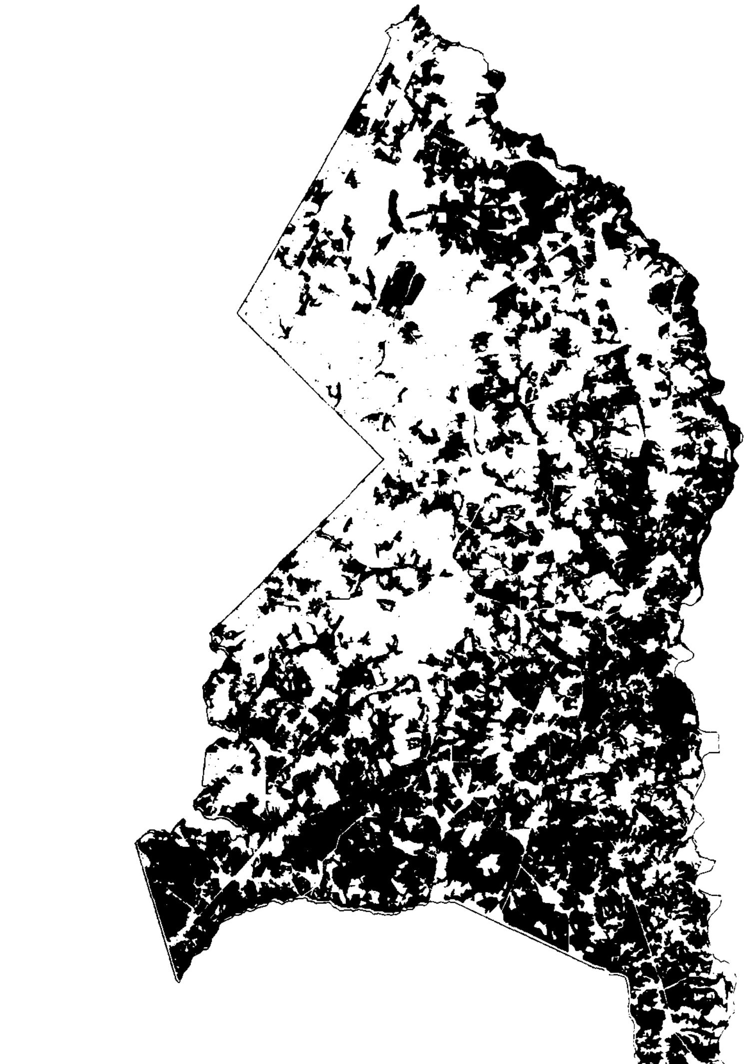

Figure 1. Map of the spatial distribution of forests within Prince George's County, Maryland, in which predicted probabilities of occurrence for ovenbird are 0.1–0.5, 0.5–0.9 and ≥0.9.

forest birds whose ranges include the jurisdiction of interest, we suggest that focus be placed on the set of bird species for which probability of occurrence increases with area, for they will be most affected by continued habitat fragmentation. Predicted probabilities of occurrence for species can be stored as attributes of forest polygons in the GIS, and data layers for different species can be combined or superimposed. Under the Woodland Conservation and Tree Preservation program in Prince George's County, this information could be used on a case-by-case basis to aid planners in delineating the portions of forested sites to be preserved, should proposals for their development be submitted. A conservation plan for a development site within a larger tract of forest should strive to keep the area of contiguous forest at a maximum. If predicted probabilities of occurrence are low for all bird species of interest, planners might recommend that, instead of preserving forest on-site, mitigation fees be used for purchase of forested land elsewhere in the county or for afforestation to increase the area of a potentially more productive forest. Knowledge of the predicted value to birds of other forests in the vicinity of a site, facilitated by maps such as that in Figure 1, also might help to clarify the course of action.

Alternatively, the predicted distributions of species in forests could be used proactively to identify sites likely to contain breeding populations of individual species or groups of species of interest (*see* Tangley 1992, Scott et al. 1993). Species-rich forests not already under public ownership could be designated as priorities for acquisition or for establishment of conservation easements, or re-zoned to restrict alternative uses and to increase the proportion of forest required to be preserved should development be proposed. Maps depicting the spatial distribution of forests with specified predicted occurrence probabilities for species (Figure 1) can be used to identify sections of the county at risk of losing breeding populations of species of interest should development of forested sites continue.

We emphasize that our models predicting bird occurrence in Prince George's County forests are preliminary, and are presented only as an example of how predictive models can be applied in land-use planning. Although we consider only area here, we also are looking at models that include other attributes of forests, including forest type, shape (by using an index of perimeter to area, or core area [*see* Temple 1986]), or measures describing the spatial distribution of forest around each site. The GIS software greatly facilitates calculation of these metrics. For species with low maximum probabilities of occurrence, such as black-and-white warbler and worm-eating warbler (Table 2), it is clear that additional factors must be considered to identify forests most likely to provide breeding habitat.

In addition, an essential, but often neglected component in the development of predictive models is the testing phase. Models developed from data collected in 1992 will be tested in an independent random sample of forests in Prince George's County during the 1993 breeding season. If no year effects exist, the datasets can be combined and used to further refine the predictive models.

Based on our results, an obvious recommendation would be to preserve all large tracts of forest within the county. However, to develop realistic guidelines for land planners and managers in landscapes that are becoming increasingly fragmented by expanding human populations, it is essential that we also identify the intra- and extra-site characteristics that allow certain smaller tracts of forest to support breeding bird populations while other tracts of equal area do not provide suitable breeding sites. Although the models we discuss here predict species occurrences in forest and not the viability of their populations, we believe that the identification of potential breeding habitat is a critical first step in avian conservation programs. Prince George's County and the State of Maryland, by enacting legislation that allows for forest conservation in association with development on private lands, have taken a second step.

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Reaction of Wild Bird Populations to a Supplemental Food Source

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In 1985, it was estimated that 82.5 million people in the United States fed birds at a cost of over $1 billion (U.S. Fish and Wildlife Service 1988). More people enjoyed wildlife by feeding birds than through hunting and fishing combined! Despite the popularity of bird feeding and its great economic implications, the significance of this activity to wild bird populations has received little study. Much that has been written about bird feeding assumes that it is important to the survival of birds. For example, people are told that once they begin feeding birds they must never stop, because the birds will become dependent on the seed they offer.

The objective of the study reported here was to gain insight into the significance of an intensive artificial feeding program at a home to the birds visiting it by comparing the size of population using the food source with the amount consumed. The data were collected over a two-year period at two important times each year: during the breeding season in June and in mid-winter. Thus, there were four study periods.

This research was planned and a pilot study conducted when the senior author was studying urban bird populations for the U.S. Fish and Wildlife Service and was carried out while the senior author worked for the Wild Bird Centers of America, Inc. Financial support at the beginning of the study was provided by Mars, Inc. and the concluding work was supported by a grant from the Wild Bird-Feeding Society.

The study was conducted at the home of Leitha M. Geis in a lightly developed area. A variety of habitat types existed immediately adjacent to the study site, including mowed lawns, pasture land, meadows and old fields growing into woody cover. The nearest mature woods was about 300 meters away.

Food attractive to seed-eating birds, primarily oil type sunflower and white proso millet was constantly available. It was provided on a large roofed platform designed for feeding preference tests (Geis 1980), in five large tubular feeders and in tubular feeders designed to dispense niger seed. Also, proso millet was placed on the ground and mealworms in a small elevated feeder. During the last winter period, almonds were presented on the table. The food presentation simulated that of a very ardent backyard birder. The amount of food and variety of feeders used were intended to maximize the importance of this food source to bird populations present in the area.

Procedures and Results

Birds were captured in mist nets and funnel traps placed within 20 meters of the feeders. Birds were captured every three or four days and they fed undisturbed at other times. They were banded with standard aluminum bands and major species were color marked to indicate the period in which they were originally banded. The results of this activity during each of the four study periods is summarized in tables 1 through 4.

To determine the relative amount of food eaten by each species, counts were made at all locations at which food was taken. This included the ground under feeders, since the birds spilled a substantial amount of food while eating. Counts were made systematically throughout the day, recording the number of birds feeding at the instant the feeder was viewed. The species composition of the counts were broken down by food and feeding situation and are summarized for each period in tables 5 through 8. The best overall estimate of the distribution of food among species is shown in Table 9, which pools all feeding locations. The total amount of food of each kind consumed each period is shown in Table 10. During the two summer periods, spilled food was collected in fine netting under the feeders, cleaned and subtracted from the total. During the winter, ground-feeding birds consumed spilled seed and no adjustment was needed. Consumption by mammals was accounted for by counting them in the same way as birds; however, consumption at night (principally by rabbits) was not recorded. Some food, especially almonds, was carried away by birds and may not have been eaten. It is therefore likely that the estimates of food consumption by birds are exaggerated.

Immediately after each period of marking, all feeding birds were observed systematically and a tally was kept of birds whose legs could be seen. It was noted whether legs

Table 1. Summary of birds captured near feeders June 8–July 7, 1989, Clarksville, Maryland.

Species	Number banded	Foreign recaptures	Recaptures	Total times species captured
House finch	1,204		213	1,417
Northern cardinal	82		26	108
Brown-headed cowbird	50		13	63
Carolina chickadee	19		4	23
Common grackle	191		10	
Red-winged blackbird	14		0	14
Gray catbird	13		3	16
Eastern tufted titmouse	9		3	12
Mourning dove	5			5
Blue jay	4			4
Carolina wren	4			4
House sparrow	4			4
House wren	3		2	5
Red-eyed vireo	3			3
Rufous-sided towhee	3			3
American goldfinch	2			2
Eastern phoebe	2			2
Wood thrush	2		0	2
Acadian flycatcher	1			1
American redstart	1			1
American robin	1			1
Brown thrasher	1			1
Common yellow-throat	1			1
Downy woodpecker	1		0	1
Eastern wood pewee	1			1
Song sparrow	1			1
White-eyed vireo	1			1
Yellow-breasted chat	1			1
Eastern bluebird		1		1
Total	1,452			1,718

were marked and, if so, when they had been marked. These observations are summarized in Table 11.

The results of the entire data collection effort were used to prepare tables 12 through 15. Arranged by study period, these tables show population estimates and estimates of the proportion of each species body weight obtained from the single artificial food source. The total weight for each species and average weight data for each population estimate were based on Dunning (1984). Population estimates were obtained by dividing the number of birds marked during the period by the proportion marked based on sight observations (The Lincoln-Peterson Method) (Pollack et al. 1990).

The population estimate for "other" species is based on their occurrence among birds seen feeding. Since the minor species are less avid seed eaters than are the feeder-feeding birds, this estimate probably is low.

The metabolic rate of wild birds is influenced by a multitude of factors. A formula for estimating the metabolism in terms of kilocalorie per 24 hours for each species is presented by Lasiewski and Dawson (1967). This formula recognizes the relationship between body size and energy requirements and was used to estimate the requirement of each bird. This estimate then was multiplied by the estimated number of birds in the total population of the species to determine the total energy requirement for the total population visiting the feeders, In Table 16, these estimates are shown for each study period. A basis for determining the metabolizable energy in the food that was consumed by wild birds provided to be more difficult than had been anticipated and is the subject of a study now in progress. However, based primarily on data from poultry, it is believed that 300 kilocalories per kilogram of food can be used as a reasonable preliminary approximation. This is supported by Brittingham and Temple's (1987) estimate of 3,275 kilocalories per kilogram for oil sunflower and the estimate of 2,984 for proso millet

Table 2. Summary of birds captured December 27, 1989–January 22, 1990, Clarksville, Maryland.

Species	Number banded	Returns from summer 1989	Foreign recaptures	Total captures	Recaptures of birds originally banded in W-90	Recaptures of birds originally banded in S-89	Total recaptures	Total times species captured
White-throated sparrow	88			88	44		44	132
Northern cardinal	35	4		39	12	1	13	52
Pine siskin	34			34				34
American goldfinch	29			29	4		4	33
Chickadee	27	13	1	41	19	3	22	63
Slate-colored junco	22			22	5		5	27
Eastern tufted titmouse	19	7		26	24	12	36	62
House finch	14			14				14
American tree sparrow	9			9	6		6	15
Song sparrow	5			5	2		2	7
Carolina wren	3	1		4	4	1	5	9
Purple finch	3			3				3
House sparrow	2			2				2
Northern mockingbird	1			1				1
Mourning dove	1			1				1
Total	292			318				455

presented by the National Research Council, Nutritional Requirements of Poultry. The fact that oil sunflower and white proso millet comprised 92 percent of food consumed further supports the use of 3,000 kilocalories per kilogram to approximate the energy provided by the feeders. The estimates of energy obtained from the feeders are based on the total food consumed per day by each species during each period. These estimates are compared with total energy requirements in Table 17 to reflect the importance of the artificial food source.

Discussion

A number of species were captured near the feeders that did not feed at them. Of the 32 species that were captured during the summer periods, less that half visited the feeders. Summer birds present that did not visit feeders included such species as flycatchers, vireos and chats. Non-feeder birds also occurred in winter. Thus, the possibility exists that, with additional food sources, a wider variety of species may have been attracted.

The much greater number of birds banded during the two summer periods was due primarily to the larger number of house finches that used the area in the summer.

The species composition counts shown in tables 5 through 9 provide a basis for breaking down consumption by kinds of food, and document the striking differences among

Table 3. Summary of birds captured near feeders June 6–July 4, 1990, Clarksville, Maryland.

Species	Number banded	Returns from		Foreign recaptures	Total captures	Recaptures of birds originally banded in			Total recaptures	Total times species captured
		W–90	S–89			S–90	W–90	S–89		
House finch	1,143	1	18	1	1,163	148		2	150	1,313
American goldfinch	48		1		49	10		1	11	60
Brown-headed cowbird	30		4		34	5		1	6	40
Common grackle	21		2		23	2			2	25
Northern cardinal	19	5	10		34	9			9	43
Blue jay	16				16	4			4	20
Red-winged blackbird	14		4		18	2		1	3	21
Mourning dove	8				8	2			2	10
Gray catbird	6				6	2			2	8
Eastern tufted titmouse	4	3	1		8	4	1	1	6	14
House wren	3				3	2			2	5
Rufous-sided towhee	3				3	1			1	4
Chipmunk sparrow	3				3					3
Acadian flycatcher	2				2					2
Carolina chickadee	2	3			5	1			1	6
Red-eyed vireo	2				2					2
House sparrow	2				2					2
Carolina wren	2				2					2
Common yellow-throat	2				2					2
Song sparrow	1				1					1
White-breasted nuthatch	1				1					1
Downy woodpecker	1				1					1
Eastern wood pewee	1				1					1
Wood thrush	1				1					1
Total	1,335				1,388					1,587

species in feeding behavior. Note, for example, that juncos always were seen feeding on the ground while chickadees always were recorded in elevated locations. As would be expected, differences in feeding preferences also were apparent.

Note the importance of mealworms in attracting Carolina wrens and titmice. You also may notice the decline in mealworm consumption in 1991 among blue jays and mockingbirds. This can be attributed to the fact that between the winter of 1990 and the winter of 1991, a 1.5 inch mesh screen was placed around the mealworm feeder to discourage these species.

The occurrence of goldfinches on niger in summer was higher in this study than it would have been if we had used a standard thistle feeder. The tubular feeders we used had perches above the openings, thus requiring that birds hang upside-down to feed. This discouraged the larger house finches that usually crowd goldfinches off the perches of conventional thistle feeders.

Almonds first were presented in the winter of 1991. They provided to be especially attractive to species such as mockingbirds, downy and red-bellied wookpeckers, white- and red-breasted nuthatches, and Carolina wrens. For the major purpose of this study it would have been better if almonds had not been used because birds carried away pieces of almond, thus exaggerating consumption during the winter of 1991. This is clearly shown by Table 16 which indicated that although almonds constituted 36 percent of the food taken, only 6 percent of the bird visits occurred at this food.

Table 4. Summary of birds captured near feeders January 3–February 2, 1991, Clarksville, Maryland.

		Returns from:				Recaptures of birds originally banded in					Total times
Species	Number banded	S-90	W-90	S-90	Total captures	W-91	S-90	W-90	S-89	Total recaptures	species captured
White-throated sparrow	64		17		81	48		7		55	136
Northern cardinal	56	3	3	9	71	17				17	88
Chickadee	30	1	12	7	50	41		4	4	49	99
Slate-colored junco	28		1		29	18		1		19	38
American goldfinch	13	1	2	1	15	1				1	16
Eastern tufted titmouse	12	2	9	4	27	21		15	3	39	66
House finch	9			1	10	1					11
Red-breasted nuthatch	7				7	5				5	12
Carolina wren	5		1		6	8		1		9	15
White-breasted nuthatch	3				3	4				4	7
Downy woodpecker	3				3	3				3	6
Blue jay	3				3		1			1	4
Brown creeper	3				3						3
Northern mockingbird	2				2	4				4	6
Song sparrow	2				2						2
Common grackle	1				1						1
European starling	1				1						1
Yellow-rumped warbler	1				1						1
Mourning dove							1			1	1
Total	243				316						513

Table 5. Species composition of various food and feeder combinations June 6–July 11, 1989, Clarksville, Maryland.

	Oil Sunflower				Niger
	Percentage tubular feeders	Percentage table	Percentage ground under		Percentage tubular feeders
Species			tubes	table	
House finch	94.7	81.2	75.3	27.2	80.4
Northern cardinal	1.9	7.2	7.4	31.3	
Mourning dove	1.4	4.6	6.8	8.2	0.4
Common grackle	1.4	5.0	3.3	5.2	
Brown-headed cowbird	0.2	1.2	1.3	15.0	
Red-wing blackbird	0.1	0.1	0.9	2.5	
House sparrow	0.1	0.3		0.7	
Carolina chickadee	0.1	0.2			
Blue jay		0.1	0.1	0.7	
Eastern tufted titmouse		0.1			
Rufous-sided towhee				2.3	
American goldfinch					19.2
Song sparrow				0.2	
Chipmunk			3.3	3.4	
Gray squirrel			0.8	2.5	
Red Squirrel			0.6	0.9	
Total	99.9	100.0	100.0	100.1	100.0
Total visits	8,203	3,609	1,586	441	239

	White Proso Millet			
Species	Percentage table	Percentage driveway	Percentage platform	Percentage ground under platform
Brown-headed cowbird	43.0	29.6	39.1	6.7
House finch	29.5	25.1	35.2	55.1
Mourning dove	21.7	12.6	13.5	9.0
House sparrow	2.3	13.5	0.6	
Red-wing blackbird		9.5	10.2	10.1
Northern cardinal	2.1	5.1		13.5
Common grackle	1.4	3.8	1.3	4.5
Song sparrow		0.2		
Carolina wren				1.1
Chipmunk		0.2		
Rabbit		0.3		
Total	100.0	99.9	99.9	100.0
Total visits	512	1,351	156	89

In summer, the distribution of bird visits correlated closely to the distribution of food consumption. In winter, there were two disparities. The first, as explained above, had to do with almonds. In addition, the percentage of visits to white proso millet during winter was about twice as great as the percentage of total grams consumed (Table 16). Thus, the data on the relationship between populations and food consumed is more reliable for summer than winter.

In terms of overall consumption, house finches were by far the most important in summer, making 79.6 percent and 77.8 percent of total visits in 1989 and 1990, with the

Table 6. Species composition of various food and feeder combinations December 16, 1989–January 27, 1990, Clarksville, Maryland.

	Oil Sunflower			Niger
Species	Percentage tubular feeders	Percentage table	Percentage ground under tubes	Percentage tubular feeders
White-throated sparrow	2.4	58.8	64.5	
Northern cardinal	19.4	28.2	22.5	
House finch	32.1	0.4		
Pine siskin	6.3		3.0	55.8
American goldfinch	9.1		1.2	44.2
Eastern tufted titmouse	16.0	8.4	1.2	
Chickadee	14.4	0.8		
Slate-colored junco			4.1	
Blue jay		2.9	1.2	
White-breasted nuthatch		0.4		
Purple finch	0.2			
Gray squirrel			2.4	
Total	99.9	99.9	100.1	100
Total visits	505	238	169	231

	White Proso Millet			Mealworms
Species	Percentage table	Percentage ground under table	Percentage driveway	Percentage table
White-throated sparrow	71.4	85.9	50.8	7.1
Northern cardinal	11.3	1.4	34.8	
House finch			0.2	
Pine siskin	1.2			
Eastern tufted titmouse	0.6			25.0
Carolina wren		0.3		53.6
Slate-colored junco	2.4	3.6	4.4	
House sparrow	3.6		6.5	
Northern mockingbird				14.3
Song sparrow		4.1	1.6	
American tree sparrow	3.6	3.6	1.3	
Blue jay			0.1	
Mourning dove	6.0	1.1		
Rufous-sided towhee			0.2	
Total	100.1	100	99.9	100
Total birds	168	362	1671	56

Table 7. Species composition of various food and feeder combinations June 4–July 12, 1990, Clarksville, Maryland.

	Oil Sunflower			Niger
Species	Percentage tubular feeders	Percentage table	Percentage ground under tubes	Percentage tubular feeders
House finch	96.7	68.7	90.5	53.2
Mourning dove	1.4	9.6	2.8	
Northern cardinal	0.8	7.2	2.2	
Common grackle	0.4	11.4	1.0	
Brown-headed cowbird			0.2	
American goldfinch	0.3			46.8
Red-winged blackbird		0.3	0.5	
Blue jay	0.1	0.7		
Eastern tufted titmouse	0.1	0.1		
Chipping sparrow			0.1	
Gray catbird			0.1	
Carolina chickadee	0.1	0.1		
Chipmunk			2.5	
Red squirrel		0.8		
Gray squirrel		1.0		
Total	99.9	99.9	99.9	100
Total visits	3,619	726	1,236	190

	White Proso Millet			Mealworms
Species	Percentage table	Percentage ground under table	Percentage driveway	Percentage hopper
House finch	45.2	2.2	29.0	
Mourning dove	22.6	37.6	16.8	
Northern cardinal	7.0	27.1	14.9	5.3
Common grackle	6.4	2.2	9.1	
Brown-headed cowbird	17.2	1.5	10.0	
House sparrow		10.5	10.4	
Red-winged blackbird			6.9	
Blue jay	1.1	0.8		42.1
Eastern tufted titmouse				42.1
Chipping sparrow		1.5	2.1	
Gry catbird				5.3
Carolina wren				5.3
Rufous-sided towhee		3.0		
White-throated sparrow		3.0		
Chipmunk		5.3	0.6	
Red squirrel	0.5			
Gray squirrel		5.3		
Total	100	100	99.8	100.1
Total visits	186	133	1,098	38

Table 8. Species composition of various food and feeder combinations January 4–February 12, 1991, Clarksville, Maryland.

	Oil Sunflower			Niger
Species	Percentage tubular feeders	Percentage table	Percentage ground under tubes	Percentage tubular feeders
Northern cardinal	18.0	70.8	38.3	
White-throated sparrow	0.5	20.4	34.7	
Chickadee	37.9			
Eastern tufted titmouse	6.5	2.3		
House finch	23.1	4.6	0.9	
American goldfinch	10.5			100
Slate-colored junco			23.3	
Red-breasted nuthatch	1.6			
Downy woodpecker	0.3		2.8	
Mourning dove	0.2		2.8	
Myrtle warbler	1.3			
House sparrow	0.2	0.5		
Total	100.1	100	100	100
Total birds	628	216	326	32

	White Proso Millet			Almonds	Mealworms
Species	Percentage table	Percentage ground under table	Percentage driveway	Percentage table	Percentage hopper
Northern cardinal	54.1	4.4	35.8	47.0	
White-throated sparrow	44.5	90.2	53.8	27.2	
Chickadee				1.8	3.3
Eastern tufted titmouse				10.6	55.7
House finch			0.2		
Slate-colored junco		4.2	7.4		
Red-breasted nuthatch				3.2	
Blue jay				3.7	
Carolina wren					36.1
Northern mockingbird				1.8	4.9
Downey woodpecker	0.4			1.8	
Mourning dove			1.9		
White-breasted nuthatch				1.8	
Red-bellied woodpecker				0.9	
House sparrow	0.4		0.4		
Song sparrow		1.2	0.1		
European starling	0.4				
Gray squirrel			0.4		
Total	99.8	100	100	99.8	100
Total visits	220	643	1,236	217	61

next most important species (e.g., cardinals, mourning doves and cowbirds) making only 2–6 percent (Table 9).

In winter, food consumption was more evenly distributed among species. White-throated sparrows represented 45.4 percent and 43.6 percent of the total visits in 1990 and 1991, followed by cardinals representing 23.8 percent and 30 percent of the observations. Note that the counts made are not literally bird visits, but the birds present in a feeding location at an "instant." Thus, the assumption is made that all species (including mammals) consume the same amount in an "instant." This is a much less biased estimate than a count of visits since some species (finches) sit and eat for a long time when they visit a feeder while other tend to take one seed and leave (chickadees). However, as stated earlier, the consumption of some foods (notably almonds) probably was exaggerated because birds picked up pieces of nutmeat, carried them away and did not entirely eat them.

The most surprising finding in regard to consumption was that it was much lower in winter than in summer (Table 10), despite the arrival of large numbers of white-throated

Table 9. Species composition of all animals eating food, all food and feeding situations combined.

Species	Percentage S–89	Percentage W–90	Percentage S–90	Percentage W–91
House finch	79.4	4.9	77.8	4.5
Northern cardinal	4.7	23.8	4.5	30.2
Mourning dove	4.5	0.4	6.0	1.0
American goldfinch	0.3	4.4	1.4	2.7
Chickadee	0.1	2.2	0.1	6.8
House sparrow	1.3	3.4	1.8	0.2
Rufous-sided towhee	0.1	0.1	0.1	
Brown headed cowbird	5.1		2.0	
Common grackle	2.7		3.1	
Red-winged blackbird	1.2		1.2	
Blue jay		0.3	0.4	0.2
Eastern tufted titmouse		3.5	0.3	2.9
White-throated sparrow		45.4	0.1	43.6
Slate-colored junco		2.9		5.4
Pine siskin		4.9		
Northern mockingbird		0.2		0.2
Carolina wren		0.9		0.6
Tree sparrow		1.2		
Chipping sparrow			0.4	
White-breasted nuthatch				0.1
Song sparrow		1.2		0.2
Red-breasted nuthatch				0.5
Myrtle warbler				0.2
Downy woodpecker				0.2
Red-bellied woodpecker				0.1
Gray squirrel	0.1	0.1	0.2	0.1
Red squirrel	0.1		0.1	
Chipmunk	0.4		0.6	
N percentage	100	98.8	100.1	99.7
Total visits	16,186	3,400	7,266	3,579
Birds per feeder per interval	2.6	0.9	3.1	1.2

sparrows. This result largely was due to the fact that house finches concentrated at feeders much less in winter than in summer. In winter, consumption of food at the study area was less than 30 percent of that in summer. Had it not been for the addition of an attractive food (almonds) in the winter of 1991, the recorded decline in consumption during winter probably would have been even greater.

The observations of marked birds shown in Table 11 provide the basis for population estimates and, also, demonstrate striking differences among species in the intensity with which they use a single feeding location. Note that after the marking period most or all of the chickadees and titmice had been captured! In contrast, even though a much larger number of house finches had been marked, the marked group represented a much lower proportion of the total house finch population. Despite the fact that we marked over one thousand house finches each summer, 75–80 percent of the house finches remained unmarked at the end of the summer. The fidelity of chickadees and titmice to the feeding location was shown in the observations after the winter of 1991 marking period of the relatively large number of birds that originally had been marked during earlier periods. For example, in the winter of 1990 more marked titmice were captured than unmarked birds. The high return rate of chickadees and titmice is also shown in the return and recapture records, tables 2 through 4, which focus on banding records.

Northern Cardinals also demonstrated relatively high feeder fidelity. Typically, about half were marked after each marking period. However, after the final period, winter 1991, about 75 percent were marked.

The most mobile species in summer, based on the relative frequency of their visits to the study area, were house finches, goldfinches, grackles and mourning doves.

Table 10. Total food consumption.

Food	Summer 1989	Winter 1989–90	Summer 1990	Winter 1991
Oil sunflower				
Total grams	159,500.0	17,685.5	141,091.0	19,284.4
Grams per day	4,430.5	570.5	3,617.7	482.2
Number of days	36	31	39	40
White proso millet				
Total grams	28,700.0	11,525.8	33,126.6	13,138.6
Grams per day	797.2	371.8	849.4	328.5
Number of days	36	31	39	40
Niger				
Total grams	1,900.0	3,413.1	4,972.8	996.2
Grams per day	528.0	110.1	155.4	25.0
Number of days	36	31	32	40
Mealworms				
Total grams		1,232.3	2,112.9	1.245.0
Grams per day		51.3	54.2	31.1
Number of days		24	39	40
Almonds				
Total grams				19,616.4
Grams per day				491.0
Number of days				40
Total consumption				
Total grams	190,100	33,857	181,303	54,281
Total grams per day	5,756	1,104	4,677	1,358

White-throated sparrows, a wintering bird in this area, demonstrated substantial feeder fidelity: about half the population was marked each winter. Twenty-two percent of birds present during the second winter had been banded the previous winter. By the end of the second winter, over 75 percent of the population had been banded.

The number of birds that visit a feeding location is much greater than most people realize. Many birds were captured, especially in summer. But when it is considered that these birds represent only a proportion of the total population, it becomes clear that total population must be very large. Thus the 1,204 and 1,143 house finches marked in the summer of 1989 and 1990 represented estimated populations of 5,798 and 5,417, respectively. Without even considering food consumption data, it is obvious that these birds obtained food from a variety of locations. The fact that many of their bills were discolored with "berry" juice is further evidence that they had been feeding elsewhere. Mourning doves and grackles in particular had population estimates far greater than the number ever observed at one time at the feeders.

When estimates of the amount of food consumed are compared with the average weight of the species consuming it, for most species the percentage of body weight represented by food consumed each day is less than 5 percent.

Table 11. Proportion of birds marked during four periods based on visual observation after each banding period.

		Proportion marked							
Period/species	Proportion unmarked	Summer 1989	Winter 1990	Summer 1990	Winter 1991	Summer unknown	Winter unknown	Total	Total seen
Summer 1989									
House finch	0.792	0.208						0.208	4,565
Northern cardinal	0.536	0.464						0.464	140
Brown-headed cowbird	0.701	0.299						0.299	154
Red-winged blackbird	0.600	0.400						0.400	27
Common grackle	0.951	0.049						0.049	9
Mourning dove	0.976	0.024						0.024	85
Winter 1990									
House finch	0.810	0.134	0.0056					0.190	431
Northern cardinal	0.376	0.324	0.299					0.623	558
Chickadee	0.196	0.092	0.712					0.804	163
Eastern tufted titmouse		0.319	0.681					1.000	163
White-throated sparrow	0.502		0.497					0.497	597
Slate-colored junco	0.917		0.083					0.083	48
American goldfinch	0.753		0.246					0.246	73
Pine siskin	0.912		0.088					0.088	137
Summer 1990									
House finch	0.739	0.045	0.002	0.210		0.004		0.261	3,346
Northern cardinal	0.416	0.112	0.136	0.166		0.168	0.008	0.584	125
Red-winged blackbird	0.231	0.179		0.769				0.769	39
American goldfinch	0.710			0.290				0.290	31
Common grackle	0.954			0.048				0.048	22
Brown-headed cowbird	0.583	0.050		0.367				0.417	60
Mourning dove	0.936			0.064				0.064	47
Winter 1991									
House finch	0.746	0.051	0.013	0.052	0.074	0.062	0.002	0.254	706
Northern cardinal	0.235	0.116	0.119	0.121	0.321	0.082	0.006	0.767	502
Chickadee		0.038	0.258	0.012	0.692			1.000	260
Eastern tufted titmouse		0.075	0.452	0.097	0.366	0.011		1.000	93
White-throated sparrow	0.224		0.220		0.556			0.776	295
Slate-colored junco	0.246				0.754			0.754	57
American goldfinch	0.615	0.154		0.154	0.077			0.385	26

The importance of the single feeding location appears to be somewhat greater in winter than in summer. This is perhaps due to the decreased concentration of house finches at feeders in winter. It is noteworthy that in winter both chickadees and titmice obtained a much higher proportion of their food from the study feeders than any other species. This is consistent with the data from banding and observations of marked birds indicating that these species used the study area much more intensely than other species. The relatively high use of feeders by white-throated sparrows also is consistent with observations relating to feeder fidelity.

The striking decline in house finch use of the area between summer and winter has been observed for some time and attributed to migration from the area to a less severe climate. The observations of returning marked birds (Table 11) clearly indicate that this is not the case. Note that after the *winter* of 1990 marking period 12.8 percent of the birds observed had been marked the previous *summer*, while only 4.5 percent had been

Table 12. Feeder bird population and weight estimates, and daily food consumption for key species, summer 1989, Clarksville, Maryland.

Species	Number banded	Proportion banded	Population estimate	Total weight (kg)	Food consumed (gm/day)		Percentage of weight consumed daily
House finch	1,204	0.208	5,798	124.1	Sunflower	3,876.7	3.10
					Millet	224.8	0.20
					Niger	42.4	0.03
					Total	4,143.9	
Northern cardinal	82	0.464	177	8.0	Sunflower	217.3	2.70
					Millet	34.3	0.40
					Total	251.6	3.10
Brown-headed					Sunflower	47.0	0.60
cowbird					Millet	260.7	3.60
	50	0.299	167	7.3	Total	307.7	4.20
Red-winged blackbird	14	0.400	35	1.8	Sunflower	1.3	0.70
					Millet	58.2	3.20
					Total	71.4	4.00
Common grackle	19	0.049	386	64.1	Sunflower	119.6	0.20
					Millet	24.7	0.04
					Total	144.3	0.24
Carolina chickadee	19	0.875	22	0.2	Sunflower	5.0	2.50
					Millet	0.8	0.40
					Total	5.8	2.90
Eastern tufted titmouse	9	0.667	14	0.3	Sunflower	1.2	0.40
Mourning dove	5	0.024	213	25.3	Sunflower	137.3	0.60
					Millet	118.0	0.50
					Niger	0.2	0.00
					Total	255.5	1.10
Others			125	4.2	Sunflower	14.0	0.30
					Millet	78.7	1.90
					Niger	10..1	0.20
					Total	102.8	2.40
Total			6,937	235.3	Sunflower	4,430.4	1.90
					Miller	800.0	0.30
					Niger	52.7	
					Total	5,283.1	2.20

marked in the winter immediately prior to the observations. The next winter (1991) 7.8 percent had been marked just before observations were made, but 11.6 percent had been marked the summers of 1989 and 1990. There is substantial house finch production during the summer of birds that could not be marked. Clearly, the high proportion of summer marked birds seen in the winter indicates that the same highly mobile population is present in the general area and that the large numbers at the feeders in summer are due to the birds concentrating at the feeders much more in the summer than in the winter.

This conclusion also is indicated by noting that population estimates indicate a winter population 10 percent that of summer, while the decline in bird visits to feeders (as indicated by bird visits per feeder per observation) indicated only 2 percent as much use in winter as in summer. These data confirm that, although house finches are a part of

Table 13. Feeder bird population and weight estimates, and daily food consumption for key species, winter 1989–90, Clarksville, Maryland.

Species	Number banded	Proportion banded	Population estimate	Total weight (kg)	Food consumed (gm/day)		Percentage of weight consumed daily
White-throated sparrows	88	0.497	177	4.6	Sunflower	163.2	3.50
					Millet	216.4	4.70
					Mealworms	3.6	0.10
					Total	383.2	8.30
Northern cardinals	35	0.299	117	5.3	Sunflower	126.6	2.40
					Millet	102.2	1.90
					Total	228.8	4.30
Chickadee	27	0.712	38	0.4	Sunflower	46.8	12.30
Eastern tufted titmouse	19	0.681	28	0.6	Sunflower	64.5	10.80
					Millet	0.2	0.03
					Mealworms	12.8	2.10
					Total	77.5	13.00
House finch	14	0.056	250	5.4	Sunflower	102.1	190
					Millet	0.7	
					Total	102.8	1.90
Pine siskin	34	0.088	386	5.6	Sunflower	23.4	0.40
					Millet	0.3	0.01
					Niger	61.4	1.10
					Total	85.1	1.50
American goldfinch	29	0.246	118	1.5	Sunflower	30.2	2.00
					Niger	48.7	3.20
					Total	78.9	5.20
Slate-colored juncos	22	0.083	265	5.2	Sunflower	4.4	0.10
					Millet	15.2	0.30
					Total	19.6	0.40
Others			125	2.6	Sunflower	9.3	0.40
					Millet	37.1	1.40
					Mealworms	34.8	1.30
					Total	81.2	3.10
Total			1,504	31.2	Sunflower	570.5	1.80
					Millet	372.0	1.20
					Niger	110.1	0.40
					Mealworms	47.6	0.20
					Total	1,100.2	3.60

the same population present in winter, they do not use the feeders nearly as intensely. In fact, a large portion of the summer population must not even visit the feeding area in winter or the proportion of winter-marked birds would have been even lower. Apparently, alternative food sources are more available in winter than in summer.

Preliminary estimates of the importance of this study's artificial food supply to wild birds is shown in Table 17. This table compares the total energy requirements of the species with that estimated to have been provided at the study area. As indicated earlier, the amount of energy provided by the feeders is very difficult to estimate and, therefore, these estimates are subject to change if and when better information becomes available.

The best information on the importance of feeding to a wild bird population relates to house finches. This is a highly mobile species that obtained most of its food elsewhere. The data clearly indicate that this species concentrates much more at the artificial feeders in summer than in winter. Goldfinches, Pine siskins, common grackles and mourning

Table 14. Feeder bird population and weight estimates, and daily food consumption for key species, summer 1990, Clarksville, Maryland.

Species	Number banded	Proportion banded	Population estimate	Total weight (kg)	Food consumed (gm/day)		Percentage of weight consumed daily
House finch	1,143	0.210	5,443	116.5	Sunflower	3,317.4	2.8
					Millet	243.8	0.2
					Niger	82.7	0.1
					Total	3,643.9	3.1
American goldfinch	48	0.290	165	2.1	Sunflower	7.9	0.4
					Niger	72.7	3.5
					Total	80.6	3.9
Brown-headed cowbird	30	0.417	72	3.1	Sunflower	1.8	0.1
					Millet	86.6	2.8
					Total	88.4	2.9
Common grackle	21	0.048	437	72.6	Sunflower	72.4	0.1
					Millet	68.8	0.1
					Total	141.2	0.2
Northern cardinal	19	0.166	119	5.4	Sunflower	72.4	1.3
					Millet	127.4	2.4
					Mealworms	2.9	0.05
					Total	209.7	3.75
Red-winged blackbird	14	0.769	18	0.9	Sunflower	5.1	0.5
					Millet	45.9	5.0
					Total	51.0	5.6
Mourning dove	8	0.064	125	14.8	Sunflower	101.3	0.7
					Millet	165.6	1.1
					Total	266.9	1.8
Other			264	8.9	Sunflower	39.4	0.4
					Millet	111.5	1.2
					Mealworms	51.4	0.6
					Total	202.3	2.2
Total			6,643	224.3	Sunflower	3,617.7	1.6
					Millet	849.6	0.4
					Niger	155.4	0.1
					Mealworms	54.3	
					Total	4,677.0	2.1

doves also range widely and do not depend on a single food source. Other species visited the artificial food source more often but still obtained substantial amounts of food elsewhere. For example, cardinals appeared to obtain about half their food from the feeders. It is unfortunate that chickadees and titmice were not represented by larger sample sizes. There is a clear indication that these species are far more regular in visiting feeders and therefore the food may be more important to them than to other species.

It seems likely that the procedures followed in this study and biases known to exist in the data all tend to exaggerate the importance of the artificial food source. Every effort was made to make the food readily available. Despite this, most species obtained much

Table 15. Feeder bird population and weight estimates, and daily food consumption for key species, winter 1991, Clarksville, Maryland.

Species	Number banded	Proportion banded	Population estimate	Total weight (kg)	Food consumed (gm/day)		Percentage of weight consumed daily
White-throated sparrow	64	0.556	115	3.0	Sunflower	66.1	2.2
					Millet	210.1	7.0
					Almonds	133.6	4.5
					Total	409.8	13.7
Northern cardinal	56	0.321	174	7.9	Sunflower	161.2	2.0
					Millet	92.2	1.2
					Almonds	230.9	2.9
					Total	484.3	6.1
Chickadee	30	0.692	43	0.4	Sunflower	98.0	22.8
					Almonds	8.8	2.1
					Mealworms	1.0	0.2
					Total	107.8	25.1
Slate-colored junco	28	0.754	37	0.7	Sunflower	31.4	4.5
					Millet	18.7	2.8
					Total	50.1	7.3
American goldfinch	13	0.077	169	2.2	Sunflower	27.0	1.2
					Niger	25.0	1.1
					Total	52.0	2.3
Eastern tufted titmouse	12	0.366	33	0.7	Sunflower	18.8	2.7
					Almonds	52.1	7.4
					Mealworms	17.3	2.5
					Total	88.2	12.6
House finch	9	0.074	122	2.6	Sunflower	65.2	2.5
					Millet	0.3	
					Total	65.5	2.5
Others			27	0.7	Sunflower	14.5	2.1
					Millet	7.1	1.0
					Almonds	64.8	9.2
					Mealworms	12.7	1.8
					Total	99.1	14.1
Total			720	18.2	Sunflower	482.2	2.6
					Millet	328.4	1.8
					Niger	25.0	0.1
					Almonds	490.2	2.7
					Mealworms	31.0	0.2
					Total	1,356.8	7.4

Table 16. Comparison of bird visits to grams consumed.

Food	Number of visits	Total visits	Percentage of total visits	Grams consumed	Total grams consumed	Percentage of total grams consumed
Summer 1989						
Oil sunflower	13,839	16,186	85.5	159,500.0	190,100	84.0
White proso millet	2,108	16,186	13.0	28,700.0	190,100	15.0
Niger	239	16,186	1.5	1,900.0	190,100	1.0
Winter 1990						
Oil sunflower	912	3,400	27.0	17,685.5	33,857	52.2
White proso millet	2,201	3,400	65.0	11,525.8	33,857	34.0
Niger	231	3,400	7.0	3,413.1	33,857	10.1
Mealworms	56	3,400	1.0	1,232.3	33,857	3.6
Summer 1990						
Oil sunflower	5,581	7,226	77.0	141,091.0	181,303	78.0
White proso millet	1,417	7,226	19.6	33,126.6	181,303	18.3
Niger	190	7,226	2.6	4,972.8	181,303	2.7
Mealworms	38	7.226	0.5	2,112.9	181,303	1.2
Winter 1991						
Oil sunflower	1,170	3,579	32.7	19,284.4	54,281	35.5
White proso millet	2,099	3,579	58.6	13,138.6	54.281	24.2
Niger	32	3,579	1.0	996.2	54,281	1.8
Mealworms	61	3.579	1.7	1,245.0	54,281	2.3
Almonds	217	3,579	6.0	19,616.4	54,281	36.0

Table 17. Comparison of estimated total energy requirements with the energy obtained from a single artificial source.

Species	Period	Estimated energy[a]		
		Total required	Obtained from feeders	Percentage of total energy from feeder
House finch	Summer 1989	52,182	12,432	24
	Winter 1990	2,250	308	14
	Summer 1990	48,987	10,932	22
	Winter 1991	1,098	195	18
Northern cardinal	Summer 1989	2,018	755	37
	Winter 1990	1,334	686	51
	Summer 1990	1,357	629	46
	Winter 1991	1,984	1,453	73
Chickadee	Winter 1990	329	140	58
	Winter 1991	271	323	119
Eastern tufted titmouse	Winter 1990	252	232	92
	Winter 1991	297	265	89
American goldfinch	Winter 1990	873	237	27
	Summer 1990	1,221	242	20
	Winter 1991	1,251	156	12
White-throated sparrow	Winter 1990	1,699	1,150	68
	Winter 1991	1,104	1,229	111
Slate-colored junco	Winter 1990	2,279	59	3
	Winter 1991	318	156	49
Pine siskin	Winter 1990	3,011	255	8
Brown-headed cowbird	Summer 1990	1,887	923	49
	Summer 1990	814	265	32
Red-winged blackbird	Summer 1990	413	214	52
	Summer 1991	212	153	72
Mourning dove	Summer 1990	3,067	766	25
	Summer 1991	1,800	801	44
Common grackle	Summer 1990	5,983	433	7
	Summer 1991	6,774	424	6

[a]In kilocalories per 24 hours.

of their food elsewhere. it can be concluded that with the possible exception of chickadees and titmice, the artificial food source was not essential to the birds' survival.

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Effects of Development on Nesting Bald Eagles: Case Studies from Chesapeake Bay

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Introduction

The Chesapeake Bay supports the second largest breeding population of bald eagles (*Haliaeetus leucocephalus*) on the east coast. In 1992, 283 breeding pairs occurred in Maryland and Virginia. This represents a 350 percent increase in the breeding population over a 16–year period. Population growth is expected to continue given the high survival rates in this area (Buehler et al. 1991a). Distribution of breeding eagles is primarily associated with tidal waters of the Chesapeake Bay and its major tributaries. Most nest sites are less than 1 mile (1.6 km) from open water (Andrew and Mosher 1982).

This expanding population and the eagle's selection of nest sites close to open water are resulting in increased conflicts with humans. Waterfront property is prime real estate in the Chesapeake Bay area for human development. The human population is projected to increase 20 percent by the year 2020 with a corresponding increase in land development (Gray et al. 1988). Conflicts with nesting bald eagles will become more frequent as a result. The availability of undeveloped shoreline may become the limiting factor for the Chesapeake Bay eagle population in the future (Buehler et al. 1991b).

State and federal wildlife agencies are becoming more involved in nest site protection every year. This protection is implemented through a variety of mechanisms, including compliance with federal and state endangered species acts, cooperation by local planning and zoning agencies and, in Maryland, through the Chesapeake Bay Critical Area Program (Therres et al. 1988).

Habitat protection guidelines (Cline 1985) are used to protect nest sites from development and other activities in the Chesapeake Bay area. These guidelines were based on national standards in use at the time. However, the guidelines were drafted with little data on the effects of development activities on nesting eagles. It had been shown that eagles generally avoid human development when selecting nest sites (Andrew and Mosher 1982, Fraser et al. 1985), though nesting eagles have tolerated development away from the immediate vicinity of their nests (Wood et al. 1989). Buehler et al. (1991b) showed that the distribution of non-nesting eagles in the northern Chesapeake Bay was inversely related to building density along the shoreline. There are numerous papers addressing bald eagle responses to human disturbance (e.g., Stalmaster and Newman

1978, Fraser 1985, McGarigal et al. 1991), but none reported the responses of established nesting bald eagles to development activities. Nesbitt and Folk (1992) evaluated the effectiveness of Florida's nest protection guidelines, but did not report the outcomes of nests disturbed within their primary protection zone.

In this paper we present the outcomes of various development scenarios in the immediate vicinity of active bald eagle nests from the Chesapeake Bay area. These case studies document the responses of territorial pairs to development activities within the established protection zone. In some cases the protection guidelines were implemented, in others the guidelines could not be enforced. The case studies presented are essentially retrospective analyses of effects of development activities near nest sites. A cause-and-effect relationship is assumed, but cannot be proven. Fraser et al. (1985) cautioned against the use of this type of analysis, but in the absence of rigorous experimental studies, case study results can provide meaningful insights for managers.

Protection Guidelines

Cline (1985) recommended the establishment of a 0.25–mile (0.4 km) radius protection area around each bald eagle nest. Within this area, three protection zones were recommended. The primary protection zone extends from the nest to a distance of 330 feet (100 m), the secondary zone from 330 feet (100 m) to 660 feet (200 m), and the third zone from 660 feet (200 m) to 0.25 mile (0.4 km).

Within the primary protection zone no timber cutting, land clearing or construction activities should be allowed at any time. During the nesting season (i.e., December 15 to June 15 in the Chesapeake Bay region), people should not be allowed in the zone.

Again, within the secondary zone no clearcutting, land clearing or construction activities should be allowed at any time. During the nesting season, people should not be allowed in the zone, but normal farming operations are allowable. Selective timber harvesting and maintenance of existing buildings and roads can occur between August 16 and November 14.

Timber harvesting, land clearing or construction activities should be restricted in the third protection zone during the nesting season, but not restricted the remainder of the year. Other activities that are within sight of the eagles may need to be restricted during the nesting season.

Guidelines similar to those in use in the Chesapeake Bay region are used in the northeastern United States and the Great Lakes region (U.S. Fish and Wildlife Service 1983). The recommended protection area in the southeast United States is 1 mile (1.6 km), with the primary zone extending to 750 feet (229 m) in Florida and 1,500 feet (457 m) elsewhere in the region (U. S. Fish and Wildlife Service 1987). In the Pacific northwest, the recommended protection area is 1,312 feet (400 m) where visual buffers occur or 2,624 feet (80 m) when no such buffers are present (U. S. Fish and Wildlife Service 1986).

Effects of Development

For the purposes of this paper, development is defined as any human activities which result in the construction of man-made structures for human occupation or use. These activities include land clearing, grading, site preparation, or construction of buildings, roads or driveways. The major elements evaluated here are the distances from the eagle nests and timing of the development activities.

Land Clearing

Often the first step in a development process, land clearing, usually involves the removal of trees from the site to be developed. Tree removal can be either selective or complete, similar to clearcutting. Land clearing for development purposes and tree harvesting for timber purposes can effect nesting bald eagles similarly and for the purposes of this paper are addressed the same. The effects of this activity on five nesting pairs of eagles in Virginia were as follows:

Selective tree removal occurred within 150 feet (46 m) of a bald eagle's nest in the city of Suffolk during the autumn of 1982. Earlier that year, the eagles had successfully raised one young. The nest site was subsequently abandoned and no nesting occurred in 1983. The pair established a new nest 300 feet (91 m) from the original nest and were observed in incubating posture in March 1984. While the birds were still incubating, three removal occurred up to the base of the nest tree. The pair abandoned their eggs and never returned to this site for nesting. They did not attempt nesting the following year. In 1986, the eagles moved 2 miles (3.2 km) away and nested successfully for the next three years.

At a newly established nest site in Surry County, clearcutting was initiated in 1984 after the eagles had laid eggs. The distance between the nest and the cutting was 1,200 feet (366 m). There was no visual buffer between the nest and the cutting operations. By May the eagles had abandoned the site and were never relocated.

Land clearing for a 10–lot subdivision was conducted within a few feet of a nest site in King George County while the bald eagles were incubating eggs in early 1987. The pair abandoned the nest by May of that year. No nesting was attempted in 1988. A new nest was established 1 mile (1.6 km) from the disturbed nest and has been used since 1989.

An extensive timber cutting operation was started in June 1988 within 1,200 feet (366 m) of a nest site that had been in use since 1979 in King William County. Two 10–week-old young were in the nest at the time logging was initiated. Though the young successfully fledged, the adults moved their nest site the following year 1.5 miles (2.4 km) away and have used the new site each year since.

In Prince George's County a pair of eagles that had successfully nested the previous two years, nested in an alternate nest in 1990. Clearcutting was initiated 300–400 feet (91–122 m) away when their young were eight weeks old. The young successfully fledged that year, but the adults moved nearly 1 mile (1.6 km) away in 1991 and successfully nested there the next two years.

Residential Development

Residential development is by far the most common form of development within the bald eagles's breeding range in the Chesapeake Bay area. Buehler et al. (1991b) classified 27.6 percent of the northern Chesapeake Bay shoreline as developed, with over half in the residential category. Housing densities range from very high (10 units/acre:24.7/ha). The following case studies illustrate the effects of home construction on nesting bald eagles.

In March 1985, house construction was initiated within 200 feet (61 m) of an active nest in Middlesex County, Virginia that had been active since 1980. At the time, the pair was incubating eggs. Construction was stopped shortly thereafter by federal law enforcement personnel. The pair successfully raised two young that season, but relocated their nesting efforts in 1986 to a nest 0.25 mile (0.4 km) away. This new nest was located on the edge of a field. It was used successfully through 1991. Land clearing for condominium development was started in July 1991 at a distance of 0.5 mile (0.8 km) from the nest. The pair moved 0.25 mile (0.4 km) away to a site that was buffered from the construction by woodlands. They raised one young there in 1992.

At a nest site in Anne Arundel County, Maryland, a pair of eagles successfully raised young two years prior to the initiation of house construction in early 1987. Construction was 800 feet (244 m) from the nest. Grading occurred in January and house construction took place while the eagles were incubating and raising two young. The following year no nesting was attempted. In 1989 the pair relocated 1 mile (1.6 km) away. Their new nest was established within 300 feet (91 m) of an existing house. They have successfully raised young two of the last four years at this new site.

In Prince George's County, Maryland, a pair of eagles built a nest 600 feet (200 m) from active home construction in early 1988. Though the area between the nest and construction was entirely wooded, the birds had clear view of the activities. They successfully raised one young that year. By the 1989 nesting season the homes were occupied and the pair never nested, though they still were observed in the area. No new nest has been found in this heavily developed portion of the county and the pair has not been seen since 1989.

House construction was started within 300 feet (91 m) of a new eagle nest during early March 1989 in King George County, Virginia. There was no visual buffer between the nest and construction activities. The incubating eagles abandoned their eggs, then moved the next season to a nest 1,500 feet (457 m) from the previous one. By April 1990, construction of another home was initiated 1,050 feet (320 m) from the new nest. The eagles were incubating when construction started. This time there was a woodland buffer and the eagles successfully raised one young. The house was occupied prior to the 1991 nesting season, but the eagles still nested and have been successful the last two years.

In Kent County, Maryland, a house was built within 100 feet (30 m) of an eagle nest that had been actively used with limited success since 1984. Only grass separated the nest tree from the house site. The year in which the construction took place (1989), the nest was occupied by nesting great horned owls (*Bubo virginianus*). In 1990, the eagles nested 1.8 miles (2.9 km) away, though no owls were using their old nest. In 1992, after the 1990 nest blew out of the tree, the eagles moved back to the previous property 1,056 feet (322 m) from the house and successfully nested. A pond and wooded buffer separates the new nest from the house.

A pair of bald eagles established a nesting territory in 1987 in a recorded, but relatively undeveloped, subdivision in Calvert County, Maryland. Within 0.25 mile (0.4 km) of the nest, 39 building lots were recorded, though none had been built upon when the eagles selected the site. The area within the habitat protection zone was entirely forested in 1987. Since then, three homes have been built. Construction on the first was initiated in December 1989 at a distance of 260 feet (79 m) from the nest. The eagles successfully raised one young in 1990. Construction of another house 260 feet (79 m) away was completed in January 1991, while construction of a third 280 feet (85 m) away was initiated early that year. The eagles raised two young in 1991 and another in 1992. Except for the immediate location of the houses and road, the area is still entirely forested.

Near Salisbury, Maryland, a pair of eagles established a nest site on the edge of a field in late 1988. This field was part of a recorded subdivision with the roads already in place when the eagles arrived. The pair has raised three young each year since 1989. Construction of three houses in the immediate area of the nest were initiated in the summer of 1991 and completed in the autumn, with occupation of one in November. Two of these houses were 750 feet (229 m) from the nest, including the occupied one, and the other was 950 feet (290 m) away. Only open field separated the nest from the houses. In 1992, the eagles nested successfully. A fourth house, 350 feet (107 m) away, was built in the autumn 1992 and interior work still was in progress in February 1993 at which time an adult was observed sitting in the nest, presumably incubating. Again, only open field separated the nest from the house.

Other Development

No bald eagles in the Chesapeake Bay area nest in the immediate vicinity of industrial or commercial development. However, within the eagle's nesting range there are other pressures besides residential development that affect the birds, including utility activities, extraction operations and road construction.

In 1987, sand and gravel extraction was initiated 200 feet (61 m) away from a nest site established in 1985 in Charles City County, Virginia. At the time extraction was started, two four-week-old young were in the nest. They successfully fledged that year. For the next two years the adults attempted nesting, with mining operations ongoing, but failed each time. In 1990, the pair moved to a new nest 1,500 feet (457 m) away from the mining. The gravel operations were still within clear view of the nest. For the next two years, the pair's nesting attempts failed. The extraction operation terminated after the 1991 nesting season with the pair successfully nesting again in 1992.

Discussion

The effects of development activities on nesting bald eagles depend on the distance of the activities from the nest, the view the eagles have of the activities and the time of year the development occurs. Other factors that may contribute include the previous nesting history of the eagles, the birds' previous experiences with humans, the availability of alternative nest sites and the amount of development in the area. A combination of these factors probably determines the final outcome.

The distance of the development activities to the nest may be more crucial during the land clearing phase than during house construction. In the case studies presented, nests were abandoned up to 1,200 feet (366 m) away from clearing operations, while house construction was tolerated as close as 260 feet (79 m). This does not imply that house construction can be tolerated at relatively close distances in all situations. Our case studies showed that eagles abandoned sites at 800 feet (244 m) away from house construction as well as closer distances. Timing and visual buffering must play a role in the distance effect.

Development activities that occur during the nesting season have more drastic effects than those conducted while the eagles are not nesting. Pairs abandoned eggs when land clearing activities were initiated at distances as close as the next tree to as far away as 1,200 feet (366 m). Nest sites were relocated as far away as 1,200 feet (366 m) the following year after land clearing occurred while young were in the nest. When house construction occurred during the nesting season eagles abandoned nest sites 57 percent of the time. Though eagles did not abandon their nest 1,500 feet (457 m) away from a sand and gravel operation, they failed in two years of nesting attempts while active mining was in progress. Fraser et al. (1985) found no difference in nesting success of eagles in Minnesota subjected to human activities within 1,640 feet (500 m) of nests compared with those without such activities, but those results were based on existing houses not ones under construction.

Similarly, Nesbitt and Folk (1992) found no evidence that productivity differed between nests for which temporal building restrictions were implemented during the nesting season and nests not subjected to human disturbance. Results in the Chesapeake Bay area support these findings. Here, young were successfully raised in a nest as close as 260 feet (79 m) from a house that was constructed outside of the nesting season. In this case, the nest was visually buffered from the house by woodlands. With no visual buffer, a pair successfully raised young 750 feet (229 m) from a house constructed prior to the nesting season.

The value of visual buffers is demonstrated by the pair in the subdivision in Calvert County, Maryland, which tolerated a new house as close as 260 feet (79 m) when buffered by woodlands from the site. Stalmaster and Newman (1978) reported greater tolerances of wintering bald eagles to human disturbances when the view was partially obscured by vegetation. Grubb and King (1991) found visual buffering reduced response frequency of nesting bald eagles to human disturbances by more than half. Thus, wooded buffers may help minimize distances between nests and houses provided they obstruct the eagle's view of the house when the bird is in the nest. However, even with visual buffers, an adequate distance needs to be maintained. With 660 feet (200 m) of woodlands between the Prince George's County, Maryland, nest and development, the eagles still abandoned their territory.

The responses by some of these nesting pairs suggests some tolerance to human activities. McGarigal et al. (1991) found bald eagles on or near their nests tolerated approaching humans more than did eagles away from their nests. This tolerance is further illustrated by a pair of eagles in Charles County, Maryland, that established a nesting territory on a golf course. The pair built a nest in a row of trees adjacent to the greens of the eighth and tenth fairways. The nest was 30 feet (9 m) from the greens. Despite more than 2,000 rounds of golf played each year (A. Conger personal communication: 1992), the pair has successfully raised young there the past three years. Fraser et al. (1985) demonstrated that nesting eagles may become sensitized to repeated disturbances and thus tolerate humans at closer distances.

Distance effects and tolerances of nesting pairs to human activities may be quite different for pairs that select nesting territories after development occurred compared to those pairs for which the habitat was altered after nest site selection. Pairs which select a nest site close to development, such as the pair in Anne Arundel County, Maryland, do so fully aware of the pre-existing condition and thus may exhibit greater tolerance to human activity than an established pair which is subsequently subjected to development pressures.

While the use of case studies does provide some insight into the responses of nesting bald eagles to development activities, one must keep in mind that these cases represent a small percentage of the breeding population of eagles in the Chesapeake Bay area. The results of this retrospective analysis are to be used in combination with the results of nest site selection studies (Andrew and Mosher 1982) and other studies measuring eagle responses to human disturbances (e.g., Buehler et al. 1991b) to make recommendations on nest site protection.

Recommendations

The protection area in use in the Chesapeake Bay area (Cline 1985) should be retained with the following modifications:

(1) Expand the primary protection zone to at least 750 feet (227 m), within which no land clearing or construction activities should be allowed. This is the size of the primary protection zone used in Florida and it appears to be adequate there (Nesbitt and Folk 1992).

(2) The other two zones should be combined. Within this secondary zone, all development activities should be restricted during the nesting season. Visual buffers should be retained when available. In the absence of visual buffers, land clearing or construction should be restricted to distances in excess of 1,000 feet (305 m).

(3) Extension of the protection area beyond 0.25 mile (0.4 km) is not recommended given the tolerances exhibited by bald eagles in the Chesapeake Bay area and elsewhere (Wood et al. 1989, Nesbitt and Folk 1992).

Summary

Case studies from the Chesapeake Bay area show that nesting bald eagles can be adversely affected by development activities too close to nest sites or during the nesting season. However, nesting eagles can tolerate limited development given adequate buffer distances. Development activities are tolerated more when conducted outside of the eagle's nesting season and where visual buffers occur.

Implementation of adequate protection measures should help protect the current nesting bald eagle population in the Chesapeake Bay area. But as human development pressures expand with a corresponding increase in human density, there will be a decline in available nesting habitat. Buehler et al. (1991b) were unable to detect evidence that the birds are adapting to human presence, so irretrievable loss of nesting habitat could occur. The key to the long-term viability of the Chesapeake Bay bald eagle population may be the retention of large areas of undeveloped shoreline habitat.

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Ecology of Urban White-winged Doves

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Introduction

Traditionally, white-winged doves (*Zenaida asiatica*) in Texas have occurred primarily in the Lower Rio Grande Valley (LRGV) (Cottam and Trefethen 1968). Before 1965, 95 percent of all breeding white-winged doves in Texas were found in the LRGV (Blankinship 1966, Waggerman 1990). Whitewing numbers in the LRGV have fluctuated widely over the last century, mainly due to continued destruction of their traditional brushland breeding habitat. Brushland habitat has decreased by an estimated 99 percent over the last half-century, due to agricultural and urban development (Cottam and Trefethen 1968).

Some biologists hypothesized that the loss of traditional white-winged dove habitat would bring about increased use of urban areas in upper south Texas (Kiel and Harris 1956, Cottam and Trefethen 1968). Whitewing nesting in urban habitats, and upper south Texas in general, was for many years thought to be insignificant (Cottam and Trefethen 1968). However, in recent years there has been a dramatic increase in the number of breeding birds outside the LRGV. Indeed, 1990 was the first year that more whitewings were estimated to be north of the LRGV than in the LRGV, and more than 50 percent of these birds were in the metro San Antonio area (≈200,000 birds) (Waggerman 1990).

The large number of white-winged doves nesting in the metro San Antonio area, and the increasing size of this population, suggest that whitewings are finding suitable habitat in urban environments (Waggerman 1990). Although whitewings have been breeding in Texas urban areas for many years, few studies have documented their use of such areas, because past occurrences were thought to be negligible (Wetmore 1920, Neff 1940, Cottam and Trefethen 1968, Oberholser 1974, Small et al. 1989). Our objectives were to examine the breeding habitat, nest density and production of the San Antonio population of white-winged doves.

Study Area

The study area was within Interstate Highway Loop 410, encircling the city of San Antonio, Bexar County, Texas. The area is a nearly level or undulating plain sloping upward from the southeast to the northwest. Elevations range from 500–1,000 feet (152.4–304.8 m) (Taylor et al. 1962). Soils are heavy black to thin limestone (Kingston and Crawford 1989).

San Antonio has a modified subtropical climate, predominantly continental in winter and marine in summer (Taylor et al. 1962). Precipitation occurs mainly in the form of short thunderstorms in the months from April through September. Average monthly precipitation is approximately 2.3 inches (5.8 cm) (Kingston and Crawford 1991). Relative humidity is greater than 80 percent during the early hours of the day, falling to 50 percent in late afternoon. Average monthly temperatures range from 52–84 degrees Fahrenheit (12–28°C), with the highest temperatures occurring from June through September (Taylor et al. 1962).

The study area was stratified into five habitats: residential areas less than 50 years of age; residential areas more than 50 years of age; the downtown area; parks larger than 124 acres (50.2 ha) (i.e., large parks, cemetaries, rural areas, military bases, campgrounds); and parks smaller than 124 acres (50.2 ha) (i.e., small parks, cemetaries). City maps were used to classify individual habitats within Highway 410 Loop. A square foot/acre grid was used to determine habitat size (Bryant 1943). The age and designation of residential areas were determined through examination of maps of the city created before 1941, and through comparison of these with current maps. The downtown area was defined as the area commonly designated as downtown on modern maps of the city, plus all residential areas immediately surrounding this area of a similar age (more than 100 years).

Methods

Nest Plots

The number of nest plots in each habitat was scaled approximately to the percentage of each habitat in the total study area (Table 1). Nest plots were randomly selected from within each habitat. Each plot was 0.5 acres (0.2 ha), following the standard size nest plot used for whitewings breeding in citrus habitat in the LRGV (Blankinship 1966, Sanderson 1977, Waggerman 1990). Each plot was divided into two sections occurring on each side of the road, in order to delete areas covered by roadways from the total area examined. Sections were 241.8 by 9.8 yards (221 by 9 m).

Nest Surveys

Plots with nests present were searched weekly from the first week in June, through the third week in August. Plots without nests present the first week were subsequently checked biweekly. Plots where no nests were observed by July 31, were not checked again for the remainder of the study year. All nest trees were individually marked. Nest contents were examined with a mirror and pole device (Parker 1972), and/or through use

Table 1. Habitat available and number of white-winged dove nest plots in San Antonio, Texas.

Habitat	Area available		Number of nest plots		
	Acres	Percentage	1991	1992	$\bar{x}$[a]
Parks <124 acres	1,317	1.2	3	3	3.0
Parks >124 acres	39,185	35.7	15	15	15.0
Downtown	18,658	17.0	6	7	6.5
Residential <50 years	25,464	23.2	7	10	8.5
Residential >50 years	25,135	22.9	8	9	8.5
Total	109,759	100.0	39	44	41.5

[a]Number presented is an average between numbers of nest plots used in 1991 and 1992.

of a ladder. Information recorded at nests included the time and date the nest was located or revisited, location of the nest, contents, probable age of eggs or young, tree species, and potential causes of nest failure (Dahlgren 1955).

Nest Habitat

The total number of nests observed in each plot was summed for each habitat. The total number of trees was summed by species for the study area. Chi-square analysis and Bonferroni confidence intervals were used to test for differences in habitat and tree species use (Neu et al. 1974).

Nest Density

Nest densities were calculated from the number of nests found in each plot during the peak week of nesting. Two-way analysis of variance was used to find differences in nest density between years and among habitats (Steel and Torrie 1960). When differences were detected ($P < 0.05$), least significant difference mean separation procedures were used to determine where differences occurred.

Production Estimates

Production indices (PI) were calculated for each nest plot. PIs were estimated by determining the number present during the peak week of nesting on each plot, and dividing this by the total number of fledglings produced over the study period in each habitat (Waggerman 1990). Two-way analysis of variance was used to find differences in PIs between years and among habitats.

Nest Success Estimation

The Mayfield method (1961) was used to determine nest survival within habitats during each interval of the nesting cycle and over the entire nesting period (Mayfield 1961, Johnson 1979). Survival rates were determined for each study year and for both years combined. These estimates were compared with Z-tests to determine possible differences among habitats and years (Steel and Torrie 1960).

Results

Nesting Levels

A total of 397 white-winged dove nests were found. Peak level of nesting occurred in the last week of June in both years (Figure 1).

Nest Habitat

Habitat use of parks smaller than 124 acres, parks larger than 124 acres, downtown and residential areas more than 50 years old in both study years was lower ($P < 0.05$) than expected (Table 2). Use of residential areas less than 50 years old was higher than expected.

Use of live oak (*Quercus virginiana*) and Arizona ash (*Fraxinus velutina*) was higher than expected. Pecan (*Carya illinoensis*), mesquite (*Prosopis glandulosa*), Texas mountain laurel (*Sophora secundiflora*), cedar elm (*Ulmus crassifolia*), crepe myrtle (*Lagerstroemia indica*) and all other tree species were used less than expected (Table 3).

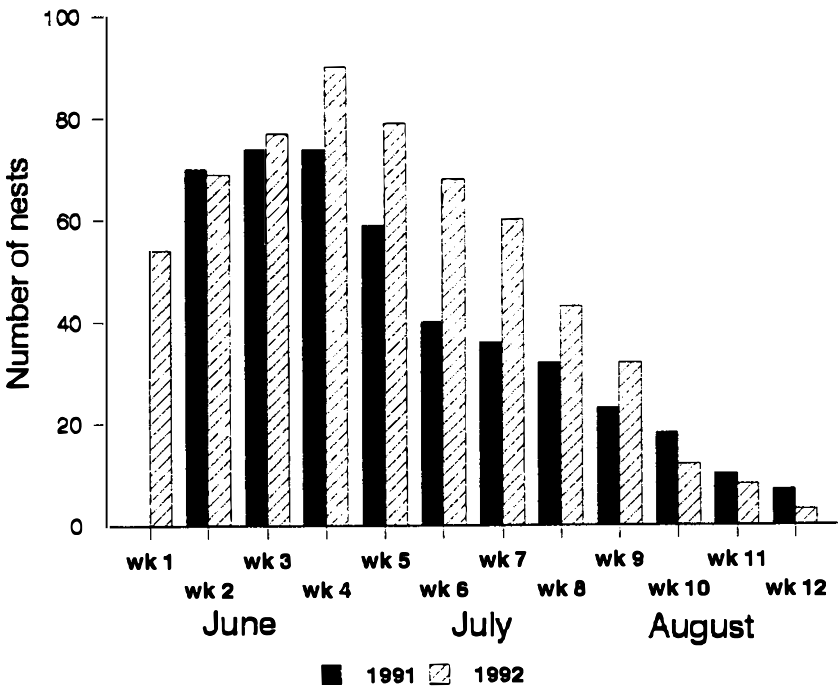

Figure 1. Numbers of white-winged dove nests found by week in San Antonio, Texas, 1991–1992.

Nest Density

Nest density varied ($P = 0.03$) among habitats. Residential areas less than 50 years old had a higher $P < 0.05$) nest density (17.4 nests/acre ± 9.0) than all other habitats (parks >124 acres [1.3 nests/acre ± 0.5], downtown [3.0 nests/acre ± 1.4] and residential <50 years [0.7 nests/acre ± 0.4]) except parks <124 acres (1.7 nests/acre ± 1.1). There were no differences ($P = 0.93$) in nest density between years.

Table 2. Numbers of white-winged dove nests, percentage observed and expected use values, and Bonferroni confidence intervals for habitats in San Antonio, Texas, 1991–1992.

Habitat	Number of nest plots used[a]	Expected proportion of usage	Number of nests found	Actual proportion of usage	95-percent CI
Parks <124 acres	3.0	0.072	7	0.018	0.001–0.035[b]
Parks >124 acres	15.0	0.361	37	0.093	0.056–0.131[b]
Downtown	6.5	0.157	31	0.078	0.044–0.112[b]
Residential <50 years	8.5	0.205	313	0.788	0.735–0.841[b]
Residential >50 years	8.5	0.205	9	0.023	0.004–0.042[b]

[a]Number presented is an average between number of nest plots used in 1991 and 1992.
[b]Indicates a difference at the 0.05 level of significance (Neu et al. 1974).

Nest Production

PI values were lower ($P < 0.05$) in 1992 (1.4 ± 0.1) than in 1991 (1.6 ± 0.3). There were no differences ($P = 0.32$) in PIs among habitats (parks <124 acres [1.2 ± 0.3], parks <124 acres [1.7 ± 0.2], downtown [2.1 ± 0.3], residential <50 years [1.4 ± 0.2], and residential >50 years [0.8 ± 0.1]).

Nest Success

In 1991, success was greater for parks smaller than 124 acres versus other habitats, during incubation, but there were only three nests present. Nest success was lower in residential areas less than 50 years old than other habitats, during the fledging interval of nesting in 1991. There were no differences in nest success among habitats when data for both years were combined (Table 4). Success rates were lower ($P < 0.04$) in 1992 than 1991 for Parks smaller than 124 acres during incubation and for the nesting cycle

Table 3. Numbers of trees and species used by white-winged doves in San Antonio, Texas, 1991-1992, percentage observed and expected use values, and Bonferroni confidence intervals for each species.

Tree species	Total number present	Expected proportion of usage	Number used	Actual proportion of usage	95-percent CI
Live oak	232	0.137	48	0.358	0.245–0.471[a]
Pecan	209	0.123	7	0.052	0.000–0.104[a]
Arizona ash	176	0.104	39	0.291	0.184–0.398[a]
Mesquite	166	0.098	6	0.045	0.000–0.094[a]
Texas mountain laurel	114	0.067	0	0.000	0.000–0.000[a]
Cedar elm	110	0.065	1	0.007	0.000–0.027[a]
Crepe myrtle	92	0.054	1	0.007	0.000 0.027[a]
Others	596	0.352	32	0.239	0.138–0.340[a]

[a]Indicates a difference at the 0.05 level of significance (Neu et al. 1974).

Table 4. Mayfield (1961) nest survival estimates for intervals of the white-winged dove nesting cycle for habitats in San Antonio, Texas (1991-1992 study years combined).

Habitat	Incubation (days 1-14)	Fledging (days 15-26)	Overall
Parks <124 acres	0.702ABC[a]	0.788AB	0.553AB
$n = 7$	(0.488-1.000)[b]	(0.561-1.000)	(0.319–0.925)
Parks >124 acres	0.648AD	1.000A	0.648A
$n = 36$	(0.540–0.764)	(1.000–1.000)	(0.532–0.778)
Downtown	0.731A	1.000A	0.731A
$n = 29$	(0.622–0.860)	(1.000–1.000)	(0.613–0.870)
Residential <50 years	0.542BD	0.725B	0.393BC
$n = 235$	(0.495–0.761)	(0.673–0.790)	(0.338–0.463)
Residential >50 years	0.414CD	1.000A	0.414AC
$n = 8$	(0.235–0.715)	(1.000–1.000)	(0.192–0.872)
Study area	0.570	0.799	0.456
$n = 315$	(0.535–0.613)	(0.747–0.844)	(0.402–0.510)

[a]Success rates followed by the same letter within columns are not different ($P > 0.05$, Z = test).
[b]95-percent confidence intervals listed in parentheses.

overall ($P < 0.01$), but sample sizes were low. Residential areas less than 50 years old had higher ($P < 0.05$) success rates during fledging in 1992 than 1991.

Discussion

Nesting Levels

The peak level of white-winged dove nesting occurred in the last week in June in both years. In the LRGV, the first week in June is the peak of nesting (Cottam and Trefethen 1968, Waggerman 1990). Also, nesting at San Antonio was documented as early as the third week in March, while nesting in the LRGV rarely starts before late April or early May (Cottam and Trefethen 1968). This suggests that whitewing nesting chronology is different in San Antonio than in the LRGV.

Nest Habitat

Parks smaller than 124 acres, parks larger than 124 acres, downtown and residential areas more than 50 years old were avoided by whitewings, while residential areas less than 50 years old were preferred habitat. Nest density estimates confirm that residential areas less than 50 years old was preferred nesting habitat. Live oak and Arizona ash were preferred nest trees. Residential areas less than 50 years old contained most of the live oaks and Arizona ash located on nest plots, but few of the total number of pecans, cedar elm or Texas mountain laurel. The high proportion of live oaks and Arizona ash in residential areas less than 50 years old could be attracting white-winged doves to these areas.

Nest Density

Nest densities were similar among most habitats. Only density in residential areas less than 50 years old (17.4 nests/acre for both study years) was higher than other habitats. No difference was observed between residential areas less than 50 years old and parks smaller than 124 acres in years combined, though this may have been due to a low sample size in parks smaller than 124 acres and high variability in the data.

Nest Production

Production indices for whitewings in past studies ranged from 1.8 to 3.4 young per breeding pair per season (Marsh and Saunders 1942, Kiel and Harris 1956, Blankinship 1966, Waggerman 1990). Production in 1991 was similar to these levels in most habitats. Indices were lower in 1992 than 1991 and generally below levels observed in other studies. Precipitation in May 1992 (8.1 inches [20.7 cm] and June 1992 (5.7 inches [14.4 cm]) was more than twice the average recorded for those months (3.7 inches [9.3 cm] and 3.0 inches [7.7 cm], respectively). White-winged dove nests are vulnerable during the incubation stage of nesting and production can been influenced by precipitation (Cottam and Trefethen 1968). PIs observed for the study area as a whole were below previously cited studies. Production per pair of doves in San Antonio may be lower than that found in traditional whitewing habitat. However, this also may be due to differences in nesting chronology between the LRGV and San Antonio. Our San Antonio PIs may be low because the whitewing breeding season may be longer overall than in the LRGV. We may have missed some early nesting (L. M. West personal files: 1993).

Nest Success

Residential areas less than 50 years old had lower nest success rates than most other habitats for the highest nest densities (17.4/acre). Areas exhibiting nest densities over 10 nests per acre have been defined typically as incidences of colony nesting (Cottam and Trefethen 1968). Only residential areas less than 50 years old contained incidences of colony nesting in San Antonio (within Loop 410). San Antonio dove fledging success rates were similar to another whitewing colony nesting study in West Texas (0.390–0.486, Galluci 1978). Whitewings flush more easily in high density nesting situations than those with low densities (Cottam and Trefethen 1968). Researcher disturbance, along with other disturbances common to residential areas (i.e. automobiles, land owners, etc.), may have contributed to low nest success, but this should have been similar among habitats. Observations also revealed numerous incidences of predation by domestic cats and great-tailed grackles (*Quiscalus mexicanus*). Although residential areas less than 50 years old may be preferred whitewing nesting habitat in San Antonio, the species' poor nest success in those residential areas raise questions concerning the overall suitability of this habitat.

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Nest-site Selection and Reproductive Biology of Roof- and Island-nesting Herring Gulls

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Introduction

Birds nesting on roofs is not a recent phenomenon. While storks (*Ciconia ciconia*) have historically nested on buildings throughout Europe and northern Africa (Lack 1968: 112–113). One of the earliest reports in North America was of a common nighthawk (*Chordeiles minor*) nesting on a warehouse roof in Philadelphia in 1869 (Bent 1940). Since that time, at least 23 species of birds have been reported to nest on roofs, 9 of which are gulls (*Larus* spp.) (*see* Fisk 1978, Blokpoel and Smith 1988).

The first report of gulls nesting on buildings was of herring gulls (*L. argentatus*) near the Black Sea during 1894 (Goethe 1960). Gulls have since been reported to nest on roofs throughout Europe and North America (Monaghan and Coulson 1977; Bourne 1979; Monaghan 1979, 1982; Albrecht 1986; Kumerloeve 1986; Blokpoel and Smith 1988; Vermeer et al. 1988; Vegelin 1989; Blokpoel et al. 1990; Dolbeer et al. 1990; Spaans et al. 1990). Use of urban areas by several species of gulls has increased substantially in recent years (Monaghan 1979, Vermeer et al. 1988, Vermeer 1992). Dolbeer et al. (1990), among others, suggested that roofs were suboptimal nesting habitat for herring gulls, hypothesizing that roof-nesting was a result of the dispersal of breeding adults in a population experiencing rapid growth and lacking more suitable nest sites. Similar dispersal of herring gulls to roofs and other urban sites subsequent to rapid growth of the original colony has been reported in other areas (Paynter 1963, Campbell 1975, Monaghan and Coulson 1977, Vermeer et al. 1988). Gulls colonizing roofs frequently have been considered to be younger, less experienced birds that were unable to compete for more desirable nest sites. However, little attention has been directed at the hypothesis that roofs may be favorable nesting habitat that only recently has been occupied (Monaghan 1979).

The objectives of this study were to compare herring gull reproductive parameters at a roof colony and a nearby island colony and to evaluate nest-site selection within the roof and island habitats. The goals were to determined (1) whether a roof population of nesting herring gulls was comprised of younger individuals than was the population at the earlier colonized island, and (2) breeding biology, especially nesting success, differed between the two colony sites.

Study Area

The study was conducted in northcentral Ohio during May through July 1992. The herring gull nesting concentration (1 of the largest of the Great Lakes with 3,250 nesting pairs in 1992) is located on Sandusky Bay, Lake Erie (Belant et al. 1993) (Figure 1). The first documented nesting of herring gulls in the area occurred on Turning Point Island (TPI), a 2.7-hectare dredge disposal island created in 1900 about 0.5 kilometer offshore from Sandusky, Ohio (Scharf et al. 1978). About 50 percent of the island has herbaceous vegetation. Dominant shrub and tree species include red mulberry (*Morus rubra*), red-osier dogwood (*Cornus stolonifera*) and eastern cottonwood (*Populus deltoides*, Scharf et al. 1978). Herring gulls have nested on TPI since at least 1976. The number of nesting pairs on TPI during 1976 and 1977 were 983 and 878, respectively (Scharf et al. 1978); in 1992 there was 1,918 nests (Belant et al. 1993).

The herring gull population on two adjacent, flat roofs in the Sandusky, Ohio business district about 1 kilometer east of TPI also was monitored (Figure 1). Both roofs, which combined comprised 1.3 hectares, contain structures (e.g., vents, skylights) on gravel, metal and tar surfaces. Scarf et al. (1978) did not report herring gulls nesting on these roofs during their surveys in 1976 and 1977. In 1992, 176 herring gull nests were present on the two roofs (Belant et al. 1993). No other gull species nested on TPI or the roofs.

Methods

Observations were made from early May-early July 1992. We monitored study nests on roofs one time weekly and, on TPI, on or two times weekly. On TPI, we marked 64 nests containing three eggs each by placing numbered 0.6-meter wire surveying flags about 1 meter from the nest. The 176 nests on roofs containing ≥1 eggs were marked individually by placing 5- × 10- × 20-centimeter numbered wooden blocks within 1 meter of them.

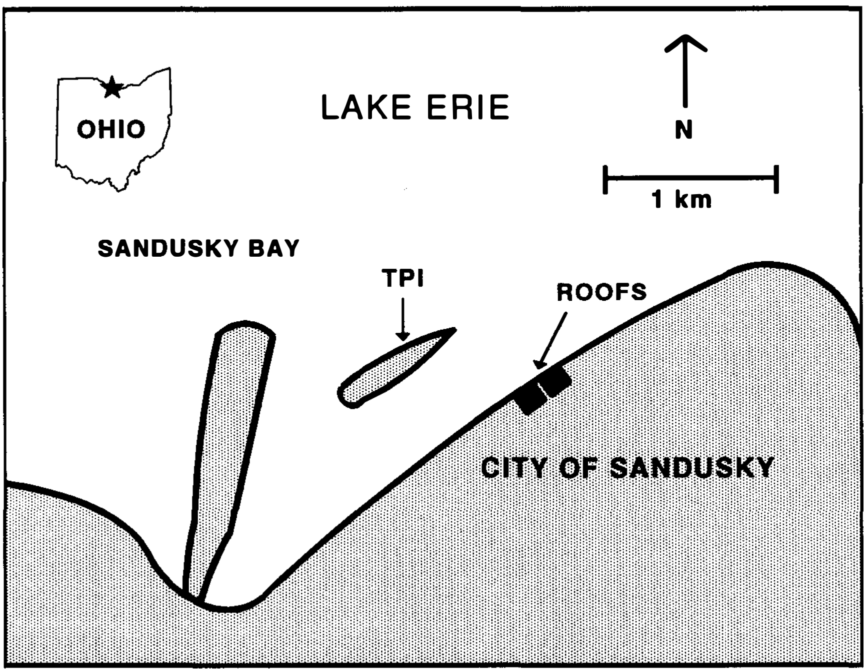

Figure 1. Location of herring gull nesting populations on Turning Point Island (TPI), Sandusky Bay, Lake Erie and on two roofs in Sandusky, Ohio.

Reproductive Parameters

During each visit to nests on roofs, clutch size and number of chicks present at the nest site were recorded. All nests with ≥1 eggs were used for comparisons of hatching success within roofs. Only three-egg clutches in roof nests were used for comparisons of hatching success on TPI (*see* Belant and Seamans 1993). Clutch size on TPI was estimated from a complete ground count of nests on May 1 by eight observers. To avoid double counting, a location on the ground within 1 meter of each nest was marked using spray paint.

Mean hatching dates for all study nests were estimated by interpolation based on the date of the previous check, the number of chicks that had hatched or were pipping, and the relative age of chicks (Kadlec et al. 1969). Clutch completion dates (using a 28-day incubation period) (Drent 1970, Pierotti 1982) were estimated by backdating from mean hatching dates. Hatching success was defined as the number of chicks hatched divided by the number of eggs laid for each comparison and is expressed as a percentage. The maximum length and width of each egg in 30 three-egg clutches on roof (15 clutches per roof) and 30 three-egg clutches on TPI were measured to the nearest 0.01 millimeter to calculate egg volume indices using the formula $length \times width^2$ (Davis 1975, Vermeer et al. 1988). I did not estimate fledging success because monitoring chicks through fledging, particularly on the roofs, likely would have caused excessive investigator-induced mortality.

Age of Incubating Adults

Walk-in traps (Weaver and Kadlec 1970) were placed over nests on TPI and the roofs to capture incubating gulls. Measurements of bill depth, head and bill length (to determine sex and relative age) (Coulson et al. 1981, Fox et al. 1981), and body mass were recorded.

Nest-site Characteristics

To assess whether suitable nesting material was limited, the maximum height and width of each nest on roofs and TPI were measured and a nest volume index (V) was calculated using the equation $V = \pi m^2(h)$ where r = radius of nest at ground level, and h = height of nest rim above ground. The presence or absence of material suitable to construct a nest within 1 meter of the nest perimeter was recorded. Material was considered present if it was estimated to comprise ≥10 percent of the volume of the nest adjacent to it. The percentage of vegetation and garbage (non-food items, e.g., bones, paper, plastic) used as nesting material also was estimated for each nest. Overhead cover within 1 meter of each nest was considered present if ≥10 percent of the nest was visually obstructed by objects (e.g., tree limbs, pipes, air vent covers) while an observer looked down directly over the center of the nest from 1 meter above ground. Nests were considered as adjacent to a structure (e.g., vents, skylights) if the center of the next was ≤1 meter from a structure. If the nest was constructed against a structure, orientation (nests built against North, East, South or West side of a structure) of the nest was recorded. The type of substrate (gravel, metal or tar) for each roof nest also was recorded. Internest distance was recorded as the distance from the center of each nest to the center of the nest nearest to it. Nests on TPI were classified as located on the edge (areas containing riprap) or center (areas with shrubs or trees present) of the island.

Statistical Analyses

Nest parameters, egg volume indices, hatching dates, and body mass and relative age (via bill depth) between gulls of each sex captured on the roofs and on TPI were compared using *t*-tests. *T*-tests and General Linear Models Procedure with Tukey multiple comparison tests (SAS Institute, Inc. 1988) were used to compare inter-nest distances. Chi-square statistics for proportional data (Fleiss 1973) were used to asses clutch size and the effects of nest-site selection on hatching success. All means are reported with ± 1 standard deviation (SD). Differences were considered significant at $P \leq 0.05$.

Results

Reproductive Parameters

The proportion of nests containing one, two or three eggs was similar ($x^2 = 1.12$, 2 df, $P = 0.55$) for TPI and roof populations, with 77–80 percent containing three eggs (Table 1). The egg volume index differed ($t = 3.17$, 178 df, $P < 0.01$), however, with gulls on roofs laying eggs 4 percent larger than those on TPI (140.1 ± 13.8 ml and 134.1 ± 10.4 ml, respectively). Overall hatching success of eggs from three-egg clutches on roofs (66 percent, $n = 414$) was similar ($x^2 = 1.85$, 1 df, $P = 0.20$) to hatching success on TPI (71 percent, $n = 192$). Gulls on roofs hatched eggs significantly ($t = 12.26$, 232 df, $P < 0.01$) later than did gulls on TPI (May 30 ± 8 days and May 19 ± 6 days, respectively). Estimated mean clutch completion dates for roofs and TPI were May 2 and April 21 respectively.

Age of Incubating Adults

Bill depth of gulls at the two locations was similar ($P \geq 0.15$) for both sexes (Table 2), which suggests that the age structure of the populations was similar. Body mass also was similar ($P \geq 0.87$) for each sex between locations.

Nest-site Characteristics

Nest density on TPI (710 per ha) was greater ($x^2 = 18.23$, 1 df, $P < 0.01$) than on roofs (135 per ha). Similarly, inter-nest distance was less ($t = 7.39$, 234 df, $P < 0.01$) on TPI (2.08 ± 0.86 m, $n = 64$) than on roofs (5.10 ± 3.23 m, $n = 172$). Looking specifically at TPI, inter-nest distance on the riprap (1.75 ± 0.55 m, $n = 45$) was less ($t = 6.00$, 62 df, $P < 0.01$) than was the inter-nest distance in the interior of the island (2.87 ± 0.94 m, $n = 19$). For roofs, inter-nest distance on gravel substrate (4.74 ± 2.74 m, $n = 156$) was less ($F = 14.68$; 2,166 df; $P < 0.01$) than that on other substrates. Inter-nest distance on metal (9.57 ± 6.41 m, $n = 8$) and tar (9.22 ± 3.29 m, $n = 5$) surfaces was similar (Tukey test $P > 0.05$).

Table 1. Clutch size of nesting herring gulls on Turning Point Island (TPI), Sandusky Bay, Lake Erie, and on two roofs in Sandusky, Ohio, 1992.

		Percentage of nests containing			Clutch size	
Location	*n*	1 egg	2 eggs	3 eggs	$\bar{x}$	SD
TPI	1,875	7	16	77	2.7	0.3
Roofs	176	7	13	80	2.7	0.3

During the first count of nests on roofs (May 5), 65 percent of nests were adjacent to a structure. Proportionally fewer (x^2 = 17.24, 1 df, P < 0.01) nests initiated after this date were built next to structure (33 percent). For roofs, clutch size was similar (t = −1.63, 169 df, P = 0.11) for gulls nesting adjacent to structure (2.8 ± 0.6, n = 106) and for those that did not (2.7 ± 0.6, n = 65). Egg volume for gulls nesting adjacent to structure ($\bar{x}$ = 179.03 ± 17.45, n = 81) also was similar (t = −0.85, 88 df, P = 0.40) to egg volumes from nests away from structure ($\bar{x}$ = 173.78 ± 18.58, n = 9). In contrast, hatching success was greater (x^2 = 23.32, 1 df, P 0.01) for clutches adjacent to structure (69 percent versus 48 percent). Hatching success also was greater (x^2 = 11.48, 1 df, P < 0.01) for eggs in nests with overhead cover (74 percent versus 58 percent). For gulls that nested against structure, there was no preference for direction in which the next was oriented (x^2 = 0.44, 3 df, P > 0.90). Also, hatching success was unaffected by nest orientation (x^2 = 0.02, 3 df, P > 0.99).

Material suitable for nesting was limited on roofs (x^2 = 134.50, 1 df, P < 0.01), being available at only 3 percent (n = 6) of nests, as compared to 77 percent (n = 51) of nests on TPI. The volume of nests on TPI (13.1 ± 11.0 L) was greater (t = −2.13, 266 df, P = 0.03) than the volume of nests on roofs (10.3 ± 7.8 L). For roofs, nest volumes against structure (10.6 ± 7.9 L, n = 102) were similar (t = −0.62, 162 df, P = 0.53) to volumes of nests away from structure (9.8 ± 7.7 L, n = 62). Percentage volume of garbage was higher (t = 5.09, 228 df, P < 0.01) in nests on roofs (6.7 ± 10.2 percent, n = 166) than in nests on TPI (0.2 ± 0.4 percent, n = 64). Percentage garbage in nests ranged from 0–50 percent. This garbage was not putrescible waste; rather, it included items such as newspaper, cardboard, toothbrushes, wire and brooms.

Discussion

Reproduction

Eggs laid by roof-nesting gulls were significantly larger than those laid by gulls nesting on TPI. Egg size of several species of gulls increases with age to a plateau (Haymes and Blokpoel 1980, Pugesek and Wood 1992). Herring gulls to eight years of age have been reported to lay larger eggs on average, after which they decrease (Davis 1975). However, our index of relative age suggests that the two populations were similar. An alternate explanation is relative fitness of adults. Gulls on roofs laid eggs 11 days later on average

Table 2. Body mass and bill depth (at gonys) of nesting herring gulls on Turning Point Island (TPI), Sandusky Bay, Lake Erie, and on two roofs in Sandusky, Ohio, 1992.

		Body mass (g)			Bill depth (mm)		
Sex	Location	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Male	TPI	11	1,139[a]	128	12	18.30[c]	0.92
	Roofs	5	1,150[a]	88	5	17.57[c]	0.77
Female	TPI	7	976[b]	34	8	16.73[d]	1.28
	Roofs	7	977[b]	61	7	16.15[d]	1.33

[a]Means are not different (t = 0.05, 12 df, P = 0.96).
[b]Means are not different (t = 0.17, 14 df, P = 0.87).
[c]Means are not different (t = −1.54, 15 df, P = 0.15).
[d]Means are not different (t = −0.85, 13 df, P = 0.41).

than did gulls on TPI, allowing additional opportunities to forage before egg laying. Both populations of gulls in this study ate primarily fish (Belant et al. 1993), which are considered "high quality" food for gulls (Pierotti and Annett 1987). Supplemental feeding of fish to gulls has caused an increase in egg size (Hiom et al. 1991, Van Klinken 1992).

There are conflicting results regarding reproductive success of roof-nesting gulls compared with gulls nesting in more traditional areas. Some authors (Mudge 1978, Monaghan 1979, Hooper 1988) have reported fledging success as equal to or greater than that at more traditional sites. Conversely, Vermeer et al. (1988) reported lower reproductive success for densely nesting roof-nesting gulls (but not for dispersed roof-nesting pairs) as compared with island-nesting gulls. Hatching success of eggs between the two populations in this study was similar. Therefore, it is likely that roof and other urban habitats suitable for nesting are similar to more traditional sites in that there is a high degree of variability in habitat quality.

Nest-site Selection

Herring gulls appeared to select areas on roofs adjacent to structures as nest sites. Proportionally fewer later-nesting gulls nested against structure, suggesting that structure is preferred habitat and that the availability of these sites was limited. Although herring gulls had greater hatching success when nesting against structure, there was no apparent preference for orientation of nests. Hooper (1988) similarly found no preference for next orientation in glaucous-winged gulls (*L. glaucescens*) on roofs. Possible causes for nesting against structure include reduction of depredation of eggs and chicks from avian predators or attacks from conspecifics, while maintaining high visibility and an escape route for adults. This may in part explain the higher hatching success of herring gulls nesting against structure in this study.

Temperature also may affect nest-site selection. Although not quantified, the roof surface adjacent to structures is sheltered from direct sun for at least part of the day; thus, adults nesting against structure may sustain lower energetic costs for thermoregulation. Also, daytime temperature appeared to be lower on the gravel surface than on other surfaces which may explain in part the greater density of nests on the light-colored gravel surfaces. Fisk (1978) reported that the daytime temperature of a roof where least terns (*Sterna antillarum*) had nested was 5 degrees Celsius lower than the temperature of a nearby beach where they also nested. If temperature was important for nest-site selection, one would expect unequal distribution in the orientation of nests. However, the aforementioned benefits of nesting near structure may have masked the effects of temperature in nest-site selection as related to nest orientation.

The majority of gulls on TPI nested on the edge of the island on riprap. Advantages to nesting here as compared to the center of the island include greater visibility and a shorter distance to water as an escape mechanism. An apparent disadvantage of nesting near the center of the island is difficulty in accessing the nest. Gulls would either have to pass through several gull territories on the perimeter of the island of maneuver through trees and shrubs during flight. During our visits to the island, we found several adult gulls entangled in tree or shrub limbs.

During this study, nest density was lower on the roofs than on TPI. Other studies have reported similar lower densities on roofs as compared to more traditional sites (Monaghan 1979, Hooper 1988, Vermeer et al. 1988). Vermeer et al. (1988), noting that roofs provide little structure relative to "natural" habitats, observed high conspecific aggression in colonial roof-nesting glaucous-winged gulls. Thus, greater inter-nest distance (i.e., larger territories) may be a strategy used to reduce chick mortality from conspecifics.

Gulls in this study selected roofs adjacent to water for nesting that were near (about 1 km) TPI. Hooper (1988), Vermeer et al. (1988) and Blokpoel et al. (1990) also stated that roof-nesting gulls seem to prefer sites adjacent to water and prefer to colonize sites in close proximity to other occupied sites. Dispersal to more inland sites appears to occur only after saturation of suitable nesting sites near to water.

Conflicts and Control Methods

Nesting by gulls on roofs and in other urban situations has increased markedly in recent years and is likely to continue (Monaghan 1979, Blokpoel and Tessier 1986, Hooper 1988, Vermeer et al. 1988, Vermeer 1992). Increasing numbers of urban-nesting gulls have caused a concurrent increase in gull/people conflicts. Herring gulls are generally considered a nuisance when nesting on buildings because they harass maintenance personnel, defecate on nearby vehicles, obstruct drain pipes with debris and cause structural damage to the roofs of buildings.

Several techniques have been used in attempts to reduce nesting or roosting of gulls on roofs. Although oiling eggs and nest and egg destruction are effective in reducing hatching success, these techniques generally are ineffective for preventing gulls from renesting on buildings (Christens and Blokpoel 1991, Blokpoel and Tessier 1992). Also, because of the breeding longevity of herring gulls, any substantial decrease in nesting population size will likely require several years of nesting failure.

As gulls are federally protected under the Migratory Bird Treaty Act, requiring special federal (and oftentimes state) permits to carry out egg oiling or destruction of eggs and nests, non-lethal techniques to discourage nesting have been employed more frequently. Overhead wires have been used successfully to eliminate ring-billed gulls from nesting and roosting sites (Blokpoel and Tessier 1983, 1984). Gull harassment techniques have been successfully used; however, they are expensive and labor-intensive, requiring persistent repetition for at least several years (Blokpoel and Tessier 1992). The best non-lethal technique to control gull nesting colonies is to modify habitat. Although expensive to implement, the desired effects are more permanent than alternative techniques (Seubert 1990, Blokpoel and Tessier 1992). To reduce the incidence of roof nesting, architectural design (e.g., eliminating or reducing the number of structures on roofs; using dark-colored, non-gravel surfaces; and using overhead wires) should be considered during the planning stage of new buildings in areas where colonization by gulls is likely (e.g., Great Lakes and Atlantic and Pacific coasts) and when roofs of existing buildings require repair or replacement.

Roofs generally have been considered as suboptimal nesting habitat for gulls. Contrary to this hypothesis, herring gulls nesting on roofs during this study were not younger, less experienced birds than those from TPI. I hypothesize that all roofs are not suboptimal habitat, and that preferences within and among roofs and other urban habitats for nest sites exist, similar to preferences within "natural" habitats. Roofs and other urban habitats appear to be a suitable resource for nesting gulls that only have recently been used.

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Exotic Species in Urban Environments: Lessons from New England's Mute Swans

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Introduction

The mute swan (*Cygnus olor*) is a European species that often inspires images of nobility, romance and elegance owing to its natural beauty and its characterization in fairy tales (Wilmore 1974). Not surprisingly, this species has been introduced several times into North America as early as the nineteenth century to adorn estates, parks and zoos (Allin 1981). Some of these birds escaped or were released, resulting in the establishment of free-ranging populations in Michigan, Minnesota, Wisconsin, Wyoming, British Columbia, Ontario and in the Atlantic coastal states from Massachusetts to Maryland (Allin 1981). Along the Atlantic, free-ranging populations have increased to an estimated 5,300 in 1987 (Allin et al. 1987).

Despite their beauty and royal pedigree, these birds have not been universally welcomed. In North America, mute swans are an exotic species, and biologists recognize that the establishment of other exotic species, especially on oceanic islands, has decimated native fauna. Given this less than positive history of exotic species, biologists are concerned that increased populations of free-ranging mute swans may adversely impact native waterfowl populations. In particular, biologists worry about the swan's aggressive nature (Reese 1975, Williams 1989), and the potential impact of its foraging on aquatic vegetation (Allin 1987).

In a recent study, Conover and Kania (unpublished) examined the consequences of interspecific aggression by territorial mute swans on native waterfowl in southern New England. They found that swans engaged in high rates of interspecific aggression, directed primarily at mallards (*Anas platyrhynchos*), American black ducks (*A. rubripes*) and Canada geese (*Branta canadensis*). However, in most cases, the swan stopped its aggression when the threatened individual moved less than 10 meters. Swans did not keep native waterfowl from using these sites and were never observed to foil a nesting attempt by another waterfowl species.

Further, Conover and Kania (unpublished) examined the effect of swan herbivory on aquatic flora at freshwater ponds. They found no significant difference in above-ground plant biomass or species composition between sites where swans could graze and sites inside exclosures where they could not. These results indicate that mute swans, at least at the time of the study, did not have an adverse impact on native waterfowl populations at freshwater ponds. Left unanswered were the questions of what impact a much higher swan population might have at these sites or what impact swans might have in other areas, such as estuaries.

Currently, management plans for mute swans differ greatly among states. In various locales, these birds are protected, unprotected or actively controlled (Allin et al. 1987). In this study, we examined the perceptions of urban residents to assess their opinions of mute swans and management options. We also were interested in determining how knowledgeable urban residents were about exotic species, whether they believed that exotic species were less desirable than native species and how they thought exotic species should be managed.

Methods

We obtained a list from the U.S. Census Bureau of the 100 largest metropolitan areas in the U.S., and identified those located in Massachusetts, Connecticut or Rhode Island. We randomly selected three of these cities (Boston, MA, Providence, RI and New Haven, CT). We obtained the latest phone directory from each of these areas and randomly selected 100 residents from each directory to receive the mail survey.

Surveys (n = 300) were distributed in January 1992 following Dillman's (1978) procedures for mail surveys. Each person received a packet containing a survey, a cover letter explaining the survey and a return post-paid envelope. A week later, we sent a postcard as a remainder to all survey recipients. Three weeks after the initial mailing, a replacement survey and follow-up letter were sent to non-respondents.

As surveys were returned, some recipients (including deceased residents and persons who had moved from the study area) were dropped from the initial sample frame, thereby reducing our initial sample size. We obtained responses from 150 individuals and an overall response rate of 50 percent. Concern for nonresponse bias prompted follow-up phone calls to a randomly selected subsample (10 percent) of those who had not responded after six weeks from the initial mailing. No systematic bias was evident among non-respondents and we continued with our analysis.

The survey contained 10 questions eliciting information about respondents' experiences with, and beliefs about, wildlife in their area. Respondents were provided with a list of wildlife species frequently encountered in urban environments and asked to indicate whether they would like populations of each of these animals to increase, decrease or stay the same in their neighborhoods.

One question explained that "... an exotic species is an animal that is not native to North America. For instance, some wild animals originally got here because they were brought over from Europe and released." Respondents were then given a list of animals and asked to identify those that they believed to be exotic species. Additional questions elicited information regarding how respondents felt mute swans or other exotic species should be managed.

Analyses were conducted using the SAS (1988) PROC FREQ routine. This routine calculated a simple percent distribution of response scores.

Results

Only 45 percent of the respondents knew that mute swans were an exotic species; the rest either considered it a native species (29 percent) or did not know (26 percent). Even fewer respondents knew pigeons (17 percent), starlings (29 percent) or house sparrows (24 percent) were exotic. Some respondents mistakenly reported that Canada geese (19 percent), mallards (7 percent), wood ducks (5 percent), blue jays (7 percent), robins (10 percent) and cardinals (14 percent) were exotic species (Table 1).

Only 5 percent of the respondents preferred fewer mute swans in their neighborhoods; 50 percent wanted more and 42 percent no change (Table 2). For the other exotic species

Table 1. Percentage of respondents from urban areas in southern New England who reported the following birds to be either a native or exotic species, or stated that they did not know after being told that an exotic species is an animal that is not native to North America.

Species	Native species	Exotic species	Don't know
Mute swans	29	45	26
Canada geese	57	19	24
Mallards	69	7	24
Wood ducks	69	5	26
Pigeons	60	17	24
Blue jays	70	7	24
Robins	67	10	23
Starlings	48	29	24
Cardinals	62	14	24
House sparrows	52	24	24

listed, 71 percent wanted fewer pigeons, 48 percent fewer starlings and 14 percent fewer house sparrows. For native species, no one wanted fewer mallards and robins, but 23 percent wanted fewer Canada geese.

When asked whether an exotic species should be treated the same as a native species, 66 percent said yes, 24 percent said no and 17 percent did not know. When asked if they preferred native or exotic species, 2 percent said they preferred exotic species, 10 percent preferred native species, and the rest stated that they liked both equally (68 percent) or did not know (18 percent).

When asked how mute swans should be managed, 22 percent reported that we should try to increase their numbers, 22 percent said we should leave them alone, 4 percent said we should try to decrease their numbers, 2 percent said we should try to get rid of them entirely and 50 percent did not know. When asked the same question about exotic species, respondents reported that we should try to increase their numbers (26 percent), leave them alone (40 percent), decrease their numbers (6 percent), get rid of them entirely (0 percent) or did not know (22 percent).

Table 2. Percentage of respondents from urban areas in southern New England who reported that they preferred more, less or no change in the number of each of the following animals in their neighborhoods.

Species	More	Less	No change
Mute swans	50	5	42
Canada geese	44	23	32
Mallards	65	0	35
Wood ducks	50	8	33
Pigeons	6	71	22
Blue jays	43	14	43
Robins	67	0	33
Starlings	19	48	33
Cardinals	80	2	18
House sparrows	22	14	61

Discussion

Our results demonstrated that most urban residents did not know whether birds common to their area were native or exotic. Few respondents preferred native species over exotic, and most felt that we should either try to increase the populations of exotic species or leave them alone. With regard to mute swans, most reported a desire for more mute swans, not fewer.

Many mute swans in southern New England have habituated to people—the birds can be easily approached and observed, and accept food handouts from people (M. R. Conover personal observation). Because of these factors, some urban residents have developed a special bond to this bird (M. R. Conover personal observation). Many of these people are not the normal benefactors or stakeholders of wildlife programs. Hence, mute swans provide wildlife managers with a unique opportunity to enhance the lives of people who normally are not reached by other wildlife programs. Therefore, wildlife managers must be careful in establishing management policies that conflict with the wishes of these people.

Kennedy (1985) argued that wildlife biologists have a distinct professional culture which includes unique language, technology, social structure, attitudes and values. We believe that one of the shared values of the wildlife profession is that exotic species are less desirable than native species. Yet as this study's results indicate, this view is not held by most urban residents.

The belief that exotic species are undesirable and should be kept out may prove costly to urban areas. Several studies have shown that as an area is urbanized, avian diversity declines (Baten 1972, Emlen 1974, Hooper et al. 1975, Geis 1976). One reason for this is because the urbanization process destroys old niches and creates new ones. Many of the new niches are unfilled, however, because native fauna have not evolved in urban areas. If exotic species were viewed as desirable, one approach to the problem of an impoverished urban fauna might be to introduce exotic species to fill the newly-created niches. Urban areas might become giant outdoor aviaries: areas alive with exotic birds dependent on exotic plants grown in urban areas (Swain 1988), or on the thousands of feeders that urban residents might set up to attract these exotic birds to their backyard. We do not endorse this as a management practice. We want to point out, however, that by not introducing exotic species, we are foregoing an opportunity to increase biodiversity in urban areas. Hence, this represents a cost that results from the decision that exotics are undesirable.

Conflicts are likely to occur when wildlife agencies implement decisions without regard to stakeholders' perceptions and experiences (Kruth et al. 1992). Our study indicates a widespread lack of understanding and conflicting attitudes among the public with regard to exotic species. For example, while respondents reported that exotics should be treated as equals to native species, the only two species whose numbers most people wanted reduced were exotic (pigeons and starlings). Managers controlling populations of exotic species should anticipate the need for a public education program, preferably one that precedes implementation of control activities.

Our intention is not to say that the wildlife profession's belief that exotic species are undesirable is erroneous. Instead, we want to suggest that elements of this idea are rooted primarily in philosophy and only partially on data gathered systematically. We also argue that fundamental beliefs should be closely examined—especially when they are costly and not shared by the general public.

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Desert Mule Deer Use of an Urban Environment

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Introduction

Boundaries of national parks and protected areas usually are politically defined. Bekele (1980) reported a positive correlation between area and the number of large mammal species for 14 national parks in the western United States. The post-establishment loss of mammalian species in national parks in western North America may indicate that these areas are not large enough to maintain populations of some species (Newmark 1987).

Urban development is one of the primary threats facing national parks in the United States (National Parks and Conservation Association 1979). As urbanization (i.e., ecological alterations "created by the growth of cities and associated human activities" [McDonnell and Pickett 1990]) occurs on areas bordering protected wildlands, information is needed to assess the impacts that development may have on wildlife resources.

In Arizona, the Tucson metropolitan area is developing and growing rapidly as formerly undeveloped lands are converted to urban environments. Urban development is particularly evident along the boundaries of Saguaro National Monument (SNM).

When the monument was established in 1933, adjacent land was undeveloped. As urbanization encroaches on the borders of SNM, desert mule deer (*Odocoileus hemionus crooki*) habitat outside the monument is rapidly disappearing and becoming fragmented.

Habitat fragmentation can be a serious threat to the survival of large mammal populations because of their needs for space and resources. Wildlife in isolated habitats may suffer from inbreeding and reduced genetic vigor (Wilcove et al. 1986, Quinn and Hastings 1987, Saunders et al. 1991). Wildlife movement patterns also may be affected by habitat fragmentation (Janzen 1986, Wilcove et al. 1986, Saunders et al. 1991). Distribution of wildlife may be limited by roads, trails and other human activities. Development occurring adjacent to SNM may cause alteration in movement and activity patterns of those animals that range along the monument's borders.

The effects of urban development on desert mule deer populations in the Southwest have not been addressed. Our objectives were to (1) describe movements of desert mule deer along the boundaries of SNM and adjacent private lands, and (2) compare observations of home range and habitat use adjacent to housing developments to similar data reported for desert mule deer in other southwestern habitats.

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Study Area

Saguaro National Monument is divided into two sections: the Rincon Mountain District (RMD) and the Tucson Mountain District. Our study area encompassed 29 square miles (76 km^2) of the RMD at elevations from 2,600 feet (792 m) to 4,000 feet (1,219 m) (Figure 1). Level terrain (less than 10 percent slope) accounted for 68 percent of the study area and was predominant below 3,000 feet (914 m). The RMD is located on the eastern edge of Tucson and is bordered on the east and portions of the north and south sides by Coronado National Forest. Residential developments border sections of the western boundaries of the monument.

Vegetation is classified as Sonoran desertscrub and is characterized by vegetation associations within the Arizona Upland Subdivision (Brown 1982). Dominant plant associations are primarily within the palo verde (*Cercidium* spp.) cacti series. Plant names follow Lehr (1978).

Tucson has an arid climate with a mean annual precipitation of 11 inches (28 cm) (Sellers and Hill 1974). The majority of rainfall occurs in late summer as geographically isolated thunderstorms and in winter as widespread, regional storms. Weather data for 1988 did not differ significantly from the long-term average, but 1989 was the fourth driest year on record with 6.5 inches (16.5 cm) of precipitation (J. Mazur, National Weather Service, Tucson Arizona: personal communication). Daily maximum temperatures at monument headquarters during 1988–89 ranged from 70 degrees Fahrenheit (21°C) in January 59 115 degrees (46°C in July, and daily minimum temperatures ranged from 28 degrees (−2°C) in January to 68 degrees Fahrenheit (20°C) in July (SNM unpublished data).

With the exception of a small water catchment located behind the visitor center at the entrance to the monument, perennial water sources on the desert floor of RMD are limited to occasional seeps, springs and tanks. Most ephemeral water sources disappear by April 30. The occurrence of free-standing water within RMD increases with elevation in the Rincon Mountains. Outside the monument water is readily available year-round. The majority of these water sources are located on residential property and are placed there intentionally for wildlife (Shaw et al. 1992).

Methods

We captured 10 desert mule deer (5 males and 5 females) in the RMD during February and March 1988. Deer were captured with a drive net or net-gun (Krausman et al. 1985) and immobilized with xylazine hydrochloride (HCl) and ketamine HCl administered intramuscularly (DelGiudice et al. 1989). Immobilizing drugs were reversed with tolazoline HCl administered intravenously. We fitted deer with color-coded radio collars (Telonics, Inc., Mesa, Arizona) prior to release.

Between February 1988 and September 1989, we radio-located and obtained visual observations of each collard animal every 7–10 days. We obtained additional telemetry locations every 7–14 days from fixed-wing aircraft (Cessna 182) between September and December 1989. We made observations from the ground during diurnal hours. Among the data we recorded for each observation was animal location, activity and distance to

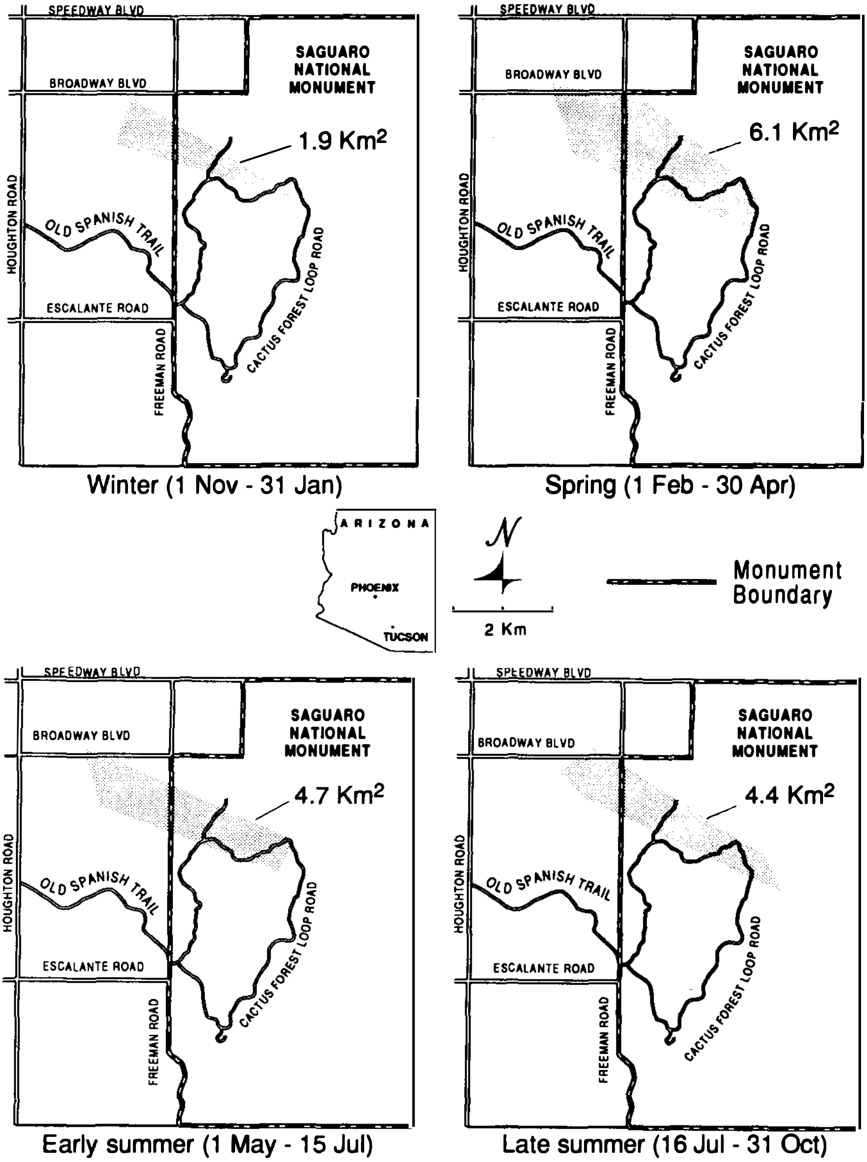

Figure 1. Minimum convex polygon (MCP) estimates of seasonal home range size (km^2) for a female desert mule deer (no. 442), Saguaro National Monument, Tucson, Arizona, winter 1988-late summer 1989.

housing. Additional data were collected by several homeowners documenting presence and frequency of collared animals on their property.

We used the harmonic mean (Dixon and Chapman 1980) and minimum convex polygon (MCP) (Southwood 1978) methods to calculate seasonal home-range size. For the harmonic mean method, we used a 75 percent isopleth to identify core areas of use. Data were analyzed seasonally be sex. Seasons were based on temperature and precipitation patterns (Ordway and Krausman 1986): spring (1 Feb–30 Apr), early summer (1 May–15 Jul), late summer (16 Jul–31 Oct) and winter (1 Nov–31 Jan). When nine or more locations per season were plotted, home range area curves did not increase by more than 10 percent; therefore, only deer located nine or more times per season were used in analysis. We present minimum convex polygon estimates for comparison to other studies.

We transformed the harmonic mean and MCP estimates to their natural logarithm to achieve homogeneity of variances. Analysis of variance was used to test for differences in these estimates between sexes and among seasons. For MCP estimates, we examined differences in home range size among seasons using Student-Newman-Keuls (SNK) multiple range test (Norusis 1988:B–159).

We surveyed homeowners to obtain information about their attitudes towards wildlife and to determine the approximate water sources provided for deer by residents. Two hundred and fifty households located within 1 mile (1.6 km) of RMD were randomly selected from Pima County property records. Each selected household was mailed a 12-page questionnaire covering wildlife-related attitudes, perceptions and behaviors (Shaw et al. 1992) following the mail survey methodology of Dillman (1978).

Results

Movements and Home-range Size

We located collared deer 596 times during the study. There was no significant difference ($P > 0.05$) for mean home range size between sexes and among seasons for the harmonic mean estimates (Table 1). Using MCP estimates, there was a significant difference ($P < 0.05$) in home-range size during late summer for all deer (males = 1.1 square miles [2.8 km^2], females = 1.6 square miles [4.1 km^2], although this difference was not significant between sexes. During late summer fawning, females increased the size of their home ranges. Females moved to higher elevations during late summer, with three females using the same general fawning area. Fawning sites generally ranged between 450 and 1,000 feet (137–305 m) above the desert floor and were located close to perennial water. Males also increased their home range by moving to higher elevations during late summer.

Individual variation was apparent in the use of areas outside of the monument by deer. Although some deer used areas outside of the park all year (Figure 1), four others (three males, one female) did not move out of RMD until early summer when ephemeral water sources dried up (Figure 2). During early summer, females were located almost 300 feet (91 m) closer ($\bar{X}$ = 528 feet [161 m]) to housing than males ($\bar{X}$ = 820 feet [250 m]), with both sexes using areas near housing for foraging and bedding. Other deer remained within the monument by day and often bedded in the vicinity of the boundary. Because the majority of deer sightings on residential property occurred between dusk and dawn (B. Burkholder [homeowner] unpublished field notes), it is likely that some radio-collared animals, undetected by us, moved out of the park only during this period.

Table 1. Harmonic mean and minimum convex polygon (MCP) estimates of mean seasonal home-range size (square miles) of desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988–89.

	Season[a]															
	Spring				Early summer				Late summer				Winter			
	$\bar{X}$	SE	Number of deer	Number of locations	$\bar{X}$	SE	Number of deer	Number of locations	$\bar{X}$	SE	Number of deer	Number of locations	$\bar{X}$	SE	Number of deer	Number of locations
Females																
75 percent isopleth	0.2 (0.5)	0.1 (0.3)	3	32	0.2 (0.6)	0.1 (0.2)	7	90	0.3 (0.9)	0.04 (0.1)	7	100	0.1 (0.2)	0.04 (0.1)	3	33
MCP	1.3 (3.3)	0.5 (1.4)	3	32	0.8 (2.0)	0.2 (0.5)	7	90	1.6 (4.1)	0.2 (0.6)	7	100	0.8 (2.1)	0.3 (0.7)	3	33
Males																
75 percent isopleth	0.2 (0.4)	0.04 (0.1)	5	63	0.1 (0.3)	0.04 (0.1)	6	72	0.2 (0.6)	0.1 (0.2)	9	111	0.3 (0.7)	0.1 (0.3)	5	57
MCP	0.9 (2.3)	0.2 (0.4)	5	63	0.6 (1.6)	0.2 (0.4)	6	72	1.1 (2.8)	0.2 (0.4)	9	111	1.5 (3.9)	0.4 (1.0)	5	57

[a]Spring = 1 Feb–30 Apr, early summer = 1 May–Jul 15, late summer = 16 Jul–31 Oct, and winter = 1 Nov–31 Jan.

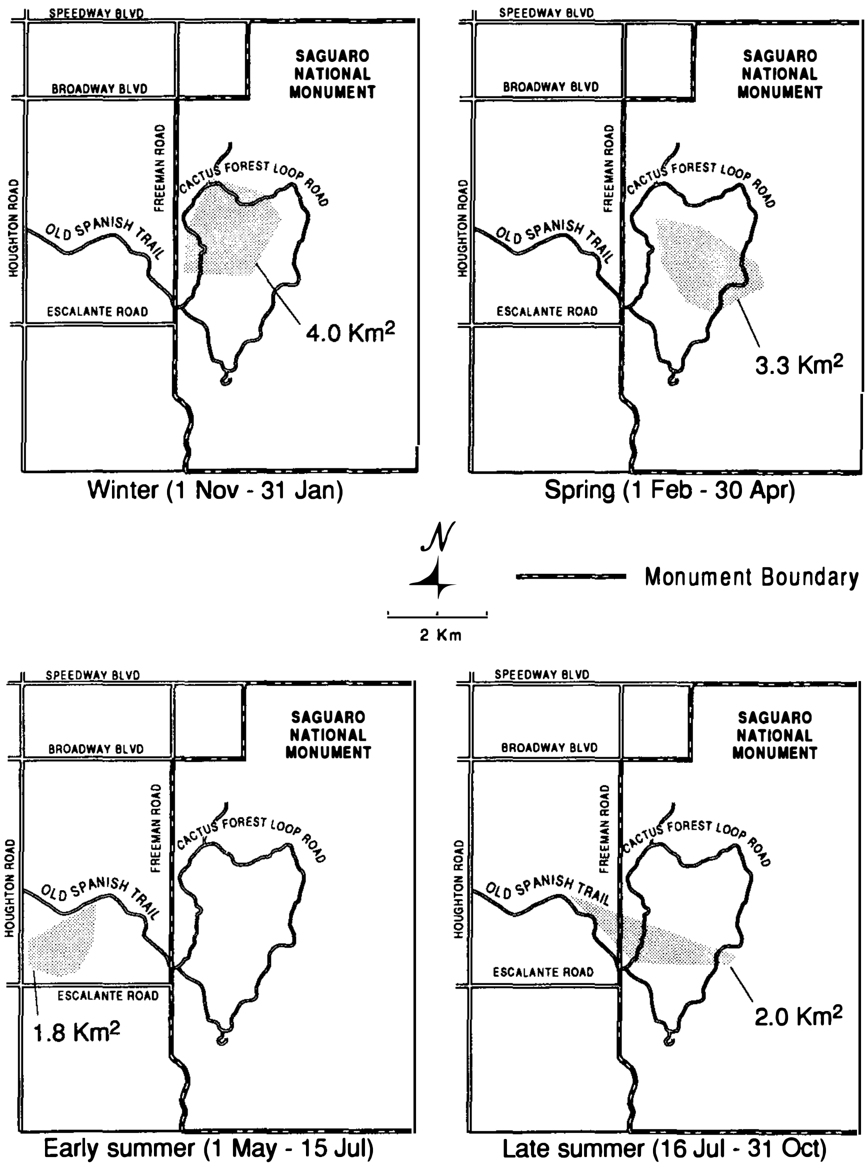

Figure 2. Minimum convex polygon (MCP) estimates of seasonal home range size (km^2) for a male desert mule deer (no. 341), Saguaro National Monument, Tucson, Arizona, winter 1988-late summer 1989.

Home range increased for four of five males during the breeding season (Dec-Jan). Two males who had never been observed out of the park previously were seen during this period in residential areas with females. Both males returned to the monument at the end of the breeding season.

Homeowners' Attitudes, Perceptions and Behavior

We eliminated unoccupied households, absentee landowners and people that resided in the area less than one year from our sample (N = 250). After these removals, our adjusted sample was 241 of which 218 responded to the questionnaire (95.5 percent response rate). There are 743 homes and rental units within 1 mile (1.6 km) of RMD. The 241 respondents in this study comprise about 32.4 percent of the total population of people who live within 1 mile (1.6 km) of RMD.

Housing densities on private lands adjacent to RMD can be characterized as low or very low. Seven percent of the respondents had lots larger than 10 acres (4.0 ha); 41 percent were 4–10 acres (1.6–4.0 ha); 34 percent were 2–4 acres (0.8–1.6 ha); 11 percent were 1–2 acres (0.4–0.8 ha); and only 7 percent were less than 1 acre (0.4 ha).

Three quarters of the respondents reported that they had observed deer on their property. Twenty-five percent saw deer on their lot 1–2 times per year; 28 percent saw them 3–10 times per year; 19 percent saw deer 11–50 times per year; and 5 percent saw deer on their property more than 50 times per year.

Five percent of the households specifically fed deer and 71 percent provided water for wildlife that deer had access to. Only 6 percent of the respondents (n = 13) considered deer a problem due to damage they caused to gardens or landscapes.

Discussion

Adult females dropped their fawns in elevations above the desert floor then returned to the desert floor after their fawns were weaned or lost. Water was more abundant at higher elevations in the RMD and at lower elevations outside RMD so water availability was not the primary reason for the shift to higher elevations. Possible explanations for this shift in habitat use may be predator avoidance (Wilson 1975, King and Smith 1980), or the result of increased nutritional demands brought on by pregnancy and lactation (Short 1981, Bowyer 1991).

Male mule deer appeared to move and expand their home range in response to water availability. The larger home range size associated with desert mule deer males during late summer (Table 1) corresponded to the start of the summer rains. Males that moved out of RMD in search of water during early summer returned to the monument in late summer as water sources became available (Figure 2).

The difference in annual precipitation between years is evidenced by the more pronounced movements of deer out of RMD in 1989 (four of nine deer moved out of RMD in three seasons in 1988 but seven of nine deer moved out of RMD in 1989 throughout the year). During the drought, deer moved earlier and remained longer outside RMD as compared to movements in 1988 when rainfall patterns were normal. In most cases, deer returned to the same residential areas where they previously used water sources.

Of 10 radio-collared deer, eight were observed out of RMD at some time during the study. A ninth animal, although not observed out of the monument, was seen on several occasions within 1,000 feet (305 m) of the boundary suggesting that she may have used areas outside of the monument. We do not know if a tenth animal, which lost its collar midway through the study, used habitats outside of the monument.

Desert mule deer appear to be behaviorally dependent on the presence of free-standing water (Wood et al. 1970, Hervert and Krausman 1986, Rautenstrauch and Krausman 1989). Seasonal home ranges exhibited by mule deer at RMD were small ($\bar{X}$ MCP = 0.62 square miles [1.6 km^2]−1.6 square miles [4.1 km^2]) compared to seasonal home-ranges reported for desert mule deer populations in western Arizona ($\bar{X}$ MCP = 2.7 square moles [7.0 km^2] −38 square miles [99 km^2]) (Krausman 1985, Rautenstrauch and Krausman 1989). Rautenstrauch and Krausman (1989) reported that desert mule deer moved to free-standing water during the driest period of summer. Hervert and Krausman (1986) demonstrated that when denied access to water, desert mule deer females searched for water outside their own home range. Similar movements in response to water loss have been reported by Clark (1953), Hanson and McCulloch (1955), Johnson (1962), Wood et al. (1970) and Rogers et al. (1978). The same general movement patterns were evident among desert mule deer at RMD.

Movements of desert mule deer are closely associated with the distribution of free-standing water during the driest seasons of the year. During years of normal precipitation, these dry periods occur in early summer and, to a lesser extent, winter, during the breeding season. Deer responded to losses of ephemeral water sources within their home range by leaving the monument in search of available water outside RMD. Because 71 percent of the homeowners near the RMD provide water for wildlife, there are numerous sources available to deer in the area, even during droughts.

The presence of abundant forage in an area may not always signify high use by deer if other habitat requirements are lacking (Leopold and Krausman 1991). The attraction exhibited by both sexes during early summer for habitat outside the monument appears to be related to water availability. In similar studies, mule deer tended to avoid areas less than 1,312 feet (400 m) from residential developments (deVos et al. 1984), or were more nocturnal and had different habitat use patterns when using intensively developed areas (Vogel 1989). Because deer were obtaining water on residential property surrounded by patches of undisturbed habitat, animals in this study were located nearer to housing than in other similar studies (deVos et al. 1984, Vogel 1989).

Management Implications

Wildlife management agencies throughout the Southwest commonly develop water sources for wildlife. By providing deer with *ad libitum* access to free-standing water during the driest times of the year, homeowners are, in effect, actively managing the deer population in RMD. They are providing a resource that otherwise would be limited during early summer, and to a lesser extent winter, thereby allowing deer to inhabit areas that otherwise could not support the high numbers of deer presently occurring on the desert floor during these seasons.

Removing water sources outside the monument, or increasing the housing density such that the increased level of human disturbance precludes the use of private lands by deer might result in changes in numbers and movements by deer that use RMD. Animals forced from suitable habitat may increase their susceptibility to predation, lower their nutritional status or decrease their reproductive fitness.

Preservation of the remaining available desert mule deer habitat outside the boundaries of RMD will be advantageous to desert fauna and also will aid in maintaining the integrity of the monument's resources. Habitat islands in strategic locations enhance wildlife resources in protected areas (Harris 1984). As development continues to occur along the monument's boundaries, a more pronounced interface between wildlife refuge and urban environment will result. This process may eventually lead to a reduction in the effective size of RMD as habitat for desert mule deer.

Results of our study demonstrate that water on lands outside the monument is important to this population of desert mule deer. Use of private lands adjacent to RMD by mule deer indicates that the current pattern of habitat islands interspersed with low density housing serves as an effective and highly desirable buffer zone between the monument and the more heavily developed urban areas 2 miles (3.2 km) west of the park. Although several radio-collared animals were observed close (<984 feet [<300 ml]) to these heavily developed areas, no animals were observed in these developments.

The deliberate efforts made to attract wildlife onto their properties indicate the high value that homeowners living adjacent to RMD place on wildlife-viewing recreation. Over the years some residents have expended hundreds of dollars for food (S. Rux [homeowner] personal communication) and elaborate watering devices on their property. Increased housing densities will result in deterioration of this form of recreation for current homeowners. A coordinated effort should be made by city and county planners, park managers and developers to take actions that will enhance the congruence of the political and biological boundaries of the SNM to minimize potential losses of wildlife resources.

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Selecting Deer Management Options in a Suburban Environment: A Case Study from Rochester, New York

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Avon

Introduction

White-tailed deer (*Odocoileus virginianus*) populations have increased to unprecedented levels during the past decade. Deer problems in residential locations are a relatively new situation, as suburban deer herds have increased dramatically since the mid-1970s (Flyger et al. 1983, Diamond 1992). Ornamental shrubs and gardens offer plentiful food, and posted lands or parks provide secure protective cover. Deer expansion into parks and suburbia has been aided by hunting restrictions (which often are intended to increase public safety) imposed by towns and rural property owners (Decker et al. 1982, Curtis and Richmond 1992). These restrictions, along with public concern about the safe use of firearms and animal rights issues (Kellert 1978), have limited or eliminated legal hunting in suburban areas, although hunting is the traditional deer population control method used in rural areas of New York. Also, many suburban deer herds in the eastern United States are relatively free from predators, except for dogs or coyotes (*Canis latrans*). Consequently, forces which would typically slow deer population growth are limited or completely lacking in many residential landscapes (Parkhurst and O'Connor 1992).

The challenge facing many state and local governments is how to manage deer herds in a suburban environment (Brush and Ehrenfeld 1991, Curtis and Richmond 1992, Diamond 1992). The debate concerning what to do, or not do, with deer in residential areas often is premised on the assumption that deer were there first, as part of a natural ecosystem (Diamond 1992). Densities of North American deer herds in precolonial times have been estimated at 8–11 deer/square mile (3–4 deer/km^2) (McCabe and McCabe 1984). These pristine herds likely were controlled by native Americans, deer predators and other ecological forces. Intensive hunting and land-use changes had eliminated deer from western New York by the late 1800s. During the early 1900s, small deer herds from northern Pennsylvania drifted into the abandoned farmland of southern parts of New York State, and continued to expand northward (J. Fodge, New York State Department of Environmental Conservation, personal communication). Secondary-growth forests and brushland found on abandoned farms provided excellent habitat (Halls 1978). The return of deer to New York also was accelerated by the removal of large carnivores during the last century (Peek 1980). Since the 1920s, deer numbers have steadily increased, and by the 1940s hunting seasons were established throughout most of New York. Deer now present safety hazards to motorists, damage ornamental shrubs and are perceived as agents in Lyme disease transmission (Connelly et al. 1987, Decker 1987, Siemer et al. 1992).

Wildlife professionals recommend public hunting as the most economical and humane method for removing excess deer (Ellingwood and Caturano 1988). In areas where: (1) proposed herd reduction objectives are clearly defined, (2) operational plans are formulated well in advance, and (3) cooperation of interested parties has been obtained, hunting can be a safe, efficient and economical management alternative (Parkhurst and O'Connor 1992, Winchcombe 1992).

Many suburban residents enjoy deer (Decker and Gavin 1987) and recognize the need for population management programs for deer. However, some residents are unlikely to support the traditional approach for controlling deer numbers, given their protective view of wildlife, and their lack of participation in sport hunting (Decker and Gavin 1987). Proposed herd reduction programs often generate vocal and emotional public discontent. Considerable public disagreement remains over the need for and the feasibility, humaneness and economics of hunting as a management tool (Parkhurst and O'Connor 1992). Involving citizens in policy decisions and the formulation of management plans improves existing deer management programs and enhances agency credibility.

This case history describes a Citizen Task Force (CTF) process (Decker 1991, Hall 1992, Stout et al. 1992) for determining goals for deer herd size for the Greater Rochester metropolitan area (New York State Deer Management Unit [DMU] 96). A similar method had been used successfully in rural areas by the New York State Department of Environmental Conservation (NYSDEC) to set herd management goals for selected DMUs throughout New York. The DMU 96 CTF applied this model in a suburbanized area with intense deer management conflicts. In addition to recommending deer population objectives, this was the first time that stakeholders in New York were requested to recommend management strategies for achieving the deer population goals they set for the DMU.

Study Area

DMU 96 is located within Monroe County in northwestern New York, along the southern shore of Lake Ontario (Figure 1). Thirty-two percent (126,400 acres [51,154 ha] of 391,586 total acres [158,475 ha]) of Monroe County currently is classified as residential property (G. E. Charipar, Monroe County Department of Planning and Development, personal communication). Business, industrial and infrastructure development occupies 12 percent (45,503 acres [18,415 ha]) of the county. Much of DMU 96 contains industrial or residential development associated with metropolitan Rochester.

Western portions of the DMU in the Town of Greece contain agricultural and forest lands. Agricultural lands account for 30 percent (118,344 acres [47,894 ha]) of Monroe County. Twenty-one percent (81,906 acres [33,147 ha]) of the county land area is classified as undeveloped or vacant.

Monroe County also operates several suburban parks within the DMU. Parks and recreational facilities comprise 5 percent (19,432 acres [7,864 ha]) of Monroe County. The largest park in DMU 96, and the site with the most intense debate concerning deer management, is the 965-acre (390 ha) Durand Eastman Park located within the Town of

Irondequoit. Many deer/people conflicts also occur in the suburban fringes of other parks and undeveloped brushlands in the unit.

Human population densities for municipalities within the DMU are: (1) Rochester City—6,470 persons/square mile (2,499 persons/km^2), (2) Town of Irondequoit—3,423 persons/square mile (1,326 persons/km^2), (3) Town of Brighton—2,222 persons/square mile (859 persons/km^2), (4) Town of Greece—1,901 persons/square mile (734 persons, km^2), and (5) Town of Pittsford—1,055 persons/square mile (408 persons/km^2) (U.S. Department of Commerce 1991). High densities of people and intense residential development would complicate firearms hunting for deer in DMU 96.

Background

DMU 96 was one of the last units in New York to be opened for deer hunting because deer only recently repopulated that area. Currently only longbows may be used to take

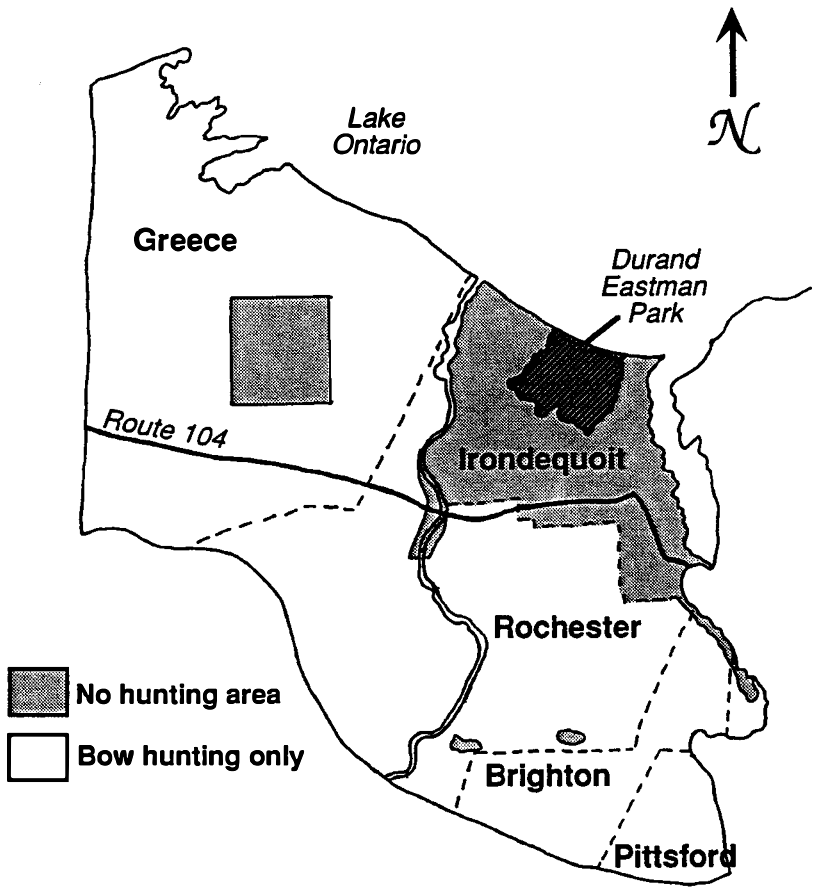

Figure 1. Town boundaries and hunting areas within Deer Management Unit 96, the Greater Rochester metropolitan area, New York.

deer (either sex) during regular or archery seasons within this DMU, with the exception of the Town of Irondequoit (Figure 1), in which no hunting is allowed. In 1978, the Irondequoit Town Council passed a local law banning the use of bow and arrows. Monroe County regulations also prohibited hunting in county parks throughout the DMU. Consequently, deer populations in Durand Eastman Park and the Town of Irondequoit have grown with little restriction since the late 1970s. Today, whitetail densities in portions of Durand Eastman Park are at least 87 deer/square mile (33 deer/km^2), and may be much higher (J. Hauber, NYSDEC, personal communication: 1992 helicopter survey data). Much of the controversy concerning deer management in DMU 96 is the result of human/deer conflicts in and around Durand Eastman Park.

Currently, deer/vehicle accidents are an important deer mortality factor in portions of DMU 96. The number of carcass-removal permits issued by NYSDEC annually as the result of deer/vehicle accidents increased from approximately 260 in Monroe County during 1980, to about 650 in 1990 (J. Palmateer, NYSDEC, personal communication). However, research indicates NYSDEC deer carcass tags may account for only 17—25 percent of the actual number of accidents in DMU 96 (Decker and Loconti 1989, Decker et al. 1990). Extrapolating from Decker et al. (1990), approximately 2,600 reported and unreported deer/vehicle accidents may occur in Monroe County annually, costing between $1.3 to $3.6 million in vehicle repairs. Research indicates about 6 percent of all deer/vehicle accidents result in human injury (Decker et al. 1990).

The debate surrounding deer management in the Town of Irondequoit led to the formation of three very vocal and active deer-related citizen organizations: (1) the Irondequoit Deer Action Committee (IDAC), (2) the Monroe County Alliance for Wildlife Protection (MCAWP), and (3) Save Our Deer (SOD). IDAC was formed to address deer problems in Irondequoit and adjoining park lands. The primary concerns of IDAC members include: (1) the potential for human injury from deer/vehicle accidents, (2) deer damage to personal and public property, (3) public liability for deer-related lawsuits against town or county government, (4) the potential threat of Lyme disease, and (5) the health of the local deer population (Town of Irondequoit 1990). MCAWP has proposed to reduce deer/vehicle accidents by publicizing defensive driving techniques and deer movement patterns, and this group wants to prevent the killing of deer (MCAWP 1992). Both MCAWP and SOD (Enos 1992) support experimental reproductive inhibition techniques (Turner et al. 1992) to regulate deer numbers in Irondequoit. These citizen organizations have lobbied town, county and state governments to make their desires known.

Town, county and state governments each have been constrained by the other's laws and regulations. NYSDEC has the authority to issue permits for the removal of deer and use of deer as a public resource. Monroe County legislators oversee county parks, and with prior agreement, Rochester city parks in DMU 96. Town government has enacted laws restricting the use of bow and arrows, and electric fences on residential properties in Irondequoit. For more than 15 years, NYSDEC has recommended bow hunting to regulate deer numbers on town and county lands. This tangled web of authorities and laws resulted in political gridlock and lack of action. For instance, after much public discussion, the Irondequoit Town Council recommended deer be trapped and transferred to venison farms (Town of Irondequoit 1991), if Monroe County funds would pay for this effort. They were denied authority to trap and transfer deer to a private, commercial game farm because the state ruled that deer, as a public resource, could not be used to economically benefit an individual interest (L. Myers, NYSDEC, personal communication). This lack of communication between authorities, and mixed messages from local citizens, contributed to a stalemate that damaged the credibility of government agencies and elected officials.

The Public Involvement Process

During autumn 1991, NYSDEC staff again attempted to resolve the deer management controversy in the Greater Rochester metropolitan area, using a modification of a CTF process which was successful elsewhere in New York. In 1990, NYSDEC and Cornell Cooperative Extension (CCE) had initiated a cooperative effort to involve citizens in wildlife management decisions (Decker 1991, Hall 1992, Stout et al. 1992). CTFs were organized in 15 DMUs across New York to provide stakeholders (i.e., farmers, sportsmen, foresters, conservationists, motorists and others with an interest in deer management) with the opportunity for choosing a desired deer population level for their particular DMU (Stout et al. 1993). The objective of these CTF meetings was to determine if an increase, decrease or no change in deer numbers was warranted in the DMU during the next five years. CCE agents facilitated meetings, and with NYSDEC input, selected 8–14 individuals to serve on each CTF. The CCE facilitator was viewed by CTF members as an objective third party with no direct stake in the outcome of the task force process.

During the first meeting of each CTF, NYSDEC staff presented background information so each member could understand the New York State deer management system. Between the first and second meeting, each member was asked to contact at least 10 other people in his or her stakeholder group and share their views with other CTF members. During the second meeting, each member shared their stakeholder-group's interests and concerns. Discussion focused on the costs and benefits of deer numbers at different levels. In some cases, consensus was reached after two meetings, and deer population objectives were recommended to the regional wildlife manager. A third meeting was held if additional discussion was necessary. Thirteen of 15 CTFs agreed on a desired deer population level for their unit, and two CTFs were deadlocked when one or two members would not compromise their positions (Hall 1992). In both cases, NYSDEC staff considered the input of all CTF members to set a deer population objective.

Cornell University's Human Dimensions Research Unit (HDRU) conducted an evaluation of these 15 CTFs to determine how well the process worked and make suggestions for improvement (Stout et al. 1992). Information gained was used to initiate the task force in DMU 96.

NYSDEC, HDRU and CCE decided citizen stakeholders in DMU 96 needed to sit face-to-face to discuss their views. If a group of citizens could reach agreement concerning deer management options, then government officials would be in a position to act on their recommendations. In this situation, agency staff would provide technical and regulatory information to stakeholders serving on the task force. Given the recent successes in other rural DMUs, a test of a similar suburban CTF model was warranted. NYSDEC wildlife managers contacted the Monroe County CCE office for assistance as in other DMUs. However, local CCE staff in DMU 96 declined to participate, at least in part, because of the politics and heated nature of the situation. Consequently, P. Curtis at Cornell University in Ithaca (approximately 120 km [75 miles] from Rochester) was contacted to facilitate the meetings.

During December 1991, NYSDEC and CCE staff organized an 11-member CTF representing various stakeholder groups within DMU 96 (Table 1). Stakeholder organization leaders were contacted and identification of CTF members was done initially by telephone. CTF members were charged with two tasks: (1) set a deer population objective for DMU 96; and (2) recommend management strategies to achieve this goal. Invitations were mailed committing members to attend a series of three monthly meetings (January–March, 1992) to set a deer population objective for DMU 96. If this phase led to a deer population decision, members would be invited to participate in additional meetings (April–September, 1992) to determine management strategies for reaching the deer population objective. SOD representatives did not serve on the DMU 96 CTF because this group was formed after the public involvement process was initiated and plans for the January meeting were finalized. SOD members were advised to provide input through the MCAWP representative because their organization shared similar welfare interests. HDRU staff provided a formal evaluation of this process.

Background information was provided to CTF members during the January 1992 meeting. Staff from Monroe County Parks, Sheriffs Department and Health Department discussed damage to vegetation, deer/vehicle accident rates and disease-related problems, respectively. The role of the CCE facilitator and NYSDEC technical staff was clearly outlined. NYSDEC wildlife managers reviewed deer population trends, and New York State's deer management system. HDRU staff outlined the evaluation process. CTF members discussed the definition of consensus to be used during the meetings. At the suggestion of the facilitator, the task force agreed consensus would not be reached if two or more CTF members opposed a specific action or deer population objective. At the conclusion of the first meeting, members were provided a suggested format for recording opinions of DMU 96 stakeholders, who would be contacted to obtain input before the second meeting.

During February, CTF members summarized input received from contacting stakeholders. Recommended deer population sizes ranged from no change to an 80 percent decrease. Eight of 11 members indicated a decrease in numbers was warranted, while three participants thought deer numbers should remain the same. Members all agreed that deer densities were quite different in the north and south half of DMU 96, and recommended the unit be split accordingly for management purposes. Consequently, DMU 96 was divided primarily along State Route 104, a major east-west traffic corridor, for the remainder of the discussions.

In March, the group decided a population objective of 20–25 deer/square mile (8–10)

Table 1. Individuals, organizations and stakeholder interests represented by Citizen Task Force members in Deer Management Unit 96, Rochester, New York, 1992.

Individual/organization	Stakeholder interest
Archery Hunter Instructor	Hunter ethics, education
Cornell Cooperative Extension Master Gardener	Gardeners, homeowners
Helmer Nature Center	Environmental educators
Irondequoit Deer Action Committee	Motorists, homeowners
Monroe County Alliance for Wildlife Protection	Animal welfare, homeowners
Monroe County Farm Bureau	General farmers
Monroe County Sportsmens' Federation	Sportsmen
N.Y.S. Forest Owner's Association	Woodland managers
Town Homeowners' Associations	Homeowners
Western N.Y. Fruit Growers Association	Fruit farmers

deer/km^2) in areas with quality deer habitat was appropriate for DMU 96. CTF members decided using a percent decrease was not appropriate because the current size of the deer herd was unknown, and perceptions concerning the number of deer in portions of DMU 96 differed. Harvest data from the south portion of the unit indicated the deer population was only slightly above this objective; therefore, a 5 percent decrease in herd size was recommended. A helicopter count of deer in the Town of Irondequoit indicated densities were about four times the recommended level, and consensus was reached that reductions were necessary in the north portion of DMU 96 during the next five years. Task force members decided to take a conservative approach for removing deer. Frequencies of reported deer/vehicle accidents were reviewed. The recommended number of deer to be removed from the northern half of DMU 96 during the first year was equal to the confirmed number of deer killed on roadways during 1991 (80 for Irondequoit, 120 for Greece). If deer/vehicle accidents and damage reports were not reduced during the following year, the number of deer removed would be doubled. Before the March meeting concluded, the purpose of the April meeting (recommending deer management techniques) was discussed with CTF members, and a videotape describing a similar suburban deer problem in Illinois (Witham 1991) was reviewed.

During the April meeting, discussion focused on alternative methods for accomplishing the deer population objective in the north portion of DMU 96. The leader of the New York Cooperative Fish and Wildlife Research Unit at Cornell University discussed the costs and benefits of various management options (Ellingwood and Caturano 1988). CTF members agreed that different strategies were needed to accomplish short-term and long-term population objectives. Because of restrictions on discharging bow or firearms, the CTF decided to evaluate options for the Town of Irondequoit separately from the remainder of DMU 96. NYSDEC staff indicated deer population objectives could be achieved with additional DMU permits in portions of DMU 96 where archery hunting was permitted (i.e., the southern half, and the Town of Greece in the northern portion).

It became apparent that the deer population objective in the Town of Irondequoit could not be reached without cooperation between town, county and state governments, and local legislative changes to permit firearms use. During the May meeting, CTF members met with elected officials and representatives from government agencies. The political realities of the situation were candidly discussed, and officials outlined steps that would be necessary before they would approve proposed management actions. The supervisor from the Town of Irondequoit declined the invitation to meet with CTF members and other officials, and received sharp criticism from local deer-related citizen organizations and the media. The president of the Monroe County Legislature emphasized that the deer management alternative selected should be low cost and very safe, and people in the community would need to be more unified in accepting a particular alternative. It was noted that CTF members should assist with building public consensus in the community.

In June, the Town of Irondequoit supervisor made a special request to meet with CTF members because of political pressure received as a result of missing the May meeting. After explaining his position, he assigned a liaison from the Town Council to work with CTF members and other government officials. An expert on deer reproductive inhibition from Eastern Montana College was invited to discuss the efficacy of remotely-delivered reproductive inhibitors for deer (Turner et al. 1992), and the feasibility of initiating a study in Durand Eastman Park. With adequate funding and cooperation from the Cornell University Veterinary College, field research could potentially begin during autumn 1993. The previous evening, this expert discussed immunocontraception in feral horses and deer at a public meeting supported by MCAWP and SOD. After much discussion and debate, selective culling with professional sharpshooters was selected as the preferred short-term removal method in the Town of Irondequoit. Research to develop practical reproductive inhibitors for deer was the long-term option of choice. CTF members agreed that the facilitator would draft a report describing their recommendations and justification for action.

CTF members met in July to review and discuss the draft report and a distribution strategy to government officials and citizens of DMU 96. NYSDEC presented a communications approach which included: (1) a series of three press releases concerning deer biology, management and the CTF process; (2) a press conference; (3) continued meetings with local government officials; and (4) an informational workshop. Local media had contacted the facilitator and NYSDEC on numerous occasions for information about the CTF and its recommendations. NYSDEC and CTF members decided to hold a press conference to publicly announce the recommendations and distribute copies of the CTF report. The press conference was scheduled in September. One member of the CTF decided not to support a portion of the final recommendations after receiving pressure from her organization, the MCAWP. Her group drafted a minority opinion (MCAWP 1992) which also was distributed at the press conference. SOD members were present at the press conference to voice their opinions as well. The minority opinion stated that current biological data did not support the CTF recommendations to selectively cull deer in the Town of Irondequoit. This minority report supported reproductive inhibition research, without selective culling, to manage the deer population in Irondequoit.

Following the press conference, a government working group was established to implement the CTF recommendations. Representatives from town, county and state governments worked together to revise existing laws in order to permit selective culling of deer in the Town of Irondequoit and Durand Eastman Park. Members from this working group provided technical advice concerning deer for elected officials in town and country government.

Research proposals were submitted by the New York Cooperative Fish and Wildlife Research Unit at Cornell, and the College of Environmental Science and Forestry in Syracuse to monitor deer populations and evaluate the efficacy of experimental deer reproductive inhibitors in Durand East Park. The Cornell proposal was developed to meet research objectives outlined in the CTF recommendations. Physiological data would be collected from deer culled by town and county personnel to develop a predictive model of population growth. Based on estimates of herd population size and sex ratios, the number of female deer to be treated with experimental immunocontraceptives could then be determined. MCAWP solicited the research proposal from the College of Environmental Science and Forestry, which included only radio-telemetry work and field testing of contraceptives for deer, as MCAWP did not want to see deer killed for research purposes (MCAWP 1992).

Monroe County legislators approved the CTF recommendations and amended their firearms law to allow the shooting of deer in Durand Eastman Park for the proposed research project. Irondequoit Town Council members also approved the CTF recommendations and amended the town firearms law to allow deer to be taken for selective culling and research purposes. Town government agreed to appropriate a total of $25,000 from their 1993 budget to support the Cornell proposal for deer research. However, the Monroe County Legislature decided not to appropriate funding for research. NYSDEC wildlife managers authorized state permits for deer culling and agreed to provide technical assistance with the research project.

As implementation of the CTF recommendations continues to come closer to reality, animal welfare and rights groups have stepped up their public campaigns to discredit the final report. MCAWP, SOD, the Humane Societies of Rochester and Monroe County, the Fund for Animals, Animal Advocates of Upstate New York, and the Humane Society of the United States filed a court injunction on February 10, 1993, delaying implementation of deer culling in Rochester for at least two weeks.

Lessons Learned from the Public Involvement Process

It's still uncertain whether the CTF recommendations will be implemented in DMU 96. However, an evaluation of the steps that have occurred to date provide insights for improving this process if it is used again in suburban areas that have a potential for controversy. The following list describes situations that influenced the outcome of the CTF process which could have been handled differently.

1. *Reaching a consensus may not be possible, however, it does not mean all is lost.* In a suburban location with a long-standing controversy concerning various deer management alternatives, building consensus was more challenging than in more rural DMUs. CTF members had difficulty comparing the merit of each other's position. Approving recommendations by a simple majority vote was not appropriate. For example, the IDAC representative indicated their group had several hundred members and was the true voice for the community. The MCAWP representative countered this argument by stating that although their membership was smaller, people in DMU 96 as a whole would be more likely to support their position. The facilitator indicated that sharing ideas and working together to resolve existing problems was the goal of the CTF, not to achieve a majority vote. At the suggestion of the facilitator, the group agreed that at least 10 of 11 members must approve of a particular action for it to be included in the final recommendations, so that no single individual should be able to stall the process. This differed from the way consensus was defined in the rural CTFs, in which all members had to agree to a recommendation to reach a consensus.

   As defined, a consensus was reached in DMU 96. Although this modified definition of consensus seemed reasonable and worked well initially, it created problems during the final stages of the process. The MCAWP representative could not approve of selective culling because her organization decided it was unacceptable, and concluded reproductive inhibition was the only acceptable alternative. What the MCAWP representative did accomplish was to bring the interests and concerns of animal welfare advocates to the forefront of CTF discussions. Her input served to strengthen the final report to the point that her group's recommendation for reproductive inhibition was included in the CTF plan. This may not have occurred if a voting procedure had been used.
2. *Emphasize problem-solving techniques so that mechanisms for including strongly-held minority opinions are built into the process.* It may be unreasonable to expect all individuals participating in a CTF to reach unanimous agreement concerning solutions for solving very complex and controversial management alternatives for suburban deer herds. In DMU 96, despite discussion and encouragement from other CTF members to support the entire plan (which included future reproductive inhibition research), the MCAWP representative would not agree with selective culling

recommendations made by the CTF. She asked CTF members to include a minority opinion in the final CTF report, which was not acceptable to the members. Instead, the MCAWP representative distributed a separate minority report at the press conference.

Including participants who have a wide range of attitudes and values about deer is essential for any public involvement process to be credible and arrive at a fair recommendation (Susskind and Cruikshank 1987). We recommend future suburban CTFs strongly emphasize a problem-solving approach in which every participant can "win" (Susskind and Cruikshank 1987). Allowances for individual beliefs and differences of opinion should be discussed at an early stage, to determine if a unanimous consensus can be achieved. To keep individuals with minority opinions involved in and supportive of the process, they should be given an outlet to voice their opinions concerning the recommendations.

3. *Procedures for receiving comments from people in the community should be part of the process.* CTF members were asked to contact other individuals in their stakeholder interest-group to broaden their perspectives on deer management issues. However, there was no formal mechanism for interested individuals in the community to have input into the CTF process. In many rural DMUs, CTF members and CCE agents agreed to have their names published in the local paper so people in the community could contact them with additional input. With the long history of controversy concerning deer management issues in DMU 96, CTF members did not want their names made public until the process was complete. Members felt they would not be able to handle the large number of anticipated calls and/or letters. Recently, some CTF approaches have incorporated a public meeting after the first CTF meeting so that CTF members could learn about opinions of people in the community (D. Faulknham, NYSDEC, personal communication). CTFs also may consider implementing an opinion survey using scientifically rigorous techniques.
4. *Attempt to involve all interests in the process, particularly those with the ability to block implementation of CTF recommendations.* In DMU 96, not all interests participated in the CTF process. Another citizens' group (SOD) with animal welfare interests was formed and became active in the community after the CTF process was initiated. The CTF organizers decided not to add a SOD member because animal welfare interests were already represented by MCAWP, which appeared to be closely allied with SOD.

   SOD and MCAWP then formed a coalition criticizing the CTF recommendations and the process. SOD and MCAWP claimed that homeowners and animal welfare concerns were not represented in the report, and the make-up of the CTF was biased towards more rural interests (MCAWP 1992). The MCAWP representative originally agreed to use the modified definition of consensus discussed at the first meeting, although later when she could not find additional support for her concerns from other CTF members, her group claimed the consensus process was invalid. Also, MCAWP and SOD disputed scientific research cited in the recommendations, using single statements from research reports that were taken out-of-context to promote their agenda. Involving all interests in the process may not necessarily prevent groups from blocking the recommendations from a citizen participation approach, however, the fairness of involving a diversity of community interests in arriving at a solution could not be disputed.
5. *Use the media aggressively to publicize the CTF effort.* Contacts with the media in

DMU 96 were limited until the CTF released its recommendations at the press conference. A press release had been issued in February 1992 announcing the formation of the DMU 96 CTF, its purpose and a tentative time frame for producing final management recommendations. Individual CTF members agreed not to discuss progress with the media, but rather issue a joint statement at the conclusion of the process. Television and newspaper reporters frequently contacted the facilitator and NYSDEC wildlife managers attempting to obtain status reports. Before the 1992 election, newspaper articles (Finnerty 1992, Smith 1992) and an IDAC newsletter (IDAC 1992) reported the stances of candidates concerning deer management issues. Names and addresses of reporters requesting information about the DMU 96 CTF were compiled to assemble a mailing list. When recommendations were nearly complete in mid-August, NYSDEC announced to the media that a press conference would be held in Durand Eastman Park during early September to inform the community of the proposed course of action.

During the CTF process, local deer-related citizen groups (MCAWP, IDAC, SOD) continued to promote their organizational goals. Articles voicing their differences of opinion often appeared in the newspaper. SOD representatives picketed the press conference, and MCAWP distributed their minority opinion. A series of news releases describing the CTF's progress, issued monthly and approved by CTF members, may have reduced misinformation in the media and the level of controversy. Media coverage of an informational workshop also could have provided educational opportunities for the community and local elected officials. MCAWP, IDAC and SOD could have provided information about their membership at booths so people could directly compare and discuss each organization's agenda for resolving deer conflicts. With additional financial resources, the media might have been used as a proactive educational tool to deliver a more structured message.

6. *Provide ample time and resources for the process to work.* Additional public education could have benefited this process. A community workshop on deer management co-sponsored by NYSDEC and CCE was discussed, however, Monroe County CCE decided not to participate because of the sensitive political nature of deer-related issues. NYSDEC biologists decided they did not have the staff or adequate financial resources to independently organize the workshop while CTF meetings were ongoing. If funding is approved for deer culling and research, educational seminars describing the purpose of the study and need for conducting deer research should occur before the actual field work is initiated. The community must understand the reasons for reducing deer numbers, why selective culling was chosen as the preferred method, and expected outcomes of future research projects.
7. *Know your bounds and be prepared to provide a timely response to the participants.* NYSDEC wildlife managers made the decision to implement CTF recommendations for a five-year period as long as the proposed actions were biologically and technically feasible. Wildlife managers had the professional expertise to discuss expected outcomes from the selection of various deer population alternatives. We emphasize that agency biologists are not giving up control of deer management, as long as wildlife managers clearly establish reasonable bounds at the beginning of the process. Allowing public involvement increases the credibility of wildlife professionals and support for agency programs.

However, the flexibility of the consensus process occasionally may put a wildlife agency in an awkward situation. For example, if CTF members decide to discuss nontraditional approaches for resolving deer conflicts (i.e., reproductive inhibition), wildlife managers may have little research-based information available to respond to questions or predict future outcomes of proposed actions. Also, decisions to use techniques other than hunting may require changes in agency policy at the highest administrative levels. The wildlife agency must be able to respond quickly to information requests and be willing to consider policy changes if the CTF process is to succeed. In DMU 96, regional wildlife managers assisted with the development of a statewide policy for using experimental contraceptive materials for regulating deer numbers in locally overabundant herds.

Discussion

Although the CTF process had many positive outcomes, the heated debate concerning management of the deer herd in Durand Eastman Park continues. Undoubtedly, suburban white-tailed deer management will continue to challenge wildlife management agencies.

Managers will need to decide whether to accept or reject local community proposals for deer population control. However, wildlife managers lack an understanding of urbanites' motives, satisfactions and needs for participating or not participating in wildlife management activities, and the reasons for these orientations (Young 1991). By promoting public involvement strategies, we believe wildlife agencies will build credibility in metropolitan communities, and managers will increase their understanding of the range of attitudes and values people hold for wildlife. Involving community leaders in management decision also will provide local policy-makers with the opportunity to build ownership in wildlife programs. Informed and dedicated community leaders can promote sound natural resource management to a variety of suburban audiences which typically have little or no interaction with wildlife management professionals.

Increasingly, wildlife management decisions are being made in the political arena. It's impossible to remove politics from the ultimate decision, and no matter what the final outcome may be, some members of the community will not be supportive of the final plan. Many suburbanites are highly educated and well-informed on topics which they find interesting. Local politicians often have little background knowledge of wildlife management or human/wildlife conflicts. It can be very difficult for elected officials to make decisions based on mixed messages from various publics, and incomplete scientific data concerning the reliability of deer management tools (Curtis and Richmond 1992). During the DMU 96 CTF process, members repeatedly challenged the validity of deer/vehicle accident statistics and the feasibility of implementing a contraceptive program for free-ranging deer. Wildlife agencies could benefit by providing in-service training for policy-makers who serve on environmental management councils and other committees which make decisions affecting natural resource management.

It also is imperative to rebut misleading information presented in newspapers or other media sources. To build community support for management actions, citizens must be able to make judgments based on interpreting scientific research. This will be a difficult task, as many people lack a general understanding of wildlife biology (Kellert 1984), or the scientific approach to problem-solving. Suburban residents also lack knowledge of methods for resolving wildlife-related conflicts (O'Donnell and VanDruff 1987). Public workshops and seminars can be used to provide wildlife-related information to interested citizens. If biologists and natural resource managers do not take leadership in this area, other interest groups will attract the attention of people who have few wildlife-related experiences, and even less formal resource management education.

The Citizen Task Force is but one example of a strategy for involving stakeholders in wildlife policy and management decisions. In Minnesota, wildlife agency staff facilitated a deer management task force to resolve urban deer management problems (McAninch and Parker 1991). A 12-member *ad hoc* committee on deer management was appointed by the Wisconsin Natural Resources Board to develop deer season structures which could be adjusted to changing conditions in deer habitat and numbers (Craven 1992). With additional refinement, citizen involvement approaches could be adapted to obtain public input in a variety of suburban wildlife management situations.

The final outcome of the process in Rochester is unclear. However, state, county and town governments are much closer to taking action to resolve deer management conflicts now than at any time during the past decade. Also, policy-makers are beginning to understand the complexity of wildlife management decisions, and the wide range of values and attitudes citizens may have. Many of these beliefs are strongly held and motivate people to take action. It may be difficult to develop unanimous support from CTF members for specific deer management alternatives. The challenge is to incorporate minority opinions into the process so that all stakeholders make significant contributions to the final plan.

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Testing the Accuracy of an HSI Model in an Urban County

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Introduction

Conservation efforts in urban and urbanizing areas increasingly focus on the protection of threatened and endangered species. Recent articles by Schaeffer (1988), Byers et al. (1988) and Beatley (1991) have described efforts by local governments to identify and protect habitats used by these rare species.

Wyandotte County, Kansas is typical of many urban areas. One of the eight counties making up the Kansas City metropolitan statistical area, Wyandotte County includes Kansas City, the second largest central city in the region (Starsinic and Forstall 1989). Three state-listed endangered or threatened species, the bald eagle (*Haliaeetus leucocephalus*), northern red-belly snake (*Storeria occipitomaculata occipitomaculata*) and western earth snake (*Virginia valeriae elegans*), are thought to occur in the county (K. Brunson personal communication: 1990). Because a Kansas state law requires the protection of habitats for state-listed threatened and endangered species (Kansas Department of Wildlife and Parks 1989), local governments and the county planning department are working to develop objective methods of habitat assessment for these species that can be used to evaluate sites proposed for development.

Habitat suitability index models have been used in urban areas to evaluate the impacts of site development on selected species (Williams-Hopper 1988, Burley 1989). These models have not been validated in urban or urbanizing areas and little information is available on their accuracy in these habitats.

In 1990 we started a project to develop and evaluate a western earth snake habitat suitability index model for Wyandotte County. Our goal was to design a model based on existing literature for the snake and determine the accuracy of the model on sites surrounded by different levels of urbanization. The objectives of the study were to determine: if western earth snake capture success is related to habitat suitability; if capture success is related to degree of urbanization; the relationship between capture success and habitat model variables; and the relationship between capture success and measures of urbanization.

Methods

Model Development

Our first step in developing the model was an extensive search of the published and unpublished literature for information documenting the habitat features associated with western earth snake food and cover requirements. This included a search of the National Agricultural Library database and other on-line reference services. We found no primary literature documenting these features. Due to this lack of information, our model is based on habitat descriptions from field guides for midwestern states.

Field guides for Kansas reptiles and amphibians report that western earth snakes inhabit rocky hillsides, riparian areas, moist woodlands and forest edges (Anderson 1965; Collins 1974, 1982; Johnson 1987). The Kansas Natural Heritage Program database includes old fields, vacant lots and wooded or brushy residential areas as additional habitats for this species (W. Busby personal communication: 1990).

The primary foods of the snake are earthworms and invertebrates found in leaf litter (Minton 1972; Collins 1974, 1982; Tennant 1984; Ernst and Barbour 1989). The snake forages for earthworms at night and spends the day hidden beneath logs, rocks or leaf litter (Webb 1970; Collins 1974, 1982).

We used this information to develop a habitat suitability index model based on five variables that assess food and cover requirements (Flood et al. 1977). Percentage ground cover by litter (LIT), distance to water (DTW), and slope and aspect (SL) were used to assess food suitability. Cover suitability was assessed by percentage canopy cover (CC), site slope and aspect (SL), and percentage ground debris (DEB).

We developed a graph for each variable showing the relationship between levels of the variable and habitat suitability (Figure 1). A suitability index value, ranging from 1 to 5, was assigned to indicate this relationship. We used these suitability values to calculate an overall habitat suitability index (HSI). The western earth snake HSI is the sum of the suitability index values for each variable divided by the sum of the highest possible values for each variable.

Study Areas

The 1,100–acre (445 ha) Naish Boy Scout Reservation (Camp Naish) is the largest open space in Wyandotte County. Located in the least developed portion of the county, Camp Naish is the only site in the county where western earth snakes have been collected (W. Busby personal communication: 1990). Twenty trap sites were randomly located on forested areas of Camp Naish that were at least 2.5 acres (1 ha).

Sixteen forested trap sites were randomly located in southwestern Kansas City. These upland hardwood sites were selected from a larger sample of sites used in a study of open spaces in Wyandotte County (Nilon 1991). Each site was a minimum of 2.5 acres (1 ha) and surrounded by an average of 50 percent developed land.

Habitat Assessment

We used the HSI model to assess western earth snake habitat suitability on the 36 trap sites in Camp Naish and Kansas City. Vegetation measurements were made using procedures developed by James and Shugart (1970). Ground and canopy cover were measured on four 49-foot (15 m) transects established in cardinal directions. Five observations for cover were made along each transect using a viewing tube. Percentages of leaf and woody litter were summed to obtain percentage ground litter. Debris was the sum of percentage woody litter, rock and artificial structure. The distance from trap site to permanent water was measured on topographic maps. Slope and aspect were measured at each site using a clinometer and compass.

Measures of Urbanization

In addition to describing the sites based on habitat characteristics, various features of urbanization were measured in areas within a 0.3 mile (0.5 km) radius of each trap site. The percentage of developed land (URB) was measured on cover maps created for a study of Wyandotte County open spaces (Nilon 1991). The number of buildings per square kilometer (BD) was measured by counting the number of buildings within 0.3 mile (0.5 km) of each trap site on 1989 1:2400 maps provided by the Wyandotte County Surveyor's Office. Distances (ft) from the trap site to the nearest building or campsite (DTB) and from the trap site to the nearest paved road (DTR) also were measured on these maps.

Model Testing

The 36 sites were trapped from June–September 1992. Each trap station consisted of one 20.7-foot by 1.7-foot (6 m by 0.5 m) plastic drift fence buried 2 inches (5 cm) into

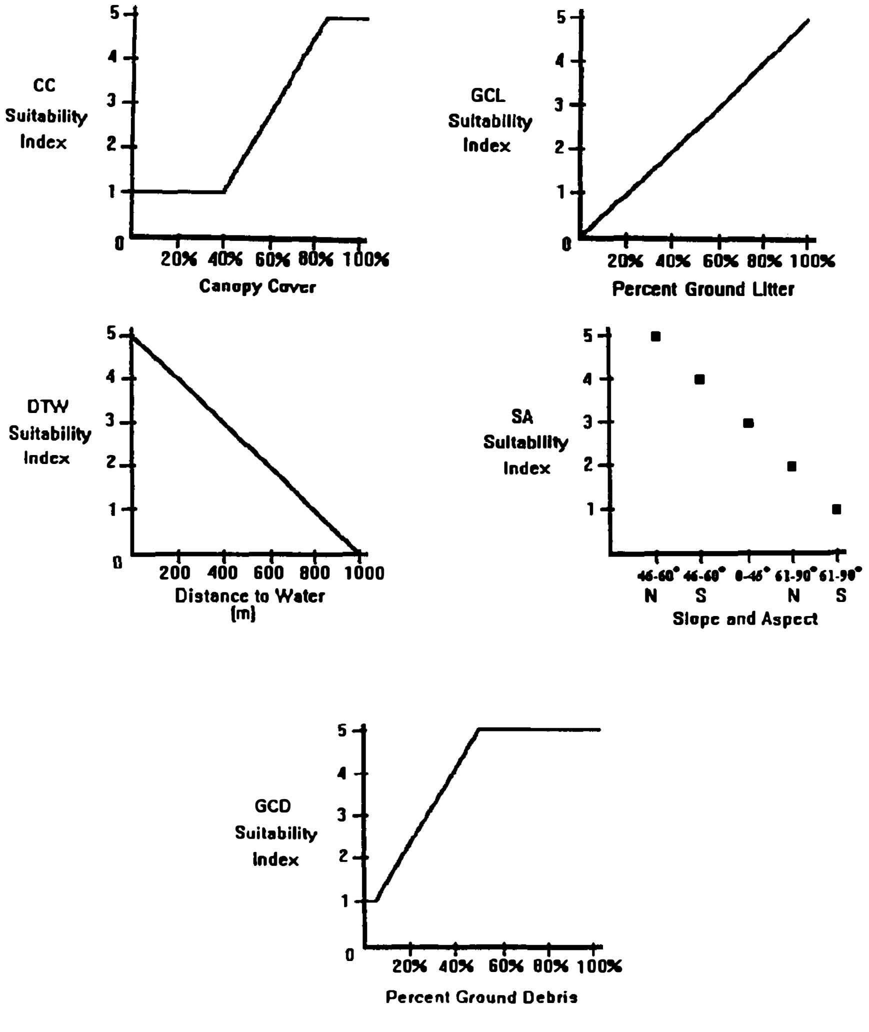

Figure 1. Western earth snake habitat suitability variables.

the ground, and two funnel traps made of aluminum window screening. Funnel traps measured 29 inches (0.7 m) long, 8.2 inches (0.2 m) across at the mouth, with an opening of 1.5 inches (3.5 cm) (Karns 1986, Fitch 1987). All snakes captured were identified and marked by scale clipping (Karns 1986). Each snake was weighed, measured and released within 58 yards (50 m) of the trap station.

Mean HSI scores, model variable values and urbanization variable values were compared using t-tests. The Wilcoxon rank-sum test was used to determine if trap sites on Camp Naish and Kansas City with identical HSI scores differed in capture success.

Results

Habitat Assessment

HSI values for the western earth snake ranged from 0.56–0.76 on Camp Naish and from 0.52–0.80 in Kansas City. There were no differences in mean model variable values, or in mean HSI between Camp Naish and Kansas City sites (Table 1). A comparison of measures of urbanization showed that mean DTB and DTR were lower in Kansas City than at Camp Naish. The two additional measures of urbanization, URB and BD, were higher in Kansas City than at Camp Naish (Table 1).

Model Testing

Twelve western earth snakes were captured on eight trap sites, all at Camp Naish. There were no differences between mean HSI scores for capture and no-capture sites. The Wilcoxon rank-sum test showed a difference in capture success between Camp Naish and Kansas City trap sites with identical HSI scores (Table 2).

A comparison of model variables showed that CC was higher and LIT lower on capture sites. We also compared measures of urbanization, finding that DTB and DTR were higher on capture sites than no-capture sites (Table 3).

Table 1. Mean HSI scores, model variable values and measures of urbanization, for Camp Naish and Kansas City trap sites.

Variable	Camp Naish	Kansas City
Habitat suitability		
HSI	0.627	0.645
Model variables		
CC	73	78
LIT	43	33
DTW	228	225
SL	15	12
DEB	20	18
Measures of urbanization		
URB[a]	0	47
DTB[a]	293	83
DTR[a]	252	74
BD[a]	12	334

[a]Different between Camp Naish and Kansas City ($P < 0.05$).

Table 2. Results of Wilcoxon sign-rank test comparing Camp Naish and Kansas City trap sites with identical HSI scores ($P = 0.031$).

HSI	Proportion of traps with captures		Difference	Rank
	Camp Naish	Kansas City		
0.56	1/5	0/2	0.2	1.5
0.60	4/5	0/4	0.8	4
0.64	1/5	0/3	0.2	1.5
0.68	1/3	0/3	0.3	3
0.72	1/1	0/1	1.0	5

Discussion

The literature-based western earth snake model found no difference in habitat suitability between trap sites in a large open space and similar sites surrounded by urban development. This indicates that the sites are similar in habitat structure and could be expected to have similar rates of trapping success. However, we found a difference in western earth snake capture success between Camp Naish and Kansas City.

One explanation for this difference could be our validation procedure. Cole and Smith (1983) state that more than one year of habitat use data are required to accurately validate habitat suitability index models. While additional years of data collection may provide information on western earth snake habitat use, the relationship between capture success, model variables and measures of urbanization provides an alternate explanation.

We found similarities between capture/no-capture locations on Camp Naish and between trap sites in Camp Naish and Kansas City. Model variables were identical on both sets of sets, while measures of surrounding urbanization were different. No-capture sites and sites in Kansas City were closer to buildings and roads. These results are similar to other studies of snakes in urban habitats.

Campbell (1974) stated that roads are the primary barriers to seasonal movements and dispersal of reptiles and amphibians in urban areas. Anderson (1965) found that bullsnake

Table 3. Mean HSI scores, model variable values and measures of urbanization, for Camp Naish capture and no-capture sites.

Variable	Capture sites	No-capture sites
Habitat suitability		
HSI	0.628	0.625
Model variables		
CC[a]	79	69
LIT[a]	39	46
DTW	214	240
SL	12	15
DEB	20	20
Measures of urbanization		
URB	0	48
DTB[a]	310	207
DTR[a]	367	176
BD	14	12

[a]Different between capture and no-capture sites ($P < 0.05$).

(*Pituophis melanoleucus sayi*) populations noticeably decreased near major roads. A study of road kills in south-central Kansas found that many snakes are killed deliberately by drivers (Langley et al. 1989).

Western earth snakes may be sensitive to the impacts associated with adjacent urban development. Schlauch (1978) found that reptiles and amphibians vary in response to urban development. Some species show marked declines, while others are associated with building sites and human activities.

Our results indicate that land-use and land-cover variables are better predictors of western earth snake presence in urban and urbanizing areas of Wyandotte County. Further research is needed to determine if these variables are associated with actual patterns of habitat use, information that is needed to refine HSI models.

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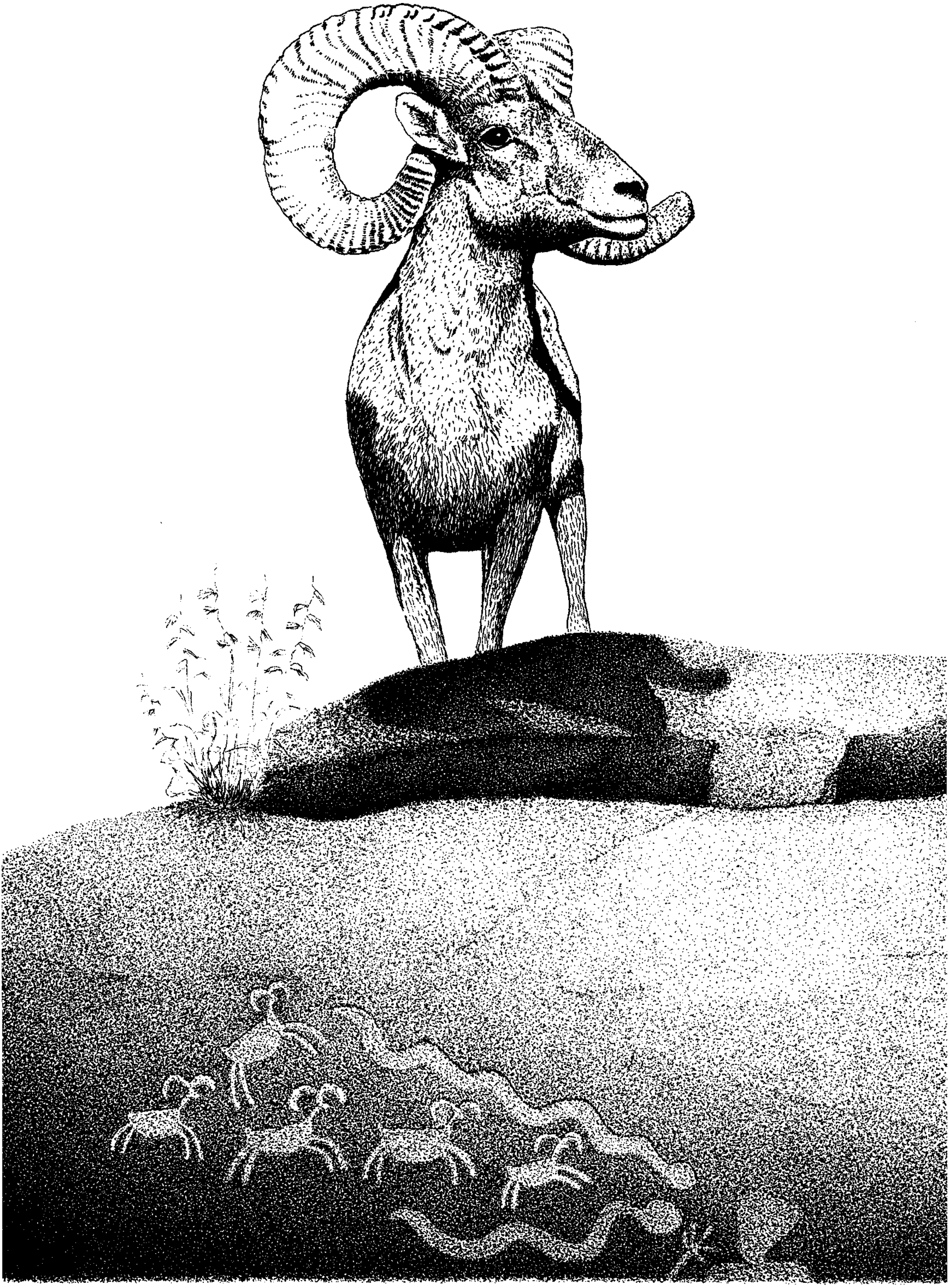

Special Session 2. *Human Overpopulation: The Unblamed Factor*

Chair
JAMES WALTMAN
National Audubon Society
Washington, D.C.

Cochair
THOMAS BANDOLIN
The Wildlife Society
Bethesda, Maryland

Of Mice and Men: Population and Consumption Trends in a Rapidly Changing World

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The United Stated today is the third largest country in the world in population, having moved up to third place when the Soviet Union dissolved. But almost all of the future world population growth will occur in the developing countries (Merrick 1991). In the next 30 years, almost 2.6 billion people will be added to the developing world at the same time that 170 million are added to the developed world. In 2020, about 85 million will be added in a single year in the developing world, compared with only 3 million in the developed world. Behind these broad population trends are three considerations that are likely to affect the United States, the rest of the world and the wildlife we share this planet with. These factors are: (1) the unprecedented rapidity of the future changes; (2) the urbanization of future populations; and (3) the increasing consumption of those populations.

The Rapid Changing of the World

Global population changes in the next 50 years will come faster than in any period in human history. Because the changes are happening so quickly, the United States and every other country will have to become increasingly flexible to adapt to the changes. A few examples of how fast countries and the world are changing are:

- It took 124 years for the world's population to increase from 1 billion to 2 billion people (1801–1925). It will take only 11 years to add the 6th billion (U. S. Department of Commerce 1989:1).
- It took 58 years for the United States' total fertility rate to drop from six children per woman to three and a half children per woman; in South Korea, it took only 12 years, 1961 to 1973 (U. S. Department of Commerce 1987:13).

- At 1990–1991 growth rates, it will take the United States about 70 years to double its population; it will take Nigeria just 23 years. Today Nigeria is the tenth largest country in the world; by 2050 it may be the fifth largest (Population Reference Bureau 1992).

The most rapid growth is occurring in countries with the least amount of infrastructure. Growth itself will induce some needed changes. But induced changes may not be able to keep up with very rapid growth. Therefore, the speed of change is likely to be important in determining how populations adjust to their growing numbers.

Of course, rapid population growth means rapid increase in population densities:

- Population density in the United States in 1991 is an estimated 71 persons per square mile. In the former Soviet Union, it is 34; in the Netherlands it is 1,146 person per square mile. But the most densely populated country in the world is Wisconsin-sized Bangladesh (or Arkansas-sized for land area only), with 2,255 persons per square mile (U. S. Department of Commerce 1991:27).
- The population density of the developed countries is going to change very slowly over the next several generations. In the United States, our population density is estimated to increase from 71 persons per square mile in 1991 to 91 in 2020 (U. S. Department of Commerce 1991:A–37).
- Eight developing countries already have population density that is 150 percent or more of the world average and will be at least double by 2020. All but Syria and Pakistan are in Sub-Saharan Africa (U. S. Department of Commerce 1991:39).

While most of the issues related to population density already have been faced in the developed world, the quite extraordinary increases in the density of the developing world create enormous pressures on the wildlife of those countries.

Urbanization of the World's Population

While the world's total population is projected to double over the next 50 years, the urban population is likely to double in just 30 years, increasing between 1990 and 2020 from 2.2 billion to 4.7 billion (U. S. Department of Commerce 1991:A–38). If it can be argued that it is better for wildlife if people settle in dense settlements instead of spreading themselves evenly across the environment, then the future trends in urbanization should in part compensate for the absolute growth in numbers.

- In 1991, about 43 percent of the world's population was urban; by 2020, nearly 60 percent of the population will be living in urban areas (United Nations 1992).
- Today there are about 94 cities with a population of 2 million or more; by 2000 there are likely to be 128 cities that size (U. S. Department of Commerce 1991:27).
- However, most urban growth will occur in cities that have under 2 million inhabitants oday.

Urban populations in the United States and in developing countries have lower fertility and mortality rates than their counterparts in rural areas. They have, in general, more education and higher income. They also have different expectations than rural populations; they consume more and different kinds of products. And their consumption patterns are likely to have as much effect on the environment as the increase in their absolute numbers.

Consumption Growth of Increasing Populations

If the increasing populations around the world would consume resources modestly, inhabit their settlements conscientiously and husband their wildlife, then people would likely be less worried about population growth than they are today. But along with population growth has come economic development and the rapacious consumption of resources. Therefore, population growth is not the only concern for the future of wildlife; population consumption may be of equal concern.

The large increases in commercial energy per capita in the last half century is symptomatic of the population growth and consumption dilemma. Consumption of commercial energy has a number of pernicious effects on the environment and therefore, indirectly, on the wildlife in those environments. And these increases in the consumption of commercial energy are likely to continue for the foreseeable future. But the effects of population growth and consumption increases on commercial energy use will be quite different in the developed countries such as the United States than in the developing world.

- Under current trends, the increase in commercial energy consumption will be the greatest in the developed countries in the next 30 years, and that increase is dominated by the increase in energy per capita (Kolsrud and Torrey 1991).
- During the same time, in the developing world, population growth and the increase in energy per capita are equally important factors in the increase in commercial energy use.
- Population growth in the developed countries such as the United States, although very low, contributes as much to global energy change from 1988 to 2020 as the much larger population growth in developing countries. That is because energy consumption per capita is so much higher in the developed countries than in the developing world.

But the current trends are unlikely to continue. People and countries change as populations increase and education improves. New technology is likely to help the growing populations consume more efficiently, and therefore consumption per capita will likely decrease, at least in the developed world. When energy constraints are imposed on the developed world, their population growth, even though it is slow, becomes the dominant factor in their increase in commercial energy. But even with severe constraints on developed countries[1] energy use and developing countries' population growth, worldwide commercial energy consumption will continue to rise.

- Under the toughest assumptions used worldwide, commercial energy consumption would grow 82 percent by 2050.
- While constraints on LDC population growth contribute to reduction in global commercial energy growth, such constraints are, in general, less important in the near term than constraints on developed countries' per capita energy consumption. All projections, of course, are hypothetical exercises that are completely dependent on the assumptions made. But they are useful in considering the order of importance of various factors. Most population estimates project a doubling of the world's population in the next 50 years. And this assumes decreasing fertility rates. Many fewer projections have been made of increases in consumption. But the simplistic one discussed above suggests that as countries develop, their consumption of natural resources, such as commercial energy, also is likely to at least double. And this assumes much more efficiency in the use of resources.

The estimated doubling of both population and of consumption will challenge individuals and governments at all levels to make the necessary changes that our environments will need. This exercise suggests that the wildlife of the planet have as much to fear from the consumption of the growing human population as from the growth of the populations themselves.

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Human Population and Wildlife: A Central American Focus

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For now I ask no more than the justice of eating.
Pablo Neruda from his poem "The Great Tablecloth"

Introduction

The world population of 5.3 billion has doubled in the last 40 years and is growing at a rate of 95 million a year (Ehrlich and Ehrlich 1990). Most of this increase is taking place in the developing world, which is degrading its natural resources rapidly to ensure economic development (World Resources Institute 1992). There seems to be a direct relationship between natural resource degradation and human population increase in developing countries, but many factors influence this. I will use Central America as a case study.

This region is made up of seven countries (Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panama) and covers 208,150 square miles (541,190 km^2) or 75 percent the size of the state of Texas (Vaughan 1990). The region is found in the tropical and subtropical belts and contains among the world's most diversified terrestrial and oceanic ecosystems and wildlife resources. Its cultures are diverse with a mixture of European, native Indian, African and West Indian bloods. The human population is expanding at one of the fastest rates worldwide, and is heavily dependent on the rich, renewable natural resource base for their economic development. This creates a dynamic yet fragile balance between these three: human population, natural resources and economic development.

Today, stepped up economic activity is stressing the natural resource systems which are rapidly deteriorating. Major problems related to expanding populations include: (1) **widespread poverty** for the majority, while a small percentage control the wealth and productive land; (2) **stagnating economic development** associated with international debt service, world and internal economic problems; and (3) **political turmoil and uncertainty** associated with social unrest, military action and new democratic processes (Leonard 1987). The Central American environmental situation is complex and worsening. This paper, focusing on wildlife, will explore how expanding human populations affect the natural resource base and how to improve the present situation.

Socioeconomic Trends

Human population characteristics which have an impact on wildlife include: (1) demographic tendencies (population growth, distribution and migrations); and (2) low quality of life (health indices, nutrition, income distribution, and land tenure and use).

Demographic Tendencies

Population growth and distribution. In recent decades, Central America has grown faster than any other region worldwide, doubling its 1960 population to more than 25 million by 1986 (Agency for International Development 1986). Today, only Africa surpasses Central America (2.8 percent per year) in annual growth rate (World Resources Institute 1992). Three countries in particular, Nicaragua, Honduras and Guatemala, average 3.5 percent annual growth rate per year (among the world's highest!) and account for over 60 percent of the region's population (Leonard 1987). With over 44 percent of the current regional population under 15 years old, pressure to utilize the existing natural resource base will increase as these adolescents reach maturity. Finally, Central America's population is expected to double to over 50 million by the year 2010. The question is "how and where will they live?"

Presently, El Salvador is the most densely populated country in continental America (245 persons per km^2) while the other Central American countries are sparsely (Belize—6 persons/km^2) or moderately (Guatemala—70 persons/km^2) populated. However, almost 80 percent of the Central American population lives in the highland Pacific watershed areas or adjacent Pacific lowlands which occupy only 25 percent of the land mass (Leonard 1987). This land has the most fertile soils and desirable climates, and as expected, little remaining natural vegetation or wildlife. The lowland forest areas of the Caribbean and the hilly interior are sparsely populated, and have most of the remaining wildlife and wild land resources, except for those found in Pacific coastal national parks and reserves (Morales and Cifuentes 1989).

Migrations. Central American human migrations in recent decades have affected natural resources. Migrating poor rural residents choose between inhabiting squatter settlements in urban areas or colonizing the underdeveloped frontier, especially along the Caribbean slope (Leonard 1987, Jones 1990). Urban growth between 1970–1980 has been extremely high, averaging about 45 percent for the region with a maximum of 74 percent for Honduras (United Nations 1985). Unfortunately, this has not reduced the population in rural areas because of high overall population growth rates. Governmental promotion of migrations has accelerated deterioration of the natural resource base, through alteration of forests and important watershed areas, contamination of water and exploitation of forest resources, such as wildlife. In Honduras and the Darien region of Panama, peasants are hired by ranchers to "clear" land for their future use (Nations and Komer 1982). Finally, displacement of Central Americans to other countries has caused a "brain drain" among college graduates where an estimated 25 percent are living abroad, reducing the number of professionals available to manage natural resources in their native countries.

Quality of Life

Health indices, nutrition and income. People living in the urban areas of Costa Rica, Panama and Belize have comparable life expectancy and infant morality to North Americans. However, humans living in the rest of the region and especially the rural areas have very serious infant and child mortality problems, characteristic of the poorest countries of Asia and Africa (World Resources Institute 1992). Enteritis, diarrhea and acute respiratory diseases cause many childhood deaths, while parasitic, viral and other infectious diseases are significant causes of death and disability for adults. Finally, malnutrition is a compensatory force, weakening many people and exposing them to other diseases (Pan American Health Organization 1982).

The availability of potable water, adequate medical care and nutrition can greatly reduce death rates. For example, Costa Rica and Panama have the highest percentages of their urban and rural population 82/68 and 82/65 percent, respectively, with access to safe water and the lowest percentage of deaths by infective and parasitic disease (5 and 14 percent, respectively). At the other end of the scale, Nicaragua and Guatemala have the lowest percentages of their urban and rural population (53/10 and 45/18, respectively) with access to safe water and the highest percentage of deaths by infective and parasitic disease (21 and 31 percent, respectively).

An average of 63 percent of the rural populations of Central America (not including Belize for lack of information) falls below the absolute poverty level, defined as the inability to afford food providing minimum nutritional requirements, with the highest rates of 77 and 70 percent, respectively in Honduras and El Salvador (Barry 1987). Obviously, this exposes them to disease by weakening their resistance. Malnutrition relates to high rates of rural poverty and declining production of basic foodstuffs in agricultural sections because land is unavailable for production.

Income is very skewed in Central America. Only 5 percent of the population receives an average yearly income of $17,600, while average annual income per capita was less than $200, and over half the Central American population was earning less than $74 per year in 1985 (Leonard 1987). In all Central American countries, except Panama and Belize, the richest 20 percent of the population control between 49 and 66 percent of the nations wealth. Due to high general levels of unemployment, seasonal employment as migratory farm workers, harvesting coffee, bananas, cotton and sugar cane occupies over 500,000 Guatemalan Indians, and large numbers of the poor from other Central American countries (James and Minkel 1985). With such a low standard of living for the majority of Central Americans, it should be no surprise that they view natural resource exploitation as a short-term investment; taking what they can, when they can get it.

Labor force, land use and land distribution. The number of Central Americans who depend on renewable natural resources (farming, ranching, forestry and fishery) for their employment varies from 27 percent in Belize to 61 percent in Honduras and averages 42 percent (FAO 1983). This results partially from the seemingly abundant and productive soils, forests, wildlife and seafood therein. However, access to land and resources is very unequal throughout most of Central America. In Costa Rica 36 percent of the land is owned by only 1 percent of the landowners, while only 4 percent of the land is owned by 60 percent of the landowners. Guatemala and El Salvador represent the extremes in landholding with 36 percent of the land owned by only 0.2 percent of the landowners in Guatemala and 50 percent of the land owned by 1.5 percent of the landowners in El Salvador. Large farms are found on the best lands, subutilized and dedicated to export crops (bananas, coffee, sugar cane, cattle) and not for production of locally consumed crops (root crops, corn, wheat, rice, beans) (Barry 1987, Leonard 1987). At present, instead of intensifying agricultural production for national needs on existing agricultural lands (Ewel 1991), and/or redistributing fertile, underutilized lands for those who need it (land reform), most governmental policies push their poor to colonize and exploit the frontier, usually found on suboptimal soils and steep slopes. This in part stems from the need to take pressure off the landlords. There is a movement in several countries by multinational corporations to destroy forests for planting export crops, especially bananas (Barry 1987). The impact of these practices on wildlife will be discussed below.

Wildlife Resources Base

The Central American isthmus generally is viewed as a land bridge linking the two continents of this hemisphere and their biota. Originally, tropical forests covered the entire landmass, but these forests were extremely heterogeneous due to wide climatic, topographical, edaphic and geographical variations. Central America's forest ecosystems provided habitats for a tremendous diversity of biota, viewed as one of the world's richest per area size. In Costa Rica, the only country other than Panama even partially inventoried, more than 8,000 vascular plant species, 2,000 orchid species, 10,000 invertebrate species and 1,460 vertebrate wildlife species (376 reptiles and amphibian species, 868 bird species and 216 mammal species) have been described (Janzen 1983). Not even the megabiodiverse nations can match the biodiversity per square kilometer which Central America has (L. D. Goméz personal communication: 1992).

A major factor limiting conservation efforts is the limited understanding of the majority of Central America's biota and especially their vertebrate species. For instance, a group of wildlife professionals representing all Mesoamerican countries (southern Mexico and Central America) met in Costa Rica to analyze the wildlife situation and propose a regional strategy. They decided that the strategy should include basic inventory, training, research and outreach projects on a regional basis. Below are some of the most important ideas from that meeting (Carrillo and Vaughan in press).

Human Population Versus Wildlife

During thousands of years, Central American indigenous groups depended on wildlife resources to obtain foods, medicines, fuels, fibers, and for religious and cultural uses (Vaughan 1987, Carrillo and Vaughan in press). Between 250–900 AC, Belize had up to a million Mayan inhabitants (four times the present population) with a suspected impact on wildlife resources. With the arrival in the 1500s of the Europeans, and the introduction of firearms, wildlife exploitation continued and increased. In general, throughout Central America's history, wildlife was considered a renewable, never ending resource.

Today, Central American human population growth has caused wildlife habitat degradation and wildlife overexploitation, leaving many ecosystems and species in a critical state (Vaughan 1987, Vaughan 1990, Cornelius 1991, Vaughan 1991, Carrillo and Vaughan in press). For the vast majority of Central Americans, poverty stricken and desperate, instability of outlook often leads to natural resource destruction because a long-term view is difficult to maintain under crisis conditions. However, large land owners and transnationals are involved either directly or indirectly in natural resource (wildlife) degradation. We will focus on habitat loss and overexploitation of wildlife.

Wildlife Habitat Loss

Since 1950 an increasing demand for forest products and agricultural land has severely altered the landscape of Central America. The major causes of deforestation slash-and-burn agriculture by small farmers struggling to survive and conversion of forests to export crops (cattle, banana, coffee, sugar cane, pineapple) by transnationals or large landowners. Even Belize, the only Central American country not experiencing major deforestation, will soon follow suit and recently had 100,000 hectares of primary and secondary forest purchased by Coca Cola Company's Minute Maid Division for citrus production (Leonard 1987).

Wildlife species have been affected by this conversion of forests to other land uses. Over two-thirds of Central America's forests have been cleared since 1950. These lands generally are unsuitable for agricultural or forestry production, because of poor soils, steep slopes and high precipitation. These lands are abandoned, losing both biodiversity and agricultural productivity. By 1985, less than 40 percent of Central America was forested, concentrated in protected areas and the Caribbean basin. Vaughan (1983) estimated that between 1940 and 1983, forested habitat for 28 endangered Costa Rican wildlife species was reduced by over 40 percent and only 23 percent of original habitat remained for them. This varied depending on the habitat requirements of each species. Such species as the Giant anteater (*Myrmechophaga tetradactyla*), Harpy eagle (*Harpia harpyja*), other species of Eagles and Hawk-eagles, Jaguar (*Panthera onca*), Bairds tapir (*Tapirus bairdii*), White-lipped peccary (*Tayassu pecari*), and Scarlet Macaw (*Ara macao*) were all considered "endangered" with extinction because of deforestation and lack of sufficient habitat (Vaughan 1983).

Size and distribution of dense forest habitat islands is more important than total remaining habitat for long-term species survival, because of the viable population size concept (Wilcox 1984). In most Central American countries, large undisturbed forest islands are becoming increasingly scarce and vulnerable to destruction by burgeoning human populations. The largest remaining forested tracts: the Petén (Guatemala-Mexico-Belize), Miskitia (Honduras-Nicaragua), Talamanca (Costa Rica-Panama) and Darien (Panama-Colombia) (Morales and Cifuentes 1989, Cornelius 1991), may protect viable populations of some wilderness wildlife species. However, in the several hundred wildland areas in Central America, for wildlife (and the areas!) to survive in the long-term, local residents must be incorporated directly into management strategies for buffer and core areas, as occurs in biosphere reserves and Costa Rica's conservation units (Garcia 1992) and extractive reserves in Guatemala (Reining 1992).

Game species adaptable to altered habitats are beginning to reappear in several areas of Costa Rica, probably as a result of lower hunting pressure, stricter game laws and alternative job sources in urban centers. I recently found sign of opossums (*Didelphis virginiana*), squirrels (*Sciurus variegatoides*), armadillos (*Dasypus novemcinctus*), rabbits (*Sylviagus* sp.) and raccoons (*Procyon lotor*) in an area only 30 minutes from the capital city of San José. In lower elevations, three species of monkeys—squirrel (*Saimiri oerstedii*), howler (*Alouatta palliata*) and white-faced (*Cebus capucinus*)— all persist under intense habitat alteration. Also, white-tailed deer (*Odocoileus virginianus*) are returning to rural areas (Vaughan and Rodríguez 1991). Finally, I was told about a tapir living on the edge of the forest-pasture habitat for six months in 1992 close to Braulio Carrillo National Park in Costa Rica. The tapir was chased by dogs to a town, captured and released well inside the national park. With limited hunting pressure, many species could survive in altered habitats.

Wildlife Overexploitation

After habitat destruction, overexploitation has been the most serious threat to most Central American wildlife species. Today different wildlife uses are practiced throughout Central America, depending on the economic status of the hunter. This includes: subsistence hunting, sport hunting, commercial hunting, ecotourism and game ranching. Game utilization was undoubtedly an important protein source for many rural Central American families. An interview carried out in 100 randomly selected, small Costa Rican villages between 1980–1981 showed that 157 of the 676 persons interviewed (23 percent) were active hunters (Vaughan, Carrillo and Wong in press). For them, game constituted 23.5 kilograms or 66 percent of the 36 kilograms of meat each family consumed monthly. The most commonly hunted game species were: paca (*Cuniculus paca*), white-tailed deer, collared peccary (*Tayassu tajacu*), nine banded armadillo and agouti (*Dasyprocta punctata*). This trend probably is similar in much of Central America, although recently local hunting seems to have declined in some countries. Local level reasons for this probably include: less game availability; stricter game laws and enforcement; protected private and public reserves; and alternative work sources (banana workers, hotel workers) in some areas.

The trade in wildlife and their products has been an important source of income for some Central Americans. Unfortunately the local people who capture wildlife receive only a small portion of the profits. For instance, local peasants who trap scarlet macaw chicks in Carara Biological Reserve, Costa Rica receive only about $100 for their efforts, while these same animals may bring $3,000 or more when sold in U.S. pet stores (Vaughan and Liske 1991). The added danger of eliminating a species locally due to a lack of scientific data makes this trade a threat for certain species. Trading in pelts such as spotted cats and crocodilians can endanger local populations (Cerrato 1991). Until 1990, Honduras was the center of a large-scale commercial wildlife traffic. For example, between 1987 and 1988, over 225,000 reptiles and amphibians, 778 mammals and 18,000 birds were exported ''legally'' from Honduras (Midence 1990). Barborak et al. (1983) concluded that local utilization and international trade were major secondary causes of decline of such species as: spotted cats, tapirs, monkeys, eagles and hawk-eagles.

The Future for Wildlife and Human Populations in Central America

If present trends continue, Central America's population will increase and pressure on rural natural resources will continue. However, for this trend to change and wildlife conservation to function, several concurrent problems must be focused on in Central America: (1) **Human population increase must be controlled and people guaranteed a minimum standard of living**. As seen in this report, Central America's natural resource base could not support a 100 percent increase in human population in the next 30 years. Population growth will be controlled only if existing humans can be assured a minimum standard of living and long-term security from society (employment, health care, nutrition, land for cultivation, safe contraceptive methods, jobs for women, etc.) (2) **An aggressive campaign for land reform is needed** so that the poor majority can cultivate many areas subutilized at present. (3) **Innovative programs in inventory, research, training and outreach are needed** to promote intelligent natural resource utilization. Regional conservation programs exists which focus on these areas. These include: Paseo Panthera (Barborak 1992), PACA (Kauck 1992), Regional Wildlife Management Program for Mesoamerica and the Caribbean (Vaughan 1990) and IUCN's Regional Wildlife Management Program. Costa Rica's National Biodiversity Institute (INBio) has set out to prepare a national biological inventory, train field personnel and promote applied research in sustainable development of biological resources (Janzen 1989). Their initial approach will be based on invertebrates and plants, but it offers a new approach to protecting biodiversity (World Resources Institute 1992). They all should be evaluated as to effectiveness, how funds are spent (percent that gets spent on ground level with community outreach or for training), adjustments made and many more projects initiated. (4) **Revision of foreign aid programs for Central America**. The United States leads developed countries in providing assistance to Central America, although most is channeled for military "assistance," which destroys human beings and the environment (Westling 1986, Vaughan 1990). It also supports the regional projects mentioned above. (5) **Changes in the current Central American economic accounting systems** to reflect the economic value of natural resources, including wildlife. This concept follows the pattern of recent research carried out in Costa Rica by a multidisciplinary team (World Resources Institute 1991).

Most of the Central American landscape has been altered (and continues to be altered!) and herculean efforts should be made to protect those remaining natural areas and restore others. Furthermore, it is necessary to develop cross-discipline communication and cooperation as well as a sustainable land-use ethic with wildlife as an integral part (Robinson and Bolen 1991). But beware! As Guatama Fonseca, Christian Democrat politician and former labor minister of Honduras, summarized the present plight of Central American people. "Those who attribute the present upheaval in Central America to communism are simply ignorant of how 80 percent of the people in the region live. The only thing the peasants know is misery. They have no land, no homes, no work, no income, no food, no medicine, no legal help, no social services, no schools, no water, no light, and no rights. It is injustice, not Marxism, that is the source of revolution." The bottom line is simple—without caring for the people, the natural resources, including wildlife and biodiversity, will not survive.

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San Francisco Bay—An Urban/Wildlife Shuffle

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Introduction

Today, we fish and wildlife managers are expected to sustain all of our natural resources despite continued loss of habitat quantity and quality to development. We manage the remaining natural habitats and wild fauna intensively in an effort to accommodate as much of the area's original biodiversity as possible. Our management focus usually is on making the best of the situation, while we refrain from addressing the core issue, the population explosion. We gather data, analyze options and talk among ourselves on how best to cope with these challenges. We often abandon urban areas and retreat to more rural areas to practice our profession. My experience at San Francisco Bay National Wildlife Refuge Complex has taught me how land managers, working with the public, can more effectively address the impacts of human development.

The San Francisco Bay Experience

The San Francisco Bay Estuary is an area of incomparable beauty, but it has been indelibly impacted by the seven and a half million people who now live along its shores. The Bay area has become the fourth largest metropolis in the United States, just behind New York, Chicago and Los Angeles.

The changes have been dramatic, but are not unique, as they are shared by many of the earth's estuaries—notably those of the Potomac, Delaware, Hudson, Rhine, Thames and Niagara. All face contaminant loading, water diversion, dredging, filling of wetlands and exploitation of fish and other fauna.

Despite overwhelming abuse of natural environments, there have been some successes in slowing or minimizing these adverse impacts. The San Francisco Bay area provides an example of one such success. Difficult choices on economically important issues are being made in favor of restoring and protecting the natural heritage of the region.

Eighteenth century European sea captains have left us vivid pictures of the wonderful wildlife they found in San Francisco Bay. Excerpts from their logs are quoted in *The Ohlone Way*: "The intermingling of grasslands, savannahs, salt and freshwater marshes, and forests created wildlife habitats of almost unimaginable richness and variety ... flocks of geese, ducks, and seabirds were so enormous that when alarmed by a rifle shot they were said to rise in a dense cloud of noise like that of a hurricane ... packs of wolves hunted elk, antelope, deer, rabbits, and other game ... (grizzly bears) were everywhere, feeding on berries, lumbering along beaches, congregating beneath oak trees during the acorn season, and stationed along nearly every stream and creek during the annual runs of salmon and steelhead" (Margolin 1978).

A History of Human Impacts

Our civilization is roughly the same age as San Francisco Bay. As the last ice age melted, about 10,000 years ago, the rising Pacific Ocean flowed through a deep, narrow canyon now spanned by the Golden Gate Bridge. The rapidly rising sea level flooded the inland basins, and combining with river flows of the Sacramento and San Joaquin, created the San Francisco Bay Estuary.

The first humans to inhabit the slowly expanding Bay arrived from the Pacific Northwest and probably had negligible impacts. These hunter-gatherers eventually spread out along the edge of the bay, creating scores of villages and camps of Ohlones or Miwoks. The estuary's rich abundance of fish, wildlife and upland oak habitats supported a thriving economy for 20,000 to 25,000 individuals, with mussels and salt exported to inland villages.

Spanish explorers discovered the Bay in 1769 and established their first mission in the Bay area in 1776 at what is now San Francisco. Several other missions were established, supported by limited agriculture, grazing, fishing and timber harvest. Although the natural resources of the estuary were not significantly altered during the mission period, introduced diseases such as smallpox, mumps and measles decimated the native people.

New England traders arrived in the late 1790s establishing a west coast fur trade with China and New England. Cattle ranching increased to meet the demand for leather in the East. Beaver and sea otters were exploited in the early 1800s by fur traders.

Gold, discovered in the Sierra Nevada in 1848, led to a human population explosion in California and San Francisco Bay. San Francisco grew from 400 to 25,000 people in two years. Between 1853 and 1884, hydraulic mining for gold washed enormous deposits of sand, silt and debris down streams and rivers, devastating fish breeding grounds and migration routes. Nearly a billion cubic yards of silt were eventually deposited in San Francisco Bay, raising the bottom as much as three feet, altering circulation patterns and expanding some marshes (Monroe 1992).

San Francisco continued to grow rapidly after 1860, creating tremendous demands for food. Seasonally flooded wetlands were converted to croplands and tidal marshes were diked to become pasture land. Bay fisheries were exploited by fishermen harvesting salmon, steelhead trout, sardines, flatfish, herring and other species. Market hunters shot millions of waterfowl, shorebirds and other waterbirds. The ever-growing Bay area population accelerated land clearing, burning, drainage and flood control measures. By 1900, water quality problems developed within the estuary, including bacterial contamination near sewage outfalls and low oxygen levels (Skinner 1962).

The rise in manufacturing industries in the early 1900s combined with improved railroad and automobile transportation led to further expansion of cities around the Bay. This urban expansion filled tidal wetlands for buildings, roads, port facilities, housing and garbage dumps. By 1930, nearly half of the remaining tidal marshes were diked to become solar salt evaporation ponds. Upstream diversions of freshwater for industrial, municipal and agricultural uses drastically altered the estuary system. Federal and state water distribution projects began to reduce the volume and upset the timing of freshwater flows into the estuary, impacting fish migrations and the ecology of entire aquatic communities throughout major portions of the Bay. Toxic industrial pollutants increased dramatically throughout the estuary during the war effort in the 1940s.

Post World War II saw nearly 4.5 million people living in the Bay area, a holdover from the wartime industrial growth. Suburban sprawl covered much of the remaining flatland farm areas and filled most of the remaining tidal wetlands. Riparian zones were eliminated as flood control projects hastened runoff flows directly to the Bay. Improvements in sewage treatment facilities beginning in the 1960s reduced some of the adverse effects of wastes (Nichols et al. 1986). Upstream, the agricultural use of fertilizers and pesticides increased dramatically and some new soils brought under cultivation added high levels of selenium, boron and other toxic trace elements to the drainage. Oil refineries and other new industries around the Bay contributed tons of new contaminants. Sediments with heavy metal loads were frequently mixed within the Bay waters by the constant dredging required to keep busy ports clear for shipping.

Other sudden changes occurred. Highly invasive non-native species were introduced. Combined with the extensive habitat modifications, these populations of exotic species have either expanded or disappeared. The introduction of oysters, bullfrogs, crayfish, striped bass and American shad were all intended to meet the growing food demand. Other new species, many stowaways on authorized transcontinental live shipments, were unintentional but wreaked additional havoc on native species. Red fox, introduced in the late 1800s from the midwest for fur farms in the Sacramento Valley, escaped and slowly immigrated to the Bay area, decimating ground-nesting birds and small mammal populations (Jurek 1992). Unintentional introductions continue today, transported for example in ship ballast water (Asian clams) or by shipment of household goods (Scotch broom). In addition, exotic pets escape or are released by humans.

The human population around San Francisco Bay had reached 6.5 million by 1980, and another million moved in within the next ten years. As a result, 85 percent of the wetlands was lost, heavy metal contaminants accumulated in fish and wildlife at levels considered hazardous to human consumption (California Department of Fish and Game 1992), and native salmon runs were decimated by diversions of fresh water and altered flow regimes. Twenty-two wildlife species that occur in the estuary basin were federally listed as threatened or endangered.

The Public Responds

The decline in natural "quality of life" in the Bay area did not go unnoticed by everyone. While many "sat in traffic" and considered the Bay waters a mere inconvenience to their commute, others sought out the tiny fragmented marshlands to restore their spirit and rejuvenate their conviction that it was not too late to save the Bay! Transcending the self-interests of property owners and the parochial plans of local municipalities, these grass-roots groups took the moral highground to save the Bay's natural resources.

Save San Francisco Bay Association

In December 1960, Kay Kerr, Sylvia McLaughlin, and Esther Gulick united in a vision of the Bay that would forever change the course of impacts on its natural resources. Realizing that the unbridled filling in of the Bay and the plans for future filling would continue until only a narrow "river" remained, these three women formed Save San Francisco Bay Association (Save the Bay). "Bay or River?" was their slogan as they reached out to anyone who would listen. With the help of friends and Don Sherwood, a popular morning radio disc jockey, Save the Bay grew in numbers and influence. Its membership sent thousands of letters to the State legislature which finally passed the McAteer-Petris Act in 1965 establishing the San Francisco Bay Conservation and Development Commission, the first agency of its kind in the country. The Commission, closely watched by Save the Bay, would regulate any further filling of the Bay and enhance public access to its shoreline and marshes.

Today, Save the Bay, with over 24,000 members, continues to expand its role. It engages in lawsuits or legislation to resolve contaminant and water diversion issues. It sponsors new local wetland protection groups and coordinates over 30 groups in drafting and implementing a comprehensive agenda to restore the Bay.

The Citizen's Committee to Complete the Refuge

While Save the Bay fought fill proposals in the Bay in the 1960s, landowners in the shallow South Bay were announcing grand plans to fill and develop the area. An employee of the Santa Clara County Planning Department, Art Ogilvie, was well aware of these plans. Another local grass-roots group was formed, the South San Francisco Baylands Planning, Conservation and National Wildlife Refuge Committee, generating tremendous public interest and support for establishing a national wildlife refuge in the South Bay. Since the U. S. Fish and Wildlife Service in the late 60s had no interest in an urban refuge, the citizen's group lobbied Congress to pass legislation to establish the refuge. In 1972, after two earlier failed attempts, Congress passed HR 111, sponsored by the Bay area Delegation (Edwards, Gubser, Burton, Dellums, Legett, McCloskey, Moss, and Wadie). San Francisco Bay National Wildlife Refuge was authorized to be 23,000 acres, with total land acquisition appropriations authorized up to 9 million dollars.

San Francisco Bay National Wildlife Refuge was the first "urban" refuge in the nation. In addition to the normal refuge programs of habitat protection and migratory bird management, endangered species recovery and public nature study were other purposes described in its enabling legislation. By the mid-1980s, this Refuge had become a model for hope in reversing the adverse impacts of humans on the environment.

Thousands of children visited the Refuge each year, spending time in hands-on activities throughout the different habitats. Hundreds of teachers were trained each year to convey ecological concepts in their classrooms throughout the school year. Intensive monitoring of endangered species including butterflies, salamanders, wallflowers and clapper rails led to practical and effective recovery actions performed by a dedicated staff and a wide host of volunteers.

Spanning both sides of the South Bay, this Refuge brought together 12 cities and 3 counties. Beginning in the mid-1980s, citizens in these communities resolved to protect all the remaining South Bay wetland areas and thereby "complete the Refuge." Development was planned for nearly all of these critical sites. Calling themselves "The Citizen's Committee to Complete the Refuge," these people carried out this ambitious campaign. Congress enacted authorizing legislation in 1988 to nearly double the size of the Refuge to 43,000 acres, as a direct result of their efforts. Separate actions also established or expanded two National Wildlife Refuges in the northern part of the estuary.

Strong public support for the Refuge enabled the successful implementation of a controversial predator management program reducing non-native red fox populations in tidal marsh areas to protect the endangered California clapper rail.

The Citizen's Committee has broadened its scope by cosponsoring the Campaign to Save California's Wetlands and supporting grass-roots wetland conservation groups in Japan. A Pacific Rim Wetlands Coalition also is in the works. Numerous other conservation and outdoor recreation groups have formed throughout the Bay area, raising public awareness and support for numerous environmental issues.

A Manager's Perspective

Fish and wildlife professionals have a responsibility to address the human population issue. We can start by including the public in our work. We have an obligation to effectively communicate and educate the public about natural resource issues and management options.

No agencies or organizations are large enough or wise enough to achieve our ultimate goals. By choosing to be accessible to the public, the media and the education system, I have witnessed astonishing results despite the pressures of the surrounding metropolis. Land managers cannot achieve society's goals alone, nor can citizens' groups. Powerful synergism comes from relating knowledge to the public and from including their collective thoughts, knowledge and innovation in decision making.

When people are aware *and* take personal responsibility for the quality of their lives in the community, the natural resources around them benefit. The future well-being of the San Francisco Bay estuary lies in an increased public understanding of its interacting physical, chemical and biological processes and how they are affected by human activities (Nichols et al. 1986). Public awareness also is fostered through environmental education that directly relates natural science in the classroom to current environmental issues in the community.

Universities and other research groups need to redouble their efforts to study and understand the influence of people on their local community. The media also can play a vital role by reporting the status of natural resource concerns and generating public enthusiasm by relating stories of successes in restoring wetlands or wildlife populations, or improving water quality. Establishing refuges and parks in urban areas directly ties natural resource agencies to current human population concerns and validates public efforts to find long-term solutions. Elected officials at all levels need to be held accountable by the public for their decisions affecting natural resources in their district, state and nation.

Tough choices need to be made with knowledgeable public involvement. For example, a limit was recently placed on sewage effluent discharged into the shallow southern portion of San Francisco Bay. This was in response to the cumulative impacts of the freshwater on the salt marsh ecology and endangered species habitat. Mitigation was required to offset the previous conversion of salt marsh to brackish marsh. All of this was brought about by active participation by an informed public.

Conclusion

By 2005, another million people are expected to move into the Bay area (Monroe 1992). There still are many tough decisions to be made and, unfortunately, the majority of people still are not fully aware of the natural resources around them and of the need to protect them. Broad public knowledge of these issues must be our highest priority. Acquisition and protection of remaining habitats must increase. The concept of "ENOUGH" must be applied to the human population growth in the Bay area.

Above all, the quality of our lives and the quality of the world around us depend on our personal sense of responsibility. The communities around San Francisco Bay are blessed with citizens who continue to take these responsibilities seriously and persist in the goal of restoring their estuary.

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Population Growth, Poverty and Wildlife in the Rio Grande Valley

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Introduction

The National Audubon Society's Sabal Palm Grove Sanctuary and the wildlife of the Lower Rio Grande Valley are seriously threatened by both rapid human population growth and the effects of human consumption. Audubon is developing solutions to reduce and mitigate the impact of these factors on the unique wildlife and habitat of the Lower Rio Grande Valley in South Texas. Audubon has had a population program for about 10 years. The long-term objection of Audubon's population program is to ensure that sound population policies are established in the United States and overseas that contribute to the health, well-being and dignity of the individual citizen, protect non-human species and their habitat.

Audubon's major lobbying efforts are aimed at reducing population growth and consumption. Audubon supports family planning and domestically and internationally, and is working to get U. S. citizens to reduce their consumption rates. Consumption rates often have a tremendous impact on natural resources. One example: in its lifetime, a baby from the U. S. will use many times the natural resources of a baby from Bangladesh. Through its television programs, videos, books and grass-roots efforts, Audubon has been working to educate people everywhere that our population growth and our environmental quality of life (and wildlife) are closely linked.

Audubon's Sharing the Earth Program, started in 1988, is one aspect of Audubon's population program. This project paired eight Audubon sanctuaries with eight wildlife refuges in developing countries. Both Audubon sanctuaries and refuges were chosen because of the similar human population growth pressures on valuable wildlife habitat. Audubon's Rowe Sanctuary on the Platte River was paired with a refuge on the Indus River in Pakistan. Both are working to protect cranes and are heavily impacted by growth and/or consumption pressures.

The Sabal Palm Grove Sanctuary was paired with the Biotopo del Maniti, a reserve on the east coast of Guatemala. Both Audubon sanctuary managers and their counterparts visited each other on their refuges and the pairs worked together to come up with plans for reducing and mitigating population pressures. The book, *Sharing the Earth: Cross Cultural Experiences in Population, Wildlife and the Environment* tells the story of the eight exchanges.

Audubon's Sabal Palm Grove Sanctuary was chosen to participate in the second phase of the Sharing the Earth Program, started in 1992. In this phase, the Palm Sanctuary staff are seeking to answer the question, "how can we empower people who have not traditionally worked on wildlife protection issues to improve their local environmental quality through attacking the problems of consumption, land use, water quality and quantity, and protecting wildlife habitat?" We are seeking to create a bilingual/bicultural environmental outreach program for the local hispanic community with the goal of helping people to empower themselves to protect the local environment for both wildlife and people.

Description of Wildlife and Habitat

Audubon's Sabal Palm Grove Sanctuary, 172 acres, is located about six miles from Brownsville, Texas, on the Rio Grande River. The sanctuary protects an endangered riparian habitat of Texas Sabal Palms (*Sabal texana*) and Texas Ebony (*Pithecellobium flexicale*). The sanctuary contains many endangered and threatened species such as Ocelot (*Felis pardalis*) and Speckled racer snake (*Drymobius margaritiferus*). It has about 7,000 visitors yearly, a majority of which are bird watchers.

The Lower Rio Grande Valley (LRGV) has tremendous diversity of biota in a semi-tropical habitat. In this area, about 700 vertebrate species are present, of which 86 species are considered to be endangered, threatened, or on a watch-list by the federal or state governments or the Texas Organization of Endangered Species. Endangered species present include Ocelot (*Felis pardalis*), Jaguarundi (*Felis yagouaroundi*), Aplomado Falcon (*Falcon femoralis*) and Piping Plover (*Charadrius melodus*). The LRGV contains many plants and animals found nowhere else in the United States. There are 21 bird species that reach the northernmost limit of their range in the LRGV such as Green Jay (*Cyanocorax yncas*), Plain Chachalaca (*Ortalis vetula*) and Buff-bellied Hummingbird (*Amazilia yucatanensis*).

Three federal wildlife refuges, numerous state properties and the National Audubon Society are protecting important habitat in the LRGV. The U. S. Fish and Wildlife Service is currently creating the Lower Rio Grande National Wildlife Refuge (the Wildlife Corridor) to protect biodiversity and endangered species in the LRGV. This project has been the number one funded project for the U. S. Fish and Wildlife Service for the last five years. Acquisition to complete the proposed 113,000–acre refuge is about half complete.

Current Wildlife Problems Due to Population Pressures

Outside the protected areas very little wildlife habitat remains in the Lower Rio Grande Valley of Texas. The native habitat of Tamulipan brushland is an unique ecosystem located in southern Texas and northeastern Mexico. Since the early 1900s, 95 percent of the original Tamaulipan brushland has been cleared, including 99 percent loss of riparian habitat. The habitat was cleared for agriculture and urban development.

The Lower Rio Grande Valley's *human population* has grown rapidly. According to the U. S. Census Bureau, the LRGV's population rose 30 percent between 1980 and 1990. There are over 7 million people within 200 miles of the Rio Grande and this figure is expected to double in less than 20 years. The Rio Grande Valley Metroplex is the third fastest growing area in Texas and the 9th fastest growing area in the United States.

The population on the Mexican side of the border seems to be growing much more rapidly than the U. S. side with the population of Matamoros (across from Brownsville) estimated to have tripled in the last 20 years. U. S. Representative Kika de la Garza recently stated that population of the border cities in Mexico is expected to double in the next 10 years.

The major wildlife habitat losses in the area have been due to agriculture and urbanization largely since the turn of the century. Wildlife and habitat also have been severely impacted by pollution from industrial and agricultural sources.

Valuable riparian habitat is being lost due to construction around existing and proposed *bridges* across the Rio Grande which effectively are cutting the Wildlife Corridor into isolated habitat islands. Riparian as well as coastal wetlands are severely threatened from development pressures in the area.

There are currently three *dams* in the area that have greatly reduced the water available for wildlife. Reduced flooding danger has opened up thousands of acres to agriculture and urbanization (causing increased habitat losses). The Rio Grande, the LRGV's only source of water, already is overallocated and there are efforts underway to build more dams that would further cut off water to downstream wildlife uses and flood important upstream habitat. Additional water attained from the proposed Brownsville dam is targeted for urban development thereby causing additional loss of habitat as the urban areas expand.

Along the United States/Mexico border in the LRGV, there already are serious problems with *pollution and toxics* and the likelihood of future cleanup is hard to predict. The Rio Grande, the LRGV's only source of water for urban, industrial and agriculture uses, is thought to be heavily polluted with industrial wastes and pesticides. Since 80 percent of the LRGV's Rio Grande water is flowing out of Mexican rivers, which also are draining industrial cities such as Monterrey, there are real water quality concerns. Also the Maquiladora Industry, U. S. owned companies located in Mexico along the border, generally has a poor record of protection of the border environment, both air and water.

Matamoros, Mexico contains numerous sites where toxic wastes are dumped in open canals by American-owned Maquiladoras. Brownsville, Texas has about four times the national average of anencephaly, a condition where babies are born without brains. There are indications that this condition may be linked to the poor local air and water quality due to Maquiladora dumping of toxics.

Humans may not be the only ones effected by toxics. Several juvenile Reddish egrets (*Egretta rufescens*) with serious birth defects were discovered in 1992 on the nesting rookeries on the coast east of Brownsville. The U. S. Fish and Wildlife Service is beginning a study in Spring 1993 to look for causes of the birth defects possibly due to toxic contamination from local toxic dumping in the Mexican coastal lagoons where these birds feed.

Future Population Growth Scenarios and Impacts on Wildlife

The population of the LRGV is projected to double in the next 20 years. The proposed North American Free Trade Agreement (NAFTA) already is having serious effects on wildlife with a local boom in development and bridge construction. A "Free Trade Frenzy" of growth has been going on for about two years and with the passage of NAFTA expected in late 1993, there will continue to be serious impacts on the border environment due to population growth and development.

These things are projected to come with free trade; more habitat loss from urbanization, the push for more bridges (13 new bridges currently are in the planning stages in the LRGV), urban developers are pushing for additional dams with loss of more estuarine and riparian habitat. There likely will be more loss of air and water quality as the area continues to grow.

Since there is currently virtually no regional land-use planning, the future for LRGV wildlife, without great changes in attitude and planning, may be grim.

Solutions/Mitigation for Growth Pressures on Wildlife

Audubon works closely with the U. S. Fish and Wildlife Service efforts to purchase land and complete the Wildlife Corridor project as soon as possible. It is vital for the Sabal Palm Grove Sanctuary to be connected to larger areas of protected habitat if it is to be successful in protecting the unique species of the palm forest habitat. It is becoming more and more difficult to buy riparian land because the land now is viewed as future sites for bridges and urban areas for the expected free trade growth. It would be beneficial if, in connection with NAFTA, the money to complete the Wildlife Corridor could be provided immediately and some protection for LRGV habitat could be assured.

On the Sabal Palm Grove Sanctuary, we are working to improve the habitat by removing non-native escaped house plants as well non-native grasses that choke out and prevent native plants from growing. We are reforesting 120 acres of Audubon land and about 25 acres of adjoining private land. We are pumping water from the Rio Grande to simulate the original floods that historically filled our ox-bow lake. Research on the sanctuary is helping us to learn more about our endangered and rare species. Reforestation projects with private landowners near the sanctuary are helping sanctuary wildlife to move up and down the riparian strip to other protected areas more safely. Through tours, displays, school programs, public speaking and festivals, we are working to education both the distant visitor and local community about the sanctuary and its wildlife.

Audubon is working on two fronts to attack the population growth issue in the LRGV. *First*, Audubon is working to help the local population (90 percent hispanic) to empower themselves to protect their own environment quality of life and to solve local environmental problems. *Second*, Audubon is working to put in place a NAFTA and an Environmental Protection Agency (EPA) Border Plan that would help to clean up and protect the environmental future of the LRGV and a plan that would protect its unique wildlife and habitat.

As part of our first effort, Audubon created an "*International Youth Alliance*," started in June 1992 with a grant from the EPA. These are high school students from both Brownsville and Matamoros that are working together to find solutions to mutual environmental problems and to empower local people on both sides of the river to solve environment problems. The students have presented environmental programs in their schools and communities, planted trees in colonias, did a door-to-door "Cholera Awareness Campaign," appeared on local radio and television programs, and held a "Healthy Planet, Healthy People Festival." Equally as exciting as working with the young people is the adult networking that is occurring about the environment with parents, schools, teachers and city officials on both sides of the river. Audubon is planning to work elsewhere along the United States/Mexico border to empower local grass-roots groups to protect their environment.

Audubon is working on solutions to population growth through participation in *Networks*:

- We are working with both Planned Parenthood and the family planning program in Matamoros to help their staff make the connection between population growth and the environment.
- We are part of the county's Agriculture and Wildlife Co-existence Committee look-

ing for win-win solutions to pesticide problems and their impacts on endangered species, working to reduce clearing of endangered species habitat along drainage ditches and to resolve conflicts concerning river flood control/habitat loss issues.

- Another network, the Binational Water Quality/Water Quantity Task Force, NGO's from both countries the United States and Mexico, is working to find solutions in both to clean up and share our scare water resource, the Rio Grande.
- We are working with the LRGV's Council of Governments which in January 1993 passed a resolution in favor of creating a land-use plan for the Rio Grande Valley and this group is lobbying the state legislature to try to change state law to allow such planning to occur.

Border trade has been and will continue to be the biggest cause of population growth in the LRGV on both sides of the Rio Grande. This trade attracts huge numbers of people to both sides of the border, putting great strains on the scarce natural resources. Audubon is working on specific suggestions (with EPA locally and in Washington) to create a North American Free Trade Agreement and the EPA's Integegrated Environmental Border Plan that will address the border's current serious environmental problems and help to create a better future for both wildlife and people in the LRGV.

Conclusion

As managers of land and protectors of wildlife, we must all work more and more off of our refuges to protect them. Population growth, development and associated pollution is affecting our efforts to protect wildlife and habitat worldwide. Refuge managers must get off their refuges and work to protect whole bioregions and look for local solutions with local citizens to local environmental problems. We also must get involved on a national level to lobby for environmentally sound national and international governmental policies that affect wildlife and habitat. We refuge managers on the border must get involved to help empower our local citizens from both countries, and foster communication and cooperation among people of different languages, cultures and occupations allowing them to work together to solve the border's population growth problems.

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Dealing with Growth: Protecting Virginia's Back Bay

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History

The Back Bay National Wildlife Refuge (Refuge) is a unit of the National Wildlife Refuge System (Refuge System). The Refuge System is a collection of over 90 million acres of lands and waters administered by the U. S. Department of the Interior's Fish and Wildlife Service (Service). Back Bay Refuge was established by Executive Order on June 6, 1938, " ... as a refuge and breeding ground for migratory birds and other wildlife." Early management efforts focused on habitat improvements for waterfowl, dune stabilization and enforcement of hunting regulations. As human populations increased, so did public use of the Refuge. From 1970 to 1985, the efforts of Refuge staff were directed toward controlling harmful public uses that were occurring on the Refuge beach. As the beach-use problems were brought under control, Refuge staff began to address other wildlife and habitat issues including growth-related impacts to the Back Bay (Bay) watershed. While growth in Virginia Beach (City) was phenomenal during the 1960–1985 period, the Refuge was shielded from immediate, growth-related impacts due to its relative isolation in the southeastern corner of the City. The potential impacts on the Bay itself largely were unrecognized by Refuge staff and citizens alike, until obvious problems surfaced. The Refuge became more concerned about growth-related impacts as the building boom extended into the northern portion of the watershed and the Bay itself began to decline. The extensive growth of Virginia Beach is illustrated by the following table:

Table 1. Population growth in Virginia Beach 1960–1990.[a]

Year	Population	Housing units
1960	85,218	16,963
1970	172,106	43,046
1980	262,200	83,154
1990	393,069	147,037
"Build out"	598,800[b]	221,556[c]

[a]Source: Virginia Beach Comprehensive Plan, HRPDC 1990 census data, A Management Plan for Back Bay (Mann 1984).
[b]Projected.
[c]Estimated based on units per person in 1990.

Service Responds to Resource Threat

Efforts undertaken within the refuge boundary. To counterbalance the decline of Back Bay habitat, improvements were accelerated within the Refuge boundary. Understanding that no degree of management of 1,000 acres of impounded wetlands would offset the massive decline in the 39 square-mile Bay itself, it was felt that immediate actions had to be taken to improve the available Refuge habitat for migrating and wintering birds. The Service recognized the importance of the Refuge and the threats to area resources by responding with increased funding and staffing at the Refuge. This supported the increase in on-Refuge management activities and the initiation of efforts to address off-Refuge population impacts. The table below illustrates these increases in funding and staffing.

Table 2. Staffing and funding increases, Back Bay Refuge.

Year	FTEs[a]	Funding
1985	9.41	$422,600
1986	9.67	$416,300
1987	11.09	$503,233
1988	11.86	$596,928
1989	9.67[b]	$380,732[b]
1990	12.39	$646,942
1991	13.98	$840,687
1992	12.97[b]	$705,910
1993	15.00[c]	$774,632

[a]FTE's = Full Time Equivalents (one person for one full year).
[b]Lower total FTEs and funding in 1989 and 1992 is due to normal staff turnover.
[c]Authorized level.

This table demonstrates that staffing in 1993 is 3.22 FTEs above the nine-year average of 11.78 FTEs, and 5.6 FTEs (59 percent) higher than the 1985 level. Funding in 1993 was nearly $200,000 above the nine-year average of $588,000 and $352,000 (83 percent) above the 1985 level.

The Refuge looks outward. In the early 1980s, development pressures already were impacting habitat in the northern portions of the drainage basin and, by extension, water quality in Back Bay. Initially, the City was concerned enough about these impacts to contract for a study of the watershed by Roy Mann and Associates. The study, released in 1984, suggested that " ... a number of management topics must be addressed if the character and resources of Back Bay and the Watershed are to be preserved" (Mann 1984). The Refuge viewed the Mann report as a positive effort and provided historical records to the consultant for use in preparing the report. At the time that the Mann report was released, it appeared that the efforts of the City in limiting development would be sufficient to maintain the rural character of the watershed and many of the wildlife values associated with it.

Despite the findings of the report, development pressures continued and the Service became more concerned about the associated impacts. In 1988, a major land-acquisition effort that would add up to 6,400 additional acres to the Refuge boundary was proposed. The Environmental Assessment (EA) recognized that the Service could not depend exclusively on state and federal laws or local zoning to protect habitat and improve water quality.

The conservation community assists the Service. The Director of the Service approved the Refuge expansion proposal on May 7, 1990. While the approval was pending, the Refuge embarked on a highly visible effort to increase awareness of the threats to the watershed. This effort was characterized by the involvement of the Refuge Manager in publicly highlighting threats to area resources encompassed by revisions of the City's Comprehensive Plan, and by testimony before the City Planning Commission and City Council on matters concerning the watershed and the Refuge. Coordination with local conservation organizations took on a new importance. The most vocal "friend" of the Refuge and the watershed became the Friends of Back Bay/Save our Sandbridge (FOBB) organization. When the Refuge expansion was announced, FOBB became a driving force behind gaining approval for the expansion effort—coordinating with other local conservation organizations in encouraging approval of the boundary proposal.

FOBB lobbied City Council, national environmental organizations, members of Congress, the media, the Service and the general public in support of Refuge expansion efforts and the protection of the watershed. Through their positive, tireless efforts, FOBB was able to counteract the negative influences of those who opposed federal involvement in resource protection activities. They played a critical role in gaining approval to expand the Refuge boundary. The Refuge Manager worked closely with FOBB throughout this effort.

Upon approval of the new boundary in 1990, the Service immediately committed over $1 million to begin acquiring land from willing sellers. At the same time, the FOBB Board, led by President Molly Brown, began to focus their efforts on Congress in an attempt to secure funding for land acquisition from the Land and Water Conservation Fund (LWCF) account. Recognizing the value of coordinating with other groups with like goals, FOBB joined in a coalition with other area conservationists and national organizations to secure funds for the Refuge. The coalition has been amazingly successful over the past three years, generating $6.4 million in LWCF funding for Refuge land acquisition. The following table illustrates land acquisition accomplishments for 1990–1993:

Table 3. Land acquisition results.

Year	Acres acquired	Refuge total
1938	4,589.00	4,589.00
1990	455.08	5,044.08
1991	207.28	5,251.36
1992	1,998.31	7,249.67
1993	428.00[a]	7,677.67

[a]Pending sales.

Beyond acquisition. Land acquisition alone will not reverse the degradation of Back Bay habitat. Individuals and organizations, both governmental and private, must work together to promote the protection of sensitive areas beyond the Refuge boundary. Toward that end, conservationists in the Hampton Roads area joined forces in 1990 to form the Southeastern Association for Virginia's Environment (SAVE). SAVE has become a leader in the campaign to limit growth in the Southern Watersheds of Virginia Beach. Local chapters of prominent environmental organizations have become more active in the area, recognizing the threat to the nationally significant resources of southeastern Virginia. The efforts of all these groups were instrumental in the passage of the Southern Watersheds Management Ordinance (SWMO) in Virginia Beach. This ordinance, while not as strong as conservationists had hoped, provides for building setbacks from streams and wetlands, recognizes the importance of "critical edge upland areas" to migratory birds and other wildlife, discourages the creation of impermeable surfaces and provides for containment of storm water runoff.

The trend toward developing cooperation and partnerships continues to build momentum. The Service's Back Bay Initiative seeks to address watershed issues through increased research and water-quality monitoring, cooperation among governmental agencies and special interest groups, and enforcement of existing wetland protection laws and regulations. The Back Bay/North Landing River Focal Area Committee, created under the auspices of the North American Waterfowl Management Plan, brings together city, state and federal officials, citizen's groups, and private conservation organizations to preserve habitat for wetland-dependent wildlife.

Results

While it still is too early to know if the efforts of these various individuals and organizations will be enough to ensure a future for wildlife and natural resources within the largest city in Virginia, it is clear that progress has been made due to the efforts of the coalition. From the Refuge perspective, the look outward also caused improvements within. The commitment of the Service to improved administration (funding and staffing) and management, has resulted in much improved migratory bird habitat at Back Bay Refuge. The vast majority of waterfowl and shorebirds that now utilize this area are found within the boundaries of the Refuge. This is directly related to improved impoundment management, control of pest plants, limits on non-wildlife-oriented public uses and other general management improvements made possible by increased staffing and funding. The improved coordination between federal and state agencies has generated a new partnership geared toward improving habitat. The involvement of local conservation organizations ensures that decisions affecting the watershed are evaluated for habitat and open-space impacts. The efforts of these groups clearly has slowed the massive, single-family residential development that once seemed destined to dominate the area. These organizations have formed partnerships to tackle controversial issues. They are now better organized and funded than they were only six years ago; their input into the local planning process carries more weight and is backed up by the testimony of experts when necessary.

The final result of the coordinated effort still is unknown. There have been successes, as evidenced by the approval of the boundary expansion and the acquisition of nearly 3,100 acres by the Service in four short years. The passage of the SWMO, is an improvement over completely unrestricted development. The monthly networking of environmental groups at the "Environmental Breakfasts" ensures that information is regularly exchanged. Government is aware that there are concerned organizations that must be included in the decision-making process. The public benefit is better served by an informed and active public.

The effort has had its shortcomings as well. There is still no comprehensive farmland protection strategy for Virginia Beach and several new subdivisions have been approved in the Back Bay watershed. If the trend continues, farm fields and woodlots will become subdivisions, roads and sewer systems eventually will be expanded, impervious surfaces and runoff will increase, and water quality inevitably will suffer. Probably the greatest shortcoming of the efforts of the coalition to date is the inability of the conservation community to join forces with farmers. Many farmers loath the conversion of the land for housing, but fear the "long arm" of government regulation and the "impact" of environmentalists. Unless this gap is bridged, the future of farming and the protection of open space and wildlife habitat that it provides may be lost.

Recommendations

Resource managers can no longer operate solely within the confines of their land-management unit boundaries and be confident that natural resources are being adequately protected. The effects of growth directly influence the health of the entire watershed—without regard to political or other artificial boundaries. If actions are not taken to positively influence decision making in areas adjacent to the management unit, management inside the unit will be less effective. Managers must take an active role. Partnerships must be formed with citizens who share concerns for area resources. Managers must maintain their credibility while helping to develop reasonable compromises and solutions to complex problems. Local coalitions are critical. Dictation of solutions by bureaucrats, including land managers, is a sure way to lose credibility and alienate the local community.

Success in these efforts is not a matter of winning or losing on each issue that arises. Success is gauged by the strength of the coalition formed, the acreage protected or enhanced and the attitudes changed or modified. Success is measured by knowing that you worked with others to make a difference in the effort to preserve our Nation's important resources.

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A Challenge: Saving the Everglades from Us and for Us

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Invading the Everglades

Nineteen-eighty-seven marked the 40th anniversary of Everglades National Park, and a reporter called me to ask how I saw the park 40 years hence. At that time we were much absorbed with controlling development in the then-privately-owned East Everglades, so that it would not prevent restoration of flows in Shark River Slough, the park's principal overland drainage. I told her, at some length, that the park's future was uniquely dependent on regulatory actions of the South Florida Water Management District and of various state and local authorities in the land-use arena. I told her that the park's future, because of its position at the downstream end of a vast water management system and adjacent to a burgeoning metropolis, was much more to be determined by the District and by country planners than by the Secretary of Interior or other of its nominal federal guardians. We finished talking and I began reflecting on the implications, for the Everglades, of what I had said.

The most disquieting of those implications was the relation of local police power exercises to the mission of the park. Everglades National Park is set aside with a direction in federal law to preserve its natural objects and processes, *forever*. How can local regulatory authorities be relied on to achieve that goal? It is not a standard that any of them has adopted. If they had, there are questions about their legal capacity to enforce it, and more serious questions about their enduring will to do so. In the nature of police power exercises and in the history of Florida, rules are highly permeable. The regulation established on a given day is thereafter under daily assault and, sooner or later, caves in. A wetland area is marginally drained for agriculture or other "compatible use." Farms become smaller, permitted accessory buildings become three-bedroom, two-bath accessory buildings, the growing population discovers that investment and personal safety is threatened, they say they need comprehensive flood control, and they get it. Another large bite is gone from the natural system; another inhibition is imposed on the managed system.

Another disquieting implication was the relationship of the water management system to natural requirements. It now seems poignant that the Central and Southern Florida Project for Flood Control and Other Purposes (Project) was authorized in the same Congress that established the park. Although considerable ink and oratory addressed provision for the Everglades, neither in its design nor in its subsequent operation has the Project met such objectives. The Project generally subjugated the Everglades to human purposes, but did not provide the margin needed to serve natural values remaining in the ecosystem. With the Project, we became more than unruly neighbors of the Everglades; we were home invaders.

I concluded that there will be development of some order to the boundary of publicly owned and managed resource areas; that the real question was where the boundary was placed and how conditions at the boundary were managed. I concluded that there is no reasonable prospect of restoring abundant and diverse wildlife populations in the Everglades without extensive and fundamental modifications of the Central and Southern Florida Project, and large, strategic acquisitions.

The most basic data underlying those conclusions were the following: at the turn of the century—when efforts to drain and realign Everglades' waters began—there were 4,955 souls in Dade, Broward and Palm Beach counties; about a half-century later—when the Project was created—there were some 400,000; after another half-century—now—there are 4.1 million in those counties and 4.5 within the boundaries of the South Florida Water Management District, the agency formed by the state to operate the Project.

In the design made to accommodate that growth, features of the Project's eastern perimeter and related development destroyed long hydroperiod wetlands that once supplied the Everglades. Rain that falls on those areas now is sped directly to the ocean, serving neither the Everglades nor the aquifer. Where Lake Okeechobee's southern outflows once supplied vast, deep pond apple and sawgrass marshes, the Project drained 700,000 acres to establish the Everglades Agricultural Areas (EAA). The only water that now reaches the Everglades from the lake comes from EAA drainage. It comes laden with polluting nutrients. It comes in response to the water table regulation desired by the EAA farmers, not the needs of the Everglades.

The Everglades remaining in more-or-less natural condition has been reduced to half of its historic area. The "less" part is that the remnant—within Loxahatchee National Wildlife Refuge, Everglades National Park, and District-managed Water Conservation Areas—is itself divided by water control structures and dependent on their operation. System operations now provide chemically altered water, in the wrong volume, at the wrong times, in the wrong places. The result of that ecological insult is a tragic diminution in the abundance and variety of Everglades' life.

Remaking the Everglades

I work for The Wilderness Society. Our members, my colleagues and I are strongly attracted by pristine landscapes and the problems of keeping them that way. Inevitably, that implicates action in places and events beyond the pristine core. It implicates issues in managing altered ecosystems. In the center of the Everglades, where there is no visible sign of man and where the water has eleven parts per billion of phosphorus, natural values are high and represented in wide array. The active threats to the Everglades are immanent even there, for the Everglades is systematically altered.

I was preceded in a recent discussion by an ecologist measuring the effects of wilderness use with a unit new to me: the "trample." When I put up a satellite photo of the Everglades region, I could not help but see it as wilderness, affected only by 6.4×10^{27} "tramples."

Where a megalopolis is imposed on a great natural system, only very active choices and carefully chosen action can save even a useful part of that system.

In so trampled an environment, some choose to celebrate its primordial condition by abandoning hope for what's left. Too often, people tell me that we must rip out the Project and the populace if restoration is to be a worthwhile goal. Such attitudes denigrate the great importance of what is left and of what can be restored. Such attitudes only serve those who mean to exploit what's left.

Others, aware of how little power we have to assess—much less replicate—conditions of the system's natural evolution would like to take action only after we have gained a ''sufficient'' understanding. I recognize the arrogance of planning restoration based on limited knowledge and blunt tools. That recognition does not require an expert knowledge of ecology or computer modeling. A layman reasonably informed in the history of man's interaction with natural systems knows enough to be deeply fearful. Any of us with the usual equipment of consciousness—and a Nintendo board— can see the vast gulf between reality and simulated reality. But that too can become a mere excuse for inaction. Our studies could be reduced to postmortems before the point of ''sufficiency'' is reached. I am affirmed in that view by the fact that the interests urging greatest caution in restoration efforts are the ones that have acted with greatest abandon in the system's destruction.

The same calculations that show us how weakly hydrological and ''ecosystem'' models simulate the world, show us that great marginal increases in their power will not make them much better as a basis for decisions. Important work is going forward on more complete electronic reflections of the Everglades' life and landscapes, but models already in use and decently verified identify needed large-scale changes in our management systems. They tell us that there is less water in the Everglades than there used to be. Surprise. They tell us that dry conditions are most pronounced upgradient in the compartments that have been made of the remaining Everglades. They tell us that flows are reduced and water levels lowered, generally. They tell us that hydroperiods are shortened and fall off more abruptly in the dry season. They tell us that we have attenuated hydrographs all over the place. Surprise.

They do not solve the vast, varied and vagarious questions about just how must water needs to be just where and when in order to save the Everglades. They do not offer control over the biological consequences of such choices. But there is in them a great simplifying principle to be observed. There is only so much that still can be done to affect the range of outcomes. We know enough now, we have enough wit and enough water to get a much closer approximation of natural regimes. If we do that now we will be building the tools to permit more precise future applications. If we do not do it we are leaving barriers in place that will forbid the application of growing, integrated knowledge.

There are inhibitions to restoration of the Everglades that must be squarely faced. Population growth is one of them.

Protection of natural values must accord with a constitutional design that we cherish equally with those values. In that design are included procreative freedom, the right to live where and with whom you choose, the right to earn an honest living and the right to keep people from messing up the commons.

Forming such an accord is the best protection for our natural systems. There certainly are limits to the demands that human populations can place on healthy ecosystems. In some places those limits are low; and limits certainly have been surpassed in the Everglades. Our long, sad list of endangered species so attests. But good design for human occupancy can vary those limits, for we now use much of the system's capacity in waste, sloth and idle indulgence.

Forming such an accord is typical of the dangerous job of America. Our historical landscape is littered with failures: the stench of slavery, the bloody ghosts of lost peoples, ravaged forests, powerless waters, and heedless extinctions. Some of that history is as recent as now. As prominent in our past and as significant in our present are triumphs of the human spirit.

One blessed corner of American life is the conservation movement. And in one blessed corner of our nation we have, in this last half-century, removed half a regional ecosystem from private ownership and the prospect of development, and made much of it wild by law.

Then there is the other half. The great conurbation that lies next to the Everglades' conservation units is not going away. It contains "deep ecologists," sugar barons and a lot of regular people seeking regular lives for themselves and their regular kids. All plead not guilty to destroying the Everglades. Some vastly more than others, but all impinge on the Everglades' health and its prospects of recovery. A single organism faced with such an invasion would respond with encystments and antibodies. Similar strategies must be employed for the Everglades.

It may be necessary for the Everglades—and even possible—that a revolution of consciousness or a hidden behavioral hand will alter our reproductive strategies. It may be necessary—and even possible—that universal increases in order and progress will lessen pressure for large human migrations. It may be, too, that entrepreneurs and regulators, customers and constituents, will agree on effective control of population growth and impacts. The Everglades are at stake, so I wouldn't want to bet on all that. Rather, we must find ways to protect the Everglades even if such pressures continue in their present patterns, for we must suppose they will.

The Everglades is about water. Human occupation in the Everglades is about water to a greater extent than most occupants are required to realize. Developing a water management system that does right by wood storks (*Mycteria americana*) and rate payers is a hard, expensive but necessary undertaking.

And it is possible. South Florida is wet. The Everglades gets about 60 inches of water in an average year, of which there are, or course, none. There is wide seasonal and annual variation in rainfall. That means that there is a premium on storage. Natural storage has been greatly invaded, and the Everglades—flat and sunny—is not an ideal location for regulated reservoirs. Lake Okeechobee is the best such, but its considerable capacity is largely wasted. Physical waste occurs when—in that same mythical average year—enough water is discharged from the lake to the Gulf and the Atlantic to meet all the region's municipal and industrial needs. Economic waste occurs all the time through application of the Lake Okeechobee's potentially high economic value to low value agricultural uses. In a better design, water management for the Everglades Agricultural Area would be internalized, physically and economically. It should be isolated from the Everglades in every possible respect, or excised.

It is possible to buffer many effects of development on the eastern perimeter of the Everglades, by establishing a system of marshes, reservoirs and recharge areas that will retain water now wasted to tide, increase supplies to cities and the Everglades, prevent—or turn back—encroachments, and provide transmission to water-short areas.

If sufficient storage is provided, water can be reintroduced, not as massive canal discharges, but as sheetflow, in volumes responding to regional rainfall, more as nature once did.

The Wilderness Society and allies in the Everglades Coalition have described an integrated set of aims, like those, for changing land-use and water management patterns. The goal is to restore the fullest possible measure of abundance, diversity and resilience in the natural life of the Everglades. Those changes conform to the declared law and policy of Florida and the United States, and they comprehend a massive project of federal public works, remaking the system imposed 50 years ago. America has lots of experience at federal public works, but little at using them for urban water supply, and less at using them for ecosystem restoration.

Common sense, although not commonly observed, tells us that human management of an ecosystem is not a finite task, either in content or duration. When we take dominion of a great system like the Everglades, and set standards like those applicable to Everglades National Park, we declare our intention to do the job permanently and as well as God did. Common sense tells us we won't make it, but common experience tells us there is a real difference in results between our best efforts and our poorer ones; a human difference, observable in human terms.

Success in the long term demands effective management of growth and growth impacts in the region of the Everglades, integrated with accurate standards and durable programs for the protection of natural values. If we try in the meantime to isolate some effects of human pressure and reverse some fundamental abuses, our best efforts will liberate nature's greater power of renewal. That is not a sentimental observation. A look at the varied life of one of the Kissimmee River's old bends after water is restored affirms it. The response of nesting storks to a good water year is a wellspring of assurance.

If humans are, finally, mere pathogens, restoring the Everglades is a funeral ceremony. So is getting up tomorrow. The Everglades is the kind of place where we might demonstrate that we are something else; that we can act, purposefully, against profligacy, greed and ignorance; that imagination, given only to us among creatures, can make us a useful part of nature's majesty and love, given, if accepted, to all.

Managing Human Population Impacts on Wildlife in a Rapidly Urbanizing Area: A Case Study of the City of Carlsbad, California

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Introduction

Human overpopulation may be the single greatest threat to biodiversity in this century. Human population growth and competition for natural resources, including habitable land, also has been postulated as a major cause of human conflict (Homer-Dixon et al. 1993). While a great deal of public and scientific attention is being focused on overpopulation in third-world nations and associated loss of topical rainforests, urban North America has yet to face up to its own contribution to the ever-increasing impacts of humanity on natural resources. In San Diego County, California, some local governments now are beginning to introduce the issue of human population growth in relation to biodiversity as one of the central issues in their land-use planning efforts. This paper describes the efforts of one city to forge a more sustainable balance between the conflicting forces of environmental protection and urban development. It describes the creation of a new planning paradigm to replace existing crisis oriented, single species and development driven mitigation efforts with a proactive plan for the long-term preservation of native habitats and species.

Population and Growth Management

Since 1986 the City of Carlsbad, California has been on the leading edge of local government efforts to manage the impacts of human population growth. This community of approximately 65,000 in north coastal San Diego County experienced intense development pressures during the early 1980s. For three consecutive years the city had a growth rate of greater than 10 percent and was reported to be one of the ten fastest growing cities in the nation. Between 1980 and 1986, the city's population increased from 35,490 to 52,190. This increase was due primarily to in-migration in response to new residential development; during the same six year period 5,769 new homes were constructed in the city.

Citizen concern over this unbridled pace of growth led the Carlsbad city council to consider various methods of managing and mitigating the impacts of growth. The outcome was a program with three key components (City of Carlsbad 1986):

- reduction in residential densities;
- a cap on the total number of dwelling units; and
- a requirement for adequate public facilities.

Although the debate over growth management was not phrased in terms of controlling human population, reduction in residential densities as part of the plan immediately lowered Carlsbad's potential population at buildout from over 200,000 to approximately

135,000.[1] The dwelling unit limitation was included in a local ballot initiative, passed on November 4, 1986, which specifies a fixed number of dwelling units that may be constructed after that date. The public facilities provision of the program included open space as a public facility, along with roads, sewers and other more traditional infrastructure elements. Property owners in specified areas of the city must dedicate 15 percent of otherwise developable land as open space.

Although the Growth Management Program did not directly address preservation of biodiversity, it effectively limited urban population growth, and the open space requirement set the stage for a subsequent planning program focused on preservation of native habitats.

Addressing the Biodiversity Issue

Limiting development densities and population is not sufficient to assure that impacts to wildlife will be lessened. Low density development, unless properly planned, can produce the same degree of fragmentation and habitat loss as more intensive development. The key to preservation of species diversity is to cluster development in the least biologically sensitive areas and conserve the biologically rich habitat. In 1990 Carlsbad initiated a program to explore this approach.

Prior to 1990, city planning officials had assumed that the only sensitive biological resources in the city were wetland habitats, including the beaches, riparin corridors and three coastal estuaries within the city's boundaries. It was thought that the open space requirement of the growth management plan and restrictions on hillside development would preserve an adequate amount and variety of the non-wetland habitats. In 1990 these assumptions were found to be in error.

With the filing of a petition for listing of the California gnatcatcher (*Polioptila califonica*) as an endangered species, a number of local governments in southern California were forced to reexamine their general plans and development assumptions (Atwood 1990). Gnatcatchers are obligate, permanent residents of coastal sage scrub, a vegetation community once common in southern California. Subsequent status review of the gnatcatcher by the U. S. Fish and Wildlife Service concluded that listing is warranted (Salata and Harper 1991).

Because the gnatcatcher was the first new endangered species issue to arise in Carlsbad in many years, officials first directed their efforts toward understanding the potential implications for land-use planning. Review of available literature on conservation biology revealed that typical project-by-project mitigation often results in undersized islands of habitat surrounded by a sea of development. Such islands have been shown to be incapable of sustaining viable populations of sensitive species (Soule et al. 1988). The territorial requirements of many sensitive species are such that only protection of large, connected blocks of habitat will preserve the species from eventual extinction. None of the current urban planning models appeared adequate to address this new challenge.

The findings of Soule et al. were particularly striking for Carlsbad because the study documented the rapid disappearance of "chaparral-requiring" birds, including the gnat-

[1]The projection for population at buildout has since been reduced even further as a result of improved information from the 1990 census regarding the average number of persons per dwelling unit. The new projection is approximately 126,550 population at buildout.

catcher, from isolated pockets of habitat in San Diego County.[2] The habitat fragments in the study had been set aside in part to preserve these species but had failed to do so. Soule et al. concluded that "the most effective tool for the prevention of extinction of chaparral-requiring species in an urban landscape is the prevention of fragmentation in the first place by proper planning of urban and suburban development." Carlsbad officials were convinced that in order to do proper planning, a new paradigm would have to be invented.

A New Planning Paradigm

As a starting point for conceptualizing a new paradigm, the author and other Carlsbad officials compiled a set of elementary principles of conservation biology which, if followed, would be more likely to maintain wildlife and ecosystem values:

(1) Avoid further habitat fragmentation; a few large, contiguous preserves are better than many small, unconnected ones.
(2) Where preserves cannot be made contiguous, use corridors to connect preserve areas.
(3) Design the boundaries of preserves and corridors to minimize edge effects.
(4) Include as much diversity of habitats in preserves as possible.
(5) Maintain large carnivores (coyotes, bobcats) within the preserve system.
(6) Plan on a scale larger than a single housing or commercial development.

Habitat conservation programs must comply with laws regarding private property rights and the limits of local governmental authority to restrict use of private property. Local government has the authority to designate acceptable land uses, but zoning regulations cannot prohibit all use of land. Therefore, the new paradigm cannot rely on the overly simplistic notion of rezoning all biologically valuable land to open space.

Existing planning approaches to habitat preservation contain many valuable components, even though the historic application of such methods is less than satisfactory. In particular, Carlsbad officials carefully reviewed the procedures for habitat conservation planning under Section 10 of the federal Endangered Species Act. An evaluation by the World Wildlife fund of habitat conservation planning efforts around the nation suggested that the approach, if properly carried out, generally achieves the objectives of preservation of biodiversity (Bean et al. 1991). Because this method also allows for reasonable economic uses of land, its provisions seemed worthy of serious consideration.

Unfortunately, the habitat conservation planning process is not typically utilized until a species is formally listed as threatened or endangered. To simply wait until the population and habitat of a species are reduced to such a level that it is in danger of extinction is not only poor planning but, in fact, not planning at all. If the new paradigm is to be proactive, it must look to the needs of species well in advance of candidacy for listing. In the case of the gnatcatcher, listing has been proposed but to date has not been effectuated. More importantly, 24 additional species of plants and animals known or believed to occur in Carlsbad are candidates for listing, and at least 16 other non-candidate species are considered sensitive. Therefore, the decision was made to treat certain key species, including the gnatcatcher, as if they already were listed and to pursue a plan that would maintain viable populations of all currently recognized candidate and sensitive species.

[2]Soule et al. grouped both coastal sage scrub and chaparral plant communities under the category of "chaparral" for purposes of the study.

Habitat Management Plan

After several months of study, Carlsbad staff presented the city council with a proposed work program for development of a Habitat Management Plan. The city council approved and funded the work program after a careful consideration of costs and risks. Funding for this planning effort would have to come entirely from the city's general fund, at least initially. One factor that helped the city make the decision to proceed with the program was the success of the Growth Management Program. Seeing that the proactive approach worked well in reducing population and assuring adequate public facilities, the city council was willing to take the political and financial risk in a long-term solution for sensitive species and habitats. The work program and key milestones are summarized below.

Phase I

An advisory committee was formed and basic operating assumptions were identified. The committee consists of all parties with an interest in the outcome of the effort, including the U. S. Fish and Wildlife Service, the California Department of Fish and Game, land owners, local conservationists and city staff. Because of the diversity of interests on the committee, an impartial facilitator with previous experience in habitat conservation planning was hired to help guide the committee and build the consensus necessary to arrive at workable solutions. Three basic ground rules were adopted to govern operation of the committee and formulation of the plan:

(1) The committee would operate by consensus, and major decisions would require agreement by all members.

(2) Normal processing of both private and public projects would continue during plan preparation. In the interim, impacts to coastal sage scrub or gnatcatchers would be treated as significant and requiring mitigation.

(3) Conservation decisions would be based first on biology, with secondary consideration given to economic impacts and other factors.

Phase II

Biological consultants prepared two maps; a vegetation map of all undeveloped land in the city; and a map of all sightings of sensitive plant and animal species. Information was compiled from existing environmental documents, aerial photographs, and some "ground-truthing." Habitat areas were rated qualitatively using a methodology developed by the consultant team. Mapping and qualitative computations were carried out with computer assistance by the San Diego Association of Governments, whose regional geographic information system was well suited to the tasks.

The habitat ratings led to designation of Preserve Planning Areas containing the largest remaining blocks of high quality habitat. The end product was a document which lays the foundation for preserve design, gap analysis and preparation of a financing/acquisition strategy (Behrends et al. 1992).

Phase III

Begun in August 1992 and current ongoing, this phase is devoted to completing the preserve design, gap analysis and financing/acquisition plan, as well as providing for a management entity and funding for perpetual maintenance. Preserve design is an evolving art and a daunting task, especially when dealing with expensive ocean view property and species that do not yet have the benefit of full legal protection. Fortunately, the participating property owners have understood the potential benefit of proactive planning, and they have supported the effort thus far.

One frequent concern of property owners regarding the Endangered Species Act has been the lack of compensation for loss of use of their property. To address this concern, it was decided that the Habitat Management Plan would emphasize mechanisms to provide compensation in some form to those whose property is designated for preservation. In this respect, the city will utilize some of the highly creative and successful land preservation techniques of The Nature Conservancy and other land trusts. One readily available compensation mechanism is the open space requirement of Growth Management. Land designated for wildlife preserve can be offered towards meeting the open space requirement, providing another link between Growth Management and habitat protection. In addition, all potential sources of funding for both acquisition and long-term stewardship are currently being explored. Options for ownership and management structures will be explored, including the possible formation of a conservancy or partnership with an existing conservancy.

Phase IV

The final phase will consist of implementation of the acquisition/financing strategy, formulation of ownership and management structure, adoption of a management and maintenance plan, integration into the Carlsbad General Plan, and execution of agreements with the state and federal resource agencies. It is anticipated that this phase will extend over a number of years. Long-term management will provide for sensitive species' needs, public access, scientific research and public education.

Early Results

At this time, the final preserve design has not been completed, and it would be premature to speculate on the ultimate size and configuration of the preserve system. However, it is possible to indicate the extent of lands and habitats already protected. Table 1 summarizes the amount of vacant land remaining in Carlsbad and the acreage of each habitat type already protected by land-use regulations.

The table indicates that while certain wetland habitat types, such as saltwater/freshwater marsh, riparian scrub and open water, have a very high level of protection, the

Table 1. Acres of undeveloped land protected by existing land-use controls within the City of Carlsbad, California.

Habitat type	Total acreage undeveloped	Acres in preserve planning areas	Protected acres	Percentage protected
Coastal sage scrub	3,363	2,640	715	21.3
Chaparral	2,028	1,475	424	20.9
Grassland	2,472	1,569	257	10.4
Saltwater/freshwater marsh	546	400	545	99.8
Riparian scrub	469	355	469	100
Oak/sycamore woodland	152	137	54	35.5
Open water	877	847	876	99.9
Disturbed	5,053	1,620	407	8.0
Total habitat	14,960	9,043	3,747	25.0

amount of protected acreage for all habitat types aggregated, and particularly upland habitats, is relatively low. Grasslands, for example, which serve as foraging areas for raptors, currently have minimal protection and are unlikely to receive regulatory protection in the near term. A key objective of the Habitat Management Plan is to develop the financing mechanisms necessary to acquire a biologically sustainable amount of land for each of the unprotected, yet valuable, habitat types.

Financing the acquisition of a large amount of land and protecting it from human impacts will involve substantial costs to the city. To offset this cost, the city will need assurances from state and federal wildlife agencies that areas not designated for inclusion in the preserve system can be developed without unreasonable restriction. Such development will, however, be required to provide mitigation if there are impacts to habitats. Mitigation may be onsite if it is connected with the preserve system, or offsite as the alternative. While Carlsbad formerly might have allowed offsite mitigation to be outside of the city, perhaps even at a great distance from the city, we now can direct offsite mitigation toward acquisition within the designated preserve system.

Conclusion

The City of Carlsbad is undertaking an innovative approach to urban planning utilizing the latest principles of growth management and conservation biology to minimize the impacts of human population growth on local biodiversity. The program is not complete, and it remains to be seen how successful the city will be in its efforts to finance acquisition of what will undoubtedly be a multi-million dollar preserve system. Nevertheless, the program already can be called a success in terms of the valuable biological information that has been gathered, the heightened awareness of city officials, citizens, land owners and developers regarding the importance of preserving local species diversity, and the positive responses of the resource agencies, the conservation community and other local governments to this new way of planning.

The Carlsbad Growth Management Program and Habitat Management Plan have revolutionized land-use planning in the region, and now almost every jurisdiction in San Diego County is involved in similar programs. The Habitat Management Plan will be the first chapter in a regional plan to preserve habitat lands and corridors from the Pacific Ocean to the Anza-Borrego desert. While the details of the Carlsbad model may not work for every city and town, our hope is simply that other communities will be encouraged to investigate the benefits of proactive wildlife habitat planning for themselves.

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Special Session 3. *Marketing Natural Resource Programs*

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Market Research that Really Counts

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Introduction

Natural resource agencies must conduct market research—or "human dimensions" studies in fish and wildlife parlance—to remain viable public service organizations of the twenty-first century. Competition among deserving social services for scarce public dollars already is intense. But in coming years, resource managers in North America will vie for citizens' attentions and financial backing in a context of domestic crises unimaginable even a decade ago: a deadly health epidemic, rapid growth in an explosive urban under-class, use of illegal drugs that crosses all social strata, a health care crisis, increase in single-parent families, citizen isolation from sources of natural production due to urbanization and loss of leisure time, an overburdened social security system, etc. (Hugick and McAney 1992). Moreover, the U. S. market for conservation services is fragmented by lifestyle choices, demographics, geography, multi-culturalism and personal values as never before (Murdock et al. 1992, Witter 1992b). Market research in support of fish and wildlife management is essential for managers hoping to keep their programs vital in a world of accelerating change (Thorne et al. 1992).

At a practical level, marketing is simply the process of determining what people value and then responding with products and services (Schick et al. 1976). But at a more profound and conceptual level, marketing is a way of thinking about consumers; it's a public service mentality.

This mentality of responsiveness to the public may threaten some natural resource managers who see themselves on an indisputable biological mission not subject to market influences. There is indeed a core of legally mandated conservation tasks. However, a vast array of conservation and recreation services of interest to a diverse public surrounds this traditional core. Organizations innovative enough to use market research to discover these opportunities and develop new services or evaluate ongoing programs can expect broad citizen support in return.

But market research can be wasted effort both in the public and private sectors (O'Leary and Weeks 1979, Townsend 1992). How can we involved with fish, forest and wildlife conservation be sure we're conducting market research that really counts?

Ask Yourself:

Can We Take the Results to the Bank?

Imagine yourself as a corporate executive officer. You're responsible for all costs of production—materials, labor, promotion, distribution—and of course, responsible for making a profit for stockholders. Based on experience and personal intuition, you already have a "good" understanding of who purchases your product or service. One of your staff suggests that a market study may provide new insights to your clientele. You should ask, "Will this market research make our present customers happier and more supportive, or produce an expanded clientele for our product? Are we confident we'll profit from this research? Can we take the results to the bank?" If, after deliberation, too many doubts remain regarding a study's profitability, the dollars that would have funded the market research are best directed at some other aspect of the firm's operation.

Market research that really counts will pass this profitability test. This criterion is particularly important for market or human dimensions research conducted in the public sector—the sector including resource management agencies and universities, and the sector that produces most such work. Just because fish and wildlife agencies are not charged to be "profitable" in a strict economic sense (Thorne 1992), they're not excused from using scarce tax dollars most economically. Subjecting market research proposals to the test of profitability will help cut the fat, including pet projects, ill-defined research and studies that have no basis other than trendiness.

Are Market Studies in the Organization's Plans?

Market studies that really count appear as work objectives in an organization's strategic or operational plans, and in turn, are tied to the organization's budget. Occasionally, unanticipated market studies relating to fish and wildlife must be completed, say, at the request of a governor or agency director (e.g., Witter et al. 1989). Obviously, it's difficult to plan for such exceptions.

Generally, however, if human dimensions studies appear in an organization's plans, it suggests that a program manager has applied the test of profitability to the proposed research and grappled with the pivotal question of how the results will benefit his or her program. Moreover, planning for market studies over a multi-year period encourages a program manager to develop a comprehensive package of market studies and communication strategies, diminishing the need for social research on a crisis-by-crisis basis.

Are the Results Translated and Interpreted Into Easy English?

Rarely do statistical tables from a market study speak clearly to even the most interested of program managers (or research analysts!). The expected benefits from a market study often go unrealized because managers don't know how to use the data (O'Leary and Weeks 1979). Market research that counts will translate methodologically intricate findings into "easy English," and include the researcher's interpretation of market implications.

Occasionally, social researchers—even those employed by agencies—refrain from offering their appraisal of study findings, thinking their insights might be uninvited and unappreciated. And in fact, discovering implications in a data set is a difficult task—actually, more art than science—that benefits from an understanding of agency traditions and operating procedures, and empathy with the organization's mission statement and administrative style—what might be called inside knowledge. But important clues to better informed decisions can come from the research methodologist's fresh insights born of new or limited exposure to the organization for which the market study is completed—outside knowledge.

Does the Market Study Have an "Advocate"?

Market research that really counts will have an advocate who both promotes the importance of findings upon initial release of the results, and remembers the study findings as months and perhaps years pass. An advocate might be the staff member or consultant who conducted the research, or a manager or administrator who is convinced of the value of the data.

This social research advocate can linger over the study findings, taking time to think about study implications. Rarely does market research in fish and wildlife management reveal empirical oddities or completely unanticipated results upon which immediate action must be taken. But over time, issues will arise for which the data have application, and a data advocate will be able to recall, retrieve and interpret the results. Testifying to top administrators' recognition of the importance of this creative role in an agency setting is the employment of human dimensions or marketing specialists in more and more fish and wildlife agencies, as well as involvement by some natural resource organizations in a marketing program called Responsive Management (Duda 1992).

Are You Painting the Big "People Picture"?

Market studies that really count will not only answer immediate management questions, but will contribute to a comprehensive model describing the wildlife-related belief system of an organization's clientele (Figure 1). This model of a constituency's belief system can guide a long-term program of market research, allowing an agency to reflect on the larger issue of the importance of resource management to contemporary culture.

A belief system is "a set of related ideas (learned and shared), which has some permanence, and to which individuals and/or groups exhibit some commitment" (Borhek and Curtis 1975:5). One model of a belief system illustrates a complex social structure composed of three separate but interactive parts (Figure 1): (1) substantive beliefs (the actual content of the belief system), (2) typological characteristics (variable traits according to which the system can be ranked or typed), and (3) organizational vehicles (social organizations that carry the system). Over time, each of these three parts interacts with and can affect the character of the other two. The system is thus subject to constant change from a variety of influences.

Citizens' interests in wildlife can vary from state to state (U.S. Fish and Wildlife Service 1992), and indeed, beliefs regarding wildlife can vary substantially within a state

(Adams and Thomas 1989, Witter 1992a). Because of these variations, the belief model should be built upon market data from an agency's own constituency.

Concluding Remarks

Marketing, or incorporating human dimensions into wildlife management, is not merely conducting a market study, advertising a program, hiring a human dimensions or marketing specialist, or even establishing a social research unit, though each of these actions certainly can be part of a successful marketing program. Marketing, or human dimensions in wildlife management, is a way of thinking and acting toward the citizenry for whom living resources are managed.

More than a half century ago, Aldo Leopold observed that wildlife conservation would make greatest advances if it drew support from a broad-based constituency—ideally, he suggested, from the general public (Leopold 1930). Market research allows an agency

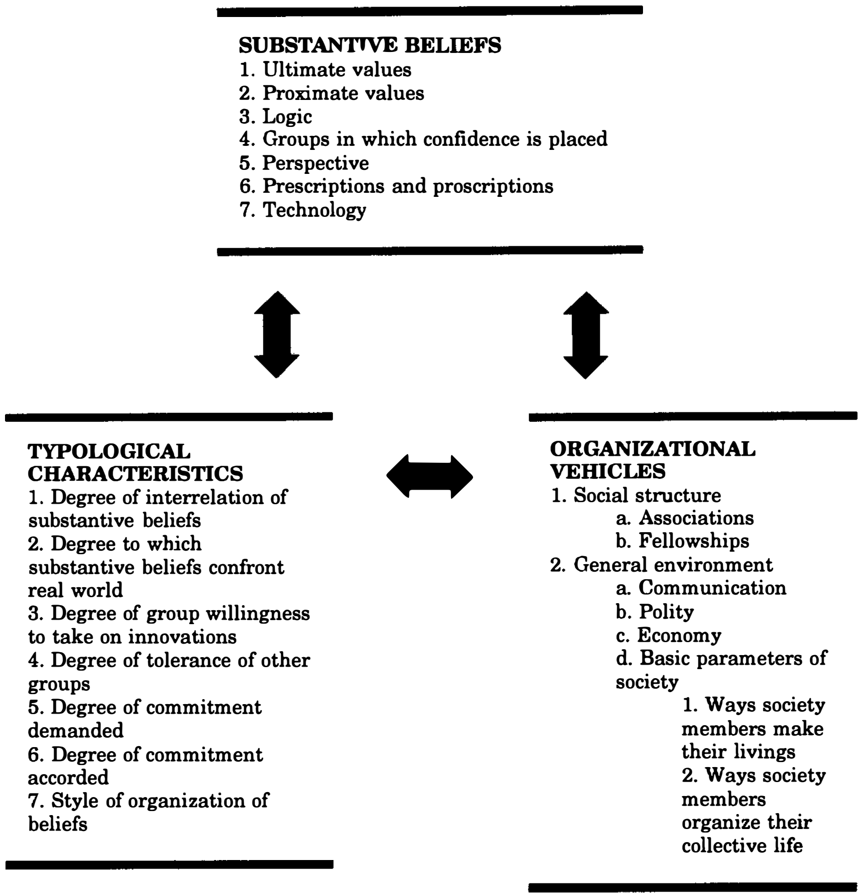

Figure 1. Belief system (Borhek and Curtis 1975).

to segment the public into identifiable clienteles with specific expectations for fish, forest and wildlife management. Market research that really counts will make us think about the services and products we provide, for whose benefit, at whose expense and why.

This Special Session of the 58th North American Wildlife and Natural Resources Conference is entitled Marketing Natural Resource Programs. Each of the four papers exemplifies market research that counts. For example, George Lapointe and Therese Thompson discuss the importance of building the big "people picture" in natural resource management. Tom Segerstrom and William Helprin, Jr. explain how their wildlife-viewing business takes market research results to the bank. Christine Thomas and Tammy Peterson are advocates for market research on becoming an "outdoors-woman." And Virginia Wallace discusses the benefits of making market research a component of long-range plans for nature interpretation. Hopefully, all the papers are written in easy English so that in years to come readers of these proceedings understand the role of market research in natural resource management.

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Marketing Wildlife to a New Constituency

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Introduction

"People can have the Model T in any color—as long as it's black." Henry Ford spoke these words some 60 years ago to describe options available with the Model T, a car that revolutionized how Americans viewed the automobile. The Model T had a long run of more than 15 million vehicles over 19 years. But the times caught up and passed the Model T. Other competing companies made it clear to the car buying public that many options were available—you could get the good attributes of the Model T, affordability and dependability, but you also could get other options, including many colors. We use this example because it provides an analogy to the present state of fish and wildlife management agencies when it comes to marketing their products. Agencies are proficient in providing products to traditional constituents, hunters and anglers, but like the Ford Motor Company of the late 1920s, we need to provide products to other segments of the market, but have not yet figured out what to offer them. In the meantime, competing interests are saying that their products are better than ours. At the 1992 North American Wildlife and Natural Resources Conference, former Assistant Secretary of the Interior Mike Hayden said that the world has passed us by and we need to catch up. Fish and wildlife professionals need to rapidly acquire new skills and methods to compete in today's world.

A fundamental assumption of developing new skills in marketing is that they be used within the foundation of fish and wildlife professionalism—resource conservation, Leopoldian ethics and professional integrity. To violate this professional foundation renders us equivalent to a stereotypical used car seller.

Discussion

Why do we need to make changes? Because the world is changing. Demographic shifts across North America are impacting public perceptions about fish and wildlife management and participation in wildlife related recreation. These changes point toward more single parent households, more elderly residents, more ethnic diversity and a more urban population. In 1960, 9.1 percent of children were raised in one parent households; that percentage is now almost 25 percent, and most single parent households are led by women (Anonymous 1991). Since most children learn traditional wildlife recreation from men, the increase in women head-of-household families will undoubtedly affect children's attitudes about wildlife.

Aging also influences participation in wildlife-related recreation; the percentage of active hunters decreases with age. The percentage of the U.S. population over 65 years old is expected to double in the next century (Anonymous 1991). In most states and provinces, the portion of the public that hunts or fishes will decline as the population continues to age.

The demographic change with the greatest potential to affect fish and wildlife management is increasing urbanization. The percentage of the U.S. population living in urban areas rose from 35 percent in 1900 to 78 percent in 1990 (Anonymous 1991). Increasing urbanization is positively correlated with desertion from hunter ranks, and isolates people from wildlife and the environment. Recent studies show that most Americans' contact with wildlife is primarily through the media (Wong-Leonard 1992).

Together, these demographic changes have dramatic implications for fish and wildlife management in the future. As these trends continue, traditional supporters of fish and wildlife agencies, white male hunters and anglers, will make up a smaller proportion of the population. Fish and wildlife agencies will be less able to rely solely on this shrinking group of strong supporters to sustain their programs. We cannot control changes in society but we can adapt to and use these changes to the advantage of fish and wildlife resources and the public.

Marketing has been defined as "the performance of business activities that direct the flow of goods and services from producer to consumer" (Ries and Trout 1986). Does this definition apply to fish and wildlife agencies? We would argue that it does. If you accept this definition, what goods and services do we produce and who is the consumer? We need to identify our markets, our consumers, the needs and desires of these consumers, and then decide what products we're going to direct at them.

Most fish and wildlife agency mandates call for managing wildlife for sustainability and public benefit. This means that the entire public is the pool from which we look for consumers of our products. Our challenge is to break this enormous pool of consumers into segments based on interest or need, a process called stakeholder identification. A stakeholder is broadly defined as any person or group with a direct, indirect or perceived involvement in an issue or project. For fish and wildlife management, a stakeholder is a person or organization with a direct, indirect or perceived interest in wildlife.

The list of stakeholders for fish and wildlife management includes hunters, anglers, ranchers, birdwatchers, animal rights activists, farmers with crop depredation problems, local businesses that are affected by wildlife related activities or landowners with concerns about potential trespass problems. This sounds like most everyone is a stakeholder in wildlife management; how many people do you know with no interest in wildlife? Using this broad definition, we can say that anyone interested in wildlife is a potential consumer for our products. It is important to recognize variation within each of the stakeholder categories mentioned. Assuming that one set of expectations adequately describes all hunters or non-consumptive users is a mistake because individual people or groups are looking for different types of wildlife experiences.

From a wildlife managers perspective, stakeholder breakdown or consumer research means recognizing unique characteristics of different segments of the public and providing products and experiences based on these characteristics. Most managers already do this with traditional stakeholders, the hunting and fishing community. And most state, provincial and federal agencies have been reaching out to newer stakeholder groups, such as those interested in nongame and endangered species. Yet, while we recognize the different needs of different types of hunters and anglers, we have tended to assume that all nonconsumptive users have identical needs.

What, then, is the product, or products, of the fish and wildlife management business? Broadly, the desired products are resource stewardship and, within the bounds of stewardship, a quality wildlife experience. For the hunter or fisherman, it means a reasonable expectation of killing or catching the target species. For a birdwatcher, it may mean seeing a new or rare bird in it's native habitat. For many urban/suburban dwellers, it may mean getting cardinals or squirrels to come to the backyard feeder. For animal activists, it may mean helping with wildlife rehabilitation, or wider use of non-lethal management techniques.

It is important not to assume that we, as professional managers, know what people want. We need to actively seek information on constituent needs and values concerning wildlife. For instance, we cannot assume that all nonconsumptive users simply want to see more birds. They may want to see a wider variety of birds, or have an opportunity to picnic in an area of abundant wildlife. Fish and wildlife agencies need to collect information on various stakeholder groups and their needs, and then determine if the agency is providing, or can provide, the desired experience. We then need to promote an appropriate program, product, or wildlife experience to that group. It is impossible to convince people to support programs that do not matter to them. Instead, we need to ascertain what *does* matter, if our programs fulfill that need, or determine what types of program provides the desired product.

Can we deliver all things to all people? No, we cannot, but we can meet the expectations of more stakeholders than we have traditionally served. In many cases, it may be as simple as promoting an experience that we already provide in a new way. For instance, instead of trying to market traditional wildlife programs to a new constituency that has different expectations, fish and wildlife agencies need to determine how existing programs meet a new constituencies need and market a new, targeted message to these groups. For example, rather than trying to convince single parents to teach their children to hunt because it helps control wildlife populations, we should emphasize how hunting can provide quality time together with the child.

Environmental and animal rights groups are very sophisticated marketers—especially when recruiting urbanites, senior citizens and children. You only need to observe Greenpeace ads on MTV, a People for the Ethical Treatment of Animals "Rock Against Fur" concert or a National Wildlife Federation mail-order catalog to understand how effectively these groups appeal to our constituents. Fish and wildlife agencies need to become as sophisticated if we want our message to be taken seriously, particularly if we want today's children to grow up to be supporters of wildlife management. If we fail to provide information and products to these groups, someone else surely will, and the resultant message or product may be unsupportive of professional fish and wildlife management.

The definition of marketing used earlier was "the performance of business activities that direct the flow of goods and services from producer to consumer." This is basically what fish and wildlife agencies have been doing with traditional consumer segments—hunters and anglers. Within the bounds of sustainability and law, agencies have tried to satisfy as many segments of these groups as possible, and have been largely successful. Through well established lines of communication, agencies have done the "consumer research" needed to deliver products to these groups.

Fish and wildlife agencies also have been hearing that non-traditional consumers, those primarily interested in non-consumptive wildlife activities, want products from the fish and wildlife management system and agencies have been trying to satisfy this demand. We have been hampered by a lack of dedicated funding, i.e., funds to develop a new product line, and because of often competing and confusing presentations on what is needed to satisfy non-consumptive wildlife consumers.

Agencies also encounter resistance to including more non-consumptive activities from traditional constituents and some agency people. Some groups do not recognize the legitimacy of non-consumptive wildlife interests. Further, they believe that these new interests are intent on "taking over" fish and wildlife agencies, leading to the ultimate demise of traditional uses of wildlife.

Conclusion

In conclusion, efforts made to market wildlife to new constituents should be accompanied by assurances that new programs will add to, not replace, existing agency functions. The goal should be to broaden, not switch, markets for fish and wildlife consumers.

There is strong consumer demand to broaden fish and wildlife agency programs. Marketing provides a means of assessing and meeting some of the demand. Taking advantage of this demand makes good sense both in providing services to the public and in protecting agency structures and flexibility to conduct professional fish and wildlife management for sustainability. These changes can be made while maintaining agency stewardship responsibilities and professional ethics.

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Marketing? Welcome to the USA, Wildlifer!: A Success Story

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Introduction

Marketing is the process of determining what people want, then responding with products and services (Schick et al. 1976). Extensive market or "human dimensions" research has been conducted on traditional "consumptive" users of wildlife (Heeringa 1984). Volumes of human dimensions research also has been done on the general public (Pomerantz 1977, Kellert 1979, 1980, 1981, Youds 1988, U. S. Department of Interior 1987) and on specific portions of the public (Kellert 1983, 1984, 1987). Witter and Adams (in press) call for more of this work and agencies have hired marketing personnel and begun further studies.

The first phase of marketing has been carried out, but the second phase has been ignored and suppressed by management agencies for two decades. Few consumable "products" have been developed by agencies for markets other than traditional users. Even fewer new programs generate funds for wildlife management needs and still fewer are self-supporting.

Agency personnel have rationalized this inaction with concerns of lack of funds, time or defined demand, potential resource degradation, liabilities, or even concern that traditional wildlife uses would be diminished (Kruckenberg et al. 1992). The truth is, however, that traditional wildlife users and management professionals do not reflect the general public demographically or attitudinally (Peyton and Langenau 1985, Herringa 1984, Wyoming Game and Fish Department 1985). These two groups have had the strongest influence over wildlife policies since World War I (Herringa 1985), while they currently represent approximately 7 percent of the nation (U. S. Department of Interior 1992).

The agencies failure to supply desirable products to the general public has allowed an erosion of political and financial support for wildlife. Moreover, non-governmental organizations have begun to satisfy these new demands. This could potentially impact the resource, generating little financial support for management needs and little opportunity to incorporate "belief systems" into the products (Borhek and Curtis 1975).

Great Plains Wildlife Institute (GPWI) analyzed a range of human dimensions research in the late 1980s (Leopold 1966, Kellert 1979, 1980, 1981, 1982, 1987, Youds 1988, U. S. Department of Interior 1987, 1992, Wyoming Game and Fish Department 1985, 1986, 1987a, 1987b). Based on this information, GPWI created consumable products for non-traditional wildlife users. Simultaneously, GPWI analyzed the biological and ethical constraints which the products could create.

Next, GPWI analyzed market information about wildlife management agencies and rural communities that could be affected by the development of these products (Wyoming Game and Fish Department 1981, 1982, 1984, 1985, 1987b, 1988, 1990, U. S. Department of Interior 1986, 1988a, 1988b, U. S. Department of Agriculture 1988, Wyoming Chambers of Commerce personal communications: 1986). Lastly, market information was used to determine promotional and advertising techniques.

Products were created and promoted, and participation increased substantially considering the limited resources of GPWI. The case history of GPWI is proof of the demand, feasibility and public benefits of this type of product. GPWI programs are self-supporting and do not utilize any traditional wildlife funding. The programs enjoy steadily increasing participation by people who are not involved with traditional uses of wildlife. Useful inventory and monitoring data for management agencies are produced at no cost to the government. Finally, GPWI programs provide interpretive or educational services and even generate revenues for the agencies through user fees.

Great Plains Wildlife Institute Case History

Institute Description

Great Plains Wildlife Institute began in 1986 as a commercial business in Casper, Wyoming, and conducted field programs throughout Wyoming and lectures across the United States. GPWI moved to Jackson, Wyoming in 1989 and currently conducts programs in the Greater Yellowstone Ecosystem.

Fees charged to program participants pay all costs incurred. These include: salaries, field work, equipment, meals, lodging, permitting, project development, contract services, marketing, advertising, ''trophies,'' and future growth capital.

Institute Objectives

(1) Develop and implement wildlife programs that are valued by people who are not involved in the traditional use of wildlife, including serious birdwatching or photography.

(2) Develop new funding sources for wildlife research or inventory projects and employ wildlife biologists.

(3) Develop public involvement in wildlife research or inventories that address wildlife management needs.
   (a) Mitigate possible impacts of nonconsumptive human activity.
   (b) Direct participants to constructive activities and human behavior (stewardship).
   (c) Foster a sense of resource ownership within participants.
   (d) Augment management agency resources and provide wildlife data to aid decision-making efforts.

(4) Broaden the economic value of wildlife resources in Wyoming.

(5) Enhance the ability of participants to constructively interact with management agencies in the future.

(6) Implement the above objectives with minimal or mitigated impacts on wildlife and natural resources. Exemplify how non-consumptive use of wildlife should occur.

(7) Interpret the role, credentials and ethics of the wildlife management profession.

Institute Products and Product Development

GPWI offers one- and five-day ''wildlife expeditions'' referred to as products which are based on the market research cited in the introduction. Both products are available year-round in Wyoming and currently cost $150 and $1,635 to $1,858 per person, respectively.

Product 1. One-day ''expeditions'' are conducted from customized vehicles to provide an overview of the ecosystem by locating and identifying wildlife and interpreting each species' ecological role, wildlife issues and needs. Participants are taught how to innocuously interact with wildlife on their own. Wildlife habitat associations, energetics and ecology are experienced by observation, lecture and discussion. Binoculars and spotting scopes are provided for each participant plus animals are filmed with video equipment and 35–milimeter cameras with telephoto lenses for each participant. Meals are taken at restaurants and modern bathroom facilities are used. Participatory projects involving data collection are conducted each day (e.g., lek surveys, capture/recapture ground squirrel censuses, radio-tracking elk, monitoring bald eagle habitat use). GPWI activities and wildlife data are reported to the agencies.

Product 2. Five-day "expeditions" travel by customized vehicles, rafts, dog sleds, snowcoaches or horse-drawn sleighs to different wildlife, landscapes and accommodations each day, and involve a variety of research projects and guest lecturers. Participants are guided through close, personal encounters with wildlife and secondary subjects (i.e., geology). Binoculars and spotting scopes are provided for each participant plus animals are filmed with video equipment and 35–milimeter cameras with telephoto lenses for each participant. "Discovery" learning through hands-on experiences is featured and data collection is more involved than on the one-day trips (e.g., capture/recapture prairie dog censuses, banding golden eagles, documenting feral horse distribution). Accommodations and meals are taken at existing hotels, ranches and restaurants, and modern bathrooms are used.

Primary Elements of Products by Market Segment

GPWI products incorporate several "primary elements" that are valued by various market segments. Market segments include: the public which is not involved with traditional wildlife uses, wildlife agencies, the wildlife resource itself, the people of Wyoming, and the wildlife profession. The primary elements are discussed in their order of importance for each segment. They were derived from human dimensions research and incorporated into the products prior to their implementation.

Primary Elements for the Public

These elements are used to promote the products to the target public. They are viewed as benefits to that market.

Wildlife is the primary focus of our programs and there is a public demand to interact with the animals. Promotion methods use photos of large, familiar animals with high human associations. Photos of humans proximal to wildlife are not used for ethical reasons.

Comfortable hotels, ranches, restaurants and modern bathrooms are used. This is desired by our market and also reduces our liabilities and time constraints. No camping, horse-packing or backpacking is conducted and wilderness areas are not used, also reducing environmental degradation, time constraints and legal liabilities. Our product does not usually provide a "wilderness experience," but our market does not appear to hold that notion as a conscious goal. Participants often fear animals and being in the wild (Kellert 1981, 1987), yet they want to have a "relationship" with wildlife.

Education is a large product component involving observation, lectures and hands-on experiences. The social and teaching skills of the biologist/leader are critically important. All other primary elements will be negated if the biologist/leader is socially inept. Lessons are taught at a college level. GPWI biologists are required to have a masters degree in wildlife biology/ecology and work experience with local wildlife agencies is preferred. Guest experts are used whenever possible. Educational values are used to enhance the attractiveness of species or activities that have less appeal (e.g., ear-tagging rodents) (Kellert 1981).

Physically demanding activities are packaged as optional for the client. This is appealing to a larger market, plus, risks and liabilities also are reduced.

Diverse wildlife viewing is featured, with a range of wildlife projects, scenery, accommodations, meals, modes of transportation and secondary products (e.g., museums and geology). This is referred to as "packaging." Species viewing preference research was used to develop this aspect (Kellert 1987, Youds 1988).

Kellert (1981) and Gilligan (1982) documented some gender differences in regard to animals and personal inter-relations. These dimensions have been incorporated into GPWI products that forms of competition are not promoted. Instead, patience, caring and interpersonal responsibilities are fostered by the biologist/leader for all groups. Interpretation promotes use of these attributes to constructively relate to natural processes. Emphasis is placed on the responsibilities of maintaining functioning ecosystems.

The conservation of wildlife during this century has been a manifestation of the sense of ownership and stewardship possessed by traditional wildlife users (Herringa 1985). To foster a sense of ownership and personal identity in the wildlife resource for nontraditional users, GPWI products allow physically close interactions with animals through research projects that can be justified to the management agencies. Thus, each participant puts forth "effort" to contribute to the well-being of wildlife. *This is a crucial element that defines our products* and the benefits are not unknown (Leopold 1966).

"Trophies" or status symbols are bestowed upon participants to provide tangible measures of personal identity. These can increase the attractiveness of a product with lesser appeal (i.e., live-capturing rodents). Trophies may include personalized ear tags, video tapes, photographs, lists of observations or data collected, certificates, research reports that utilize data collected by the participants, meeting experts, newsletters, personalized field forms or legally unregulated animal parts (e.g., porcupine quills or coyote bones).

The last primary element for participants is termed "adventure." This is a minor element, but consists of the participant being involved in activities that are unfamiliar to them and often involves *perceived* risk. (e.g., driving unmapped or steep roads, observing a poisonous snake).

Primary Elements for the Agencies

Management agencies operate under mandates to manage wildlife resources and to sustainably allow the public to use these resources. To achieve these goals they require political and financial support. Their secondary needs are for information about the resources on which to base wise decisions.

Nonconsumptive products are under-developed (Youds 1988) but provide inherent public benefits. Facilitating this development concurs with federal agency mandates of "multiple use" and state mandates of "maximizing benefits to the public."

GPWI wildlife inventory and research projects are developed to match the needs and plans of the agencies. Research data are obtained at no cost to the agency, thus augmenting government funds, equipment and manpower.

GPWI teaches the public about management issues, agency roles, agency limitations and the natural processes that form a basis for agency actions. Public understanding through experience promotes political support for agency actions.

Agencies safeguard the wildlife resources by requiring reports to monitor and direct GPWI activities. Agencies collect user fees and review GPWI services, training, expertise and liabilities.

Primary Elements for the Resource

No new developments or facilities for human presence are required for GPWI products. Human activity is localized by using existing hotels, ranches, restaurants, roads and bathrooms. Wilderness areas are only viewed and additional camping facilities are not required. Some impacts of GPWI products can be mitigated by contributions to wildlife research, education or funding efforts. Resources can be degraded by nonconsumptive use but they are not removed from public ownership. The value of functioning natural systems and culturally maligned species (e.g., coyotes) are increased and some of the costs of maintaining wildlife are directly defrayed.

Primary Elements for the People of Wyoming

Wyomingites benefit from the economic returns of GPWI operations. This financial benefit helps defray the costs of maintaining healthy ecosystems and wildlife resources.

Nonresident participants also are exposed to local life-styles which can be affected by federal political or legal actions. Research information generated by GPWI assists agencies in making accurate management decisions which affect local people and communities. Little or no infrastructural improvements are required at this time to support this type of enterprise.

Primary Elements for the Wildlife Profession

GPWI products promote stewardship of natural resources through science. The ethics and educational requirements of the wildlife profession are presented with the complexity of biopolitical issues. Clients meet professionals and participate in their work and thus, experience the requirements of conducting wildlife research and management.

Funds for employing wildlife professionals are expanded. GPWI fosters professionalism in its employees by facilitating professional society memberships, professional relationships, attending symposiums, producing publications, even the creation of new wildlife organizations.

Institute Promotion

What did not work. GPWI promotion began in 1986 by advertising in national magazines, general promotion through the state government, plus lectures to outdoor oriented groups. The magazines ads were one-inch classified and one-sixth-page black and white picture ads. Publications were selected to target birdwatchers (*American Birds*), photographers (*Outdoor Photographer*), wildlife art enthusiasts (*Wildlife Art News*) and general scientific markets (*Natural History*). This approach matched the conclusions of Youds (1988). However, none of these avenues produced many participants. In retrospect, only the readership of *Natural History Magazine* matches our intended market, but the classified section was not well read by that market. The type of ad that was necessary to reach that intended readership was too expensive. The lecture series only generated more speaking engagements, not participants.

What did work. Promotion through private travel itinerary planners, chambers of commerce and concierges at hotels generated participants and publicity. This approach capitalizes on tourists already visiting an area. Publicity was directed at upscale travel publications such as *Conde Nast Traveler* and *Travel and Leisure* and the travel sections of national newspapers. These mechanisms, word of mouth and repeat clientele generate most of the participants.

This type of product often must be "piggy-backed" with generic promotion or promotion of large-scale attractions, such as a ski area or national park. The cost of introducing a new product, such as a "wildlife expedition," as a destination/event likely would require many hundreds of thousands of dollars, over many years, outstripping the estimates made by Youds (1988).

Results and Discussion

Funding, participation and employment. GPWI programs became self-supporting by their fifth year and generated enough revenues to allow growth since that time (Figures 1 and 2). Numbers of annual participants have increased exponentially and are expected to top 700 in 1993. GPWI participants are expected to gross over $160,000 in annual revenues in 1993. GPWI currently employs one full-time biologist, two seasonal biologists, one part-time, seasonal technician; and seasonal, full-time office personnel. No government funds have ever been used.

Demographics—gender. The most striking result is that females represent 56 percent of the participants. Participants fell into the following social groups: single males—6.2

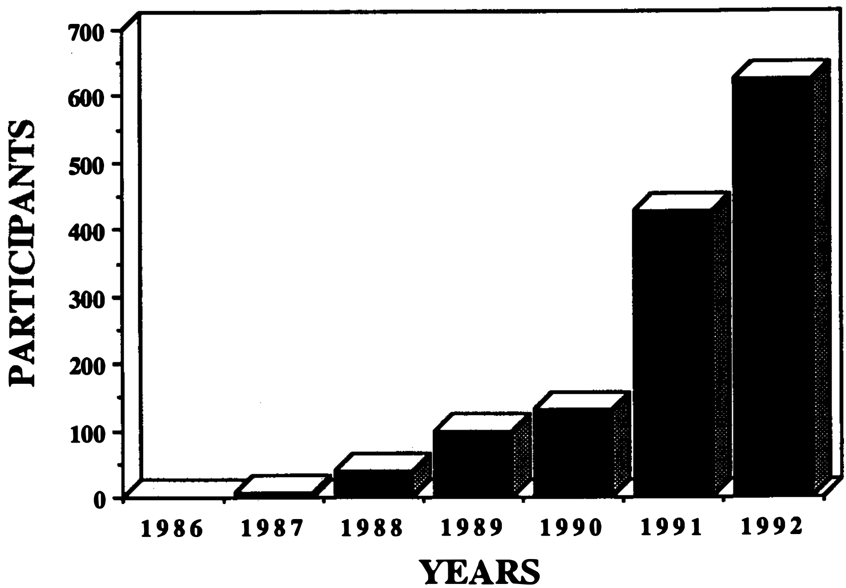

Figure 1. Numbers of annual participants in Great Plains Wildlife Institute programs from 1986–1992.

percent, single females—22.8 percent, families—26.5 percent,and couples —44.5 percent. Analysis of social groupings and client interviews indicate that the female component of these social groups is very important. Within the social groups of couples and families, the adult female participant is often the key person who selects our product and makes arrangements to participate.

Among couples, women are generally first attracted to the product and their partners later agree that they too would enjoy the product. Among families, women are attracted to the educational values for their children and often have a child with a high interest in animals. If the cost of expeditions were lower, the level of participation by families might be higher.

The high participation by "single females" is partly the result of female disinterest in more competitive, physically demanding activities in which their male partners are participating, such as fishing, snowmobiling or skiing.

Age. Over 42 percent of participants were between the ages of 40 and 60, and nearly another 12 percent were between ages 60 and 70. Younger individuals, particularly males, may not participate because GPWI products are not considered physically active or adventuresome enough.

Region of residency. A person's attitudes toward wildlife are strongly influenced by the region of the country in which that person was raised (Kellert 1981). Attitudes, in turn, affect the activities that people are likely to enjoy (Kellert 1980). GPWI participants

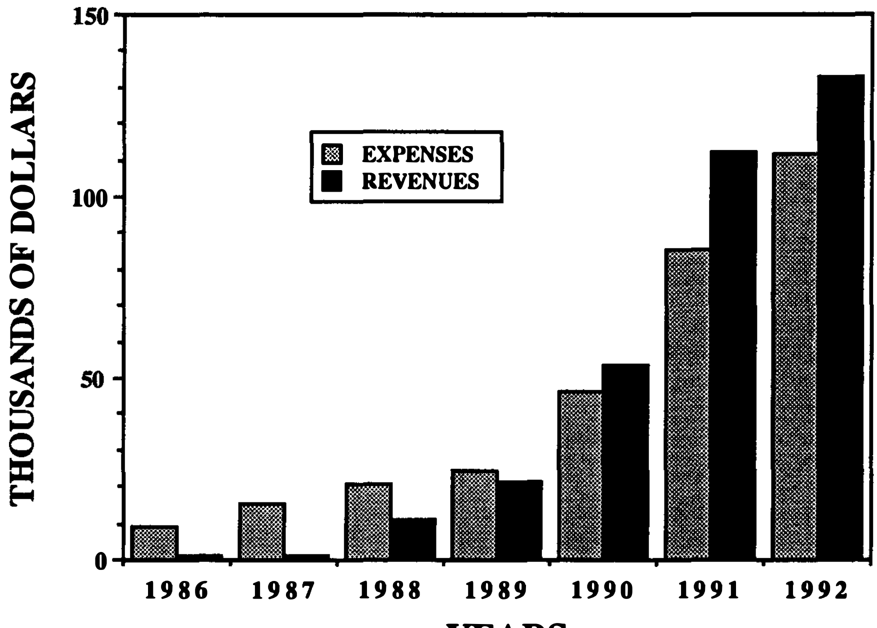

Figure 2. Great Plains Wildlife Institute expenses and revenues for 1986–1992.

are largely (36.6 percent) from the northeastern region of the United States. This could be a result of the general wildlife attitudes of that region as influenced by a high level of urbanization. The second most important region is the southeastern U. S. (21.5 percent). This is surprising because the prevalent attitudes of that region are similar to those of the Rocky Mountain region (higher on the utilitarian and dominionistic scale), which is a region dramatically absent from GPWI demographics. Some residents of the southeast in the 40–70 age range are originally from the northeast. The southwestern region's proportion of our participants (15.2 percent) largely is people from Texas who may share many attitudes similar to those of the southeastern U. S.

Cost. The price of GPWI programs probably influences the age of clients and social group participation rates. High price dictates that prospective clients must highly value the potential experiences that they expect to receive from a GPWI product. A post-participation survey of clients showed that 88.8 percent felt that the price of our product was equal to its value. The perceived value of our products may be strongly related to the participant's prior opportunities to be involved with wildlife in the region where they live.

Other factors. Participation seems positively correlated with a tendency to travel for the primary purpose of viewing wildlife in other parts of the world. An informal survey of clients showed that more than half had been to Africa or Alaska to view wildlife. Over 86 percent of participants who returned product evaluations stated that they would be interested in similar wildlife programs in other locations. Alaska, the Rocky Mountains and the southwestern U. S. were the most frequently mentioned locations of interest.

Wildlife Research and Inventories

Since 1986, GPWI participants have been involved in a wide range of wildlife projects. Some are hands-on, such as banding eagle chicks, and others simply involve observation and recording, such as sage grouse lek surveys. The projects that GPWI was involved with during 1991 are shown in Table 1. A significant amount of data has been collected

Table 1. GPWI projects and data collection efforts during 1991.

Description of project	Number of observations
Sage grouse lek census	5 lek counts
Sage grouse brood area use	17 observations
Marked trumpeter swan searches	126 observations
Heron rookery survey	3 surveys
Elk calf telemetry	165 relocation attempts
Opportunistic bear observations	10 observations (14 individuals)
Moose classifications	30 surveys, 508 observations
Bighorn sheep lambing area observations	18 observations
Small mammal inventory	363 trap nights, 145 captures
Pertinent incidental observations	25 observations
Prairie dog mark/remark survey	5 grid samples
Flea burrow samples	4 grid samples
Feral horse summer distribution	22 observations
Buffalo valley eagle/human activity surveys	19 surveys

for the agencies at no cost and very little administrative effort. Some agencies are paid user fees by GPWI to allow this work.

Most projects were suggested by GPWI to agency biologists after reading agency reports that listed informational needs or funding shortfalls, or during personal interviews with agency biologists.

The element of hands-on wildlife experiences represents an effort to be a steward of the resource and separates GPWI products from simple use of wildlife. The effort required to participate in GPWI products constitutes a contribution to the well-being of the resource. This feature may be among the most important of our product elements and can elicit strong feelings of ownership and commitment to the resource from participants. Based on follow-up surveys to clients, 83 percent of the participants felt that the research portion of their expedition was worthwhile.

Orchestrating these projects is very time and resource consuming. Management agencies themselves may be the best equipped entities to implement these projects. Changing wildlife markets dictate that professionals expand on the potential benefits of hands-on wildlife experiences to the general public.

Only the management agencies can objectively determine the benefits and potential impacts to the resource. Human activity proximal to wildlife through research is a closely guarded privilege of the agency professionals. The human trait of territorialism and the attitudes of wildlife professionals have severely limited these experiences for the public.

Current regulatory permitting for non-agency research of wildlife is extensive. It may not be reasonable for non-governmental entities to maneuver through the regulatory and ethical scrutiny of these processes. Equipment and promotional costs, along with permitting expenses, may make these experiences available only to the rich if left to the private sector. ''Partnerships'' between government and the private sector may be logical, but the wildlife resource is sensitive, commonly owned and highly valued. Ethical judgements regarding the origins of funding are inevitable and pervasive, thus the likelihood of constructive opportunities may be severely limited.

The public must come to know the joys of appropriate wildlife husbandry, nurturing and stewardship for the common good. Aldo Leopold (1966) believed that it is necessary for the agencies to become the source of this human enterprise. Texas Parks and Wildlife Department is beginning to tap this potential with their ''Passport'' program, which generated 2.1 million dollars in 1992 (Joel Seffel personal communications: 1993).

Summary

Few consumable wildlife products have been created or implemented based on decades of human dimensions research. Great Plains Wildlife Institute began in 1986 to create products in Wyoming for non-traditional wildlife users throughout the nation. The products provide a diversity of unique wildlife experiences; they are not physically strenuous; they do not involve camping, packing, wilderness areas or competition; and the products contain a large educational component. Participants become involved in hands-on wildlife research projects orchestrated by wildlife biologists which match agency objectives. All activities and data collected are reported to management agencies. A wide variety of wildlife projects have been completed.

Within five years, GPWI was self-supporting and currently employs one full-time and two seasonal biologists, as well as seasonal, full-time office staff. Promotional efforts that targeted birdwatchers, serious amateur photographers, wildlife art enthusiasts and scientific hobbyists were not productive. A combination of promotion with existing human attractions, such as skiing or national parks, travel planners and publicity in upscale general travel magazines and newspapers effectively generated participants.

The demographics of participants are skewed to females 30 to 70 years of age (56 percent). Couples were the most prevalent social group among participants, followed by families, single females and single males. Approximately 73 percent of the participants are residents of the northeastern, southeastern and southwestern regions of the U. S. Participants also tend to be well traveled. The product price, physical activity level, plus the availability of wildlife experiences where the participant lives, may influence the observed demographics.

The success of GPWI demonstrates the demand for wildlife experiences that appeal to non-traditional wildlife users. Similar programs can generate substantial revenues that will pay for their development and administration costs.

Due to the sensitivity of the resource and the common ownership of wildlife, the agencies should develop these products for the public (e.g., portions of the Texas Parks and Wildlife "Passport" program). Non-traditional wildlife users can become avid stewards of the resource through unique wildlife experiences. If the results of 25 years of human dimension research and now, the successful implementation of new products are ignored by the management agencies then they may fail to perpetuate the wildlife resource we know today.

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Becoming an Outdoors-woman: Concept and Marketing

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Introduction

Natural resource management agencies recently have increased emphasis on investigating the needs of their non-traditional clientele (Thorne et al. 1992). This undoubtedly has been motivated to some extent by a decline in the numbers of their traditional clients. The figures reported by the U. S. Fish and Wildlife Service's *National Survey of Hunting and Wildlife-associated Recreation* demonstrate a significant decline in the sale of hunting and fishing licenses between 1985 and 1991. Fishing license sales fell from 58.6 million to 34.8 million, while hunting license sales declined from 18.5 million to 14 million. While these figures may not be entirely due to changes in participation (the methodology changed between studies), other research has shown a drop in hunting participation from 16 percent in 1959 to 10 percent in 1989 (Gallup and Newport 1990) and some states have experienced a decline in fishing license sales. Based on these figures, some sociologists have predicted the end of hunting during the early decades of the next century (Heberlein 1992).

Women have not been a traditional clientele of resource management agencies. Their participation in hunting and angling has historically been at a rate much lower than their representation in the general population. While the overall number of hunters and anglers continues to decline, the number of women participating in these activities, though still small, continues to increase (Snepenger and Ditton 1985). The percentage of female hunters may have increased to nearly 10 percent of the hunting population (Stange 1992) (National Shooting Sports Foundation 1991), while women make up greater than 30 percent of anglers (U. S. Fish and Wildlife Service 1985).

While agencies have done little to encourage or facilitate participation of women in hunting and angling (Thomas 1990), this group of previously ignored agency clients may hold the key to the future of traditional wildlife-based recreation. Research has shown that unless an individual is introduced to hunting in childhood, he or she is unlikely to pursue the activity as an adult (O'Leary et al. 1987). It also has been determined that mothers play a dominant role in shaping the recreational choices of children (Howard and Madrigal 1990). With predictions regarding children born in 1989 indicating that 60 percent will be reared at some point in their first 18 years by a single parent (usually a woman) (Jackson 1990), it is clear that if hunting and fishing are to survive the next century, women will play an important role. Whether or not women choose to participate in these activities, it is important for them to understand resource management and environmental protection programs.

Identifying Barriers

In August 1990, the College of Natural Resources of the University of Wisconsin—Stevens Point, in conjunction with the Wisconsin Department of Natural Resources, hosted a workshop, "Breaking Down the Barriers to the Participation of Women in Angling and Hunting." The purpose was to identify barriers preventing women from participating and to identify strategies for breaking those barriers (Thomas and Peterson 1990).

The workshop was attended by 65 participants and speakers. The attendees represented a very broad base. There were hunters and anglers who came because of personal interest. The Wisconsin Coon Hunters Association, Badger Fly Fishers and the Wisconsin Wildlife Federation all were represented. In addition, the Wisconsin Hunter Education Association sent a number of their members. National representatives from both Safari Club International and the National Rifle Association attended. Personnel from the Iowa, Georgia and Virginia fish and wildlife management agencies attended. There were requests for proceedings from at least 20 other agencies.

One unexpected benefit was the very high interest on the part of the press. There were dozens of news stories about the workshop. There were radio reports, interviews and talk shows. The workshop itself was covered by television and public radio. University archives report that this may be one of the most widely written about events in the history of the University. This interest and publicity became important later as we sought to move forward on the workshop recommendations.

The workshop participants were divided into seven focus groups. We tried to have representation from balanced interests in each group. The groups identified 21 barriers to the participation of women in hunting and angling. Table 1 shows the identified barriers, as well as the number of groups which identified each barrier.

Many of these barriers are consistent with those identified by recreation researchers. Ewert (1988), for instance, found that women were significantly more fearful than men in facing outdoor recreational situations. Some of the fears were a direct result of lack of training, fear of low ability and fear of not fitting in. Theobald (1978) identified discrimination by agencies in public recreation programs. Shaw (1985) confirmed that women have significantly fewer weekend leisure hours to expend than do men.

While there is little that agencies and sports clubs can do about some of the barriers, 14 of the 21 barriers were directly or indirectly related to lack of educational opportunities for women. The focus groups recognized this and addressed it in the strategies they recommended. Those recommendations follow.

Strategies

1. Provide educational opportunities for women to learn outdoor skills in an environment that is not intimidating. This might involve classes that enroll mostly female students and might provide female instructors or male instructors who are supportive of women joining the sport. It also was suggested that courses be held in urban areas with consideration for choosing locations where women would feel safe in attending. A further suggestion was that provision of child care at these courses might encourage women to attend.
2. Promote hunting, angling and outdoor skills programs for *all* youth, boys and girls, through the elementary and secondary school programs, Scouts, 4-H, and other youth organizations.

3. Promote the image of the sportswoman through media coverage of female participants. There were numerous suggestions that outdoor writers be encouraged to write about the activities of women. It also was suggested that the national or state hunting and fishing interests find a positive female role who would be willing to act as a spokesperson for hunting and fishing.
4. Encourage clothing and equipment manufacturers to develop lines that are specifically designed for women. It also was suggested that a women's area within the sporting goods section of the discount department stores would be helpful and that perhaps pattern companies could be encouraged to introduce a line of patterns that is geared to the sportswoman.
5. Promote hunting and angling as family activities. This could be done through the media and could be encouraged by the agencies and sport clubs.
6. A number of groups suggested a "Take Mom Hunting/Fishing Day" that might be promoted through the agencies or the clubs.
7. Encourage the clubs to be more open to the participation of women.
8. Establish mentor programs that would pair up female hunters and anglers with hunters or anglers (male or female) who would be willing to share outdoor experiences.
9. Make information about where to hunt or fish readily available through an "800" number of through local chambers of commerce.
10. Work to improve the image of the sport by encouraging ethical behavior and by reducing the reliance on expensive, complicated equipment.
11. Promote demonstrations and seminars at sport shows that focus on or are conducted by women.

Table 1. Barriers to participation in hunting and angling.

Barrier	Number of responses
Image of sport as portrayed by anti-hunting movement	7
Expense or availability of suitable equipment	7
Social pressure from peers, significant others, family members, male hunters or outfitters who view hunting as a man's sport	6
Lack of female role models	5
Raised in non-hunting or angling family situation	5
Image of "slob" hunter or "Rambo" attitude is a "turn-off"	5
Lack of information	5
Increased urbanization of society	4
Lack of time	4
Seen as dangerous	4
Single parent families	4
Early childhood conditioning	3
Fear of looking stupid	3
Co-ed facility problems	3
Lack of place to go	3
Isolation of being only female	2
Tradition	2
Fear of guns	1
Attitude of agency personnel	1
Attitude toward game vs. packaged meat	1
Vanity	1

12. Promote the aspects of the sport that are not directly related to "killing."
13. Publicize images of fathers taking daughters hunting and fishing. Encourage printing of stories in sports publications that do the same.
14. Promote partnerships between organizations, agencies and sporting publications for the purpose of implementing these strategies.

Implementation of the Strategy

Three months after the workshop, representatives of the University of Wisconsin—Stevens Point's College of Natural Resources, the Wisconsin Department of Natural Resources and the Wisconsin Wildlife Federation met to plan a prototype outdoor skills clinic for women. The idea was to use the vehicle of a skills clinic to address some of the educational barriers, while using the publicity that such a clinic would generate to begin to lever social barriers and to generate interest by manufacturers and retailers in breaking the equipment and clothing barriers. The balance of this paper will examine the design of the program, the marketing strategy and results of implementation of three clinics, two in Wisconsin and one in Nebraska. Full details are available to the reader through the "Becoming an Outdoors-Woman" planning guide (Thomas et al. 1993).

Location

Two Wisconsin clinics were held at the Treehaven Field Station, located between Tomahawk and Rhinelander, Wisconsin. The Nebraska program was held at the State 4-H Camp near Halsey, Nebraska. These residential facilities met a number of criteria important to the program design:

- comfortable lodging for approximately 100 people;
- lodging for approximately 20 faculty;
- on-site food service;
- meeting space to accommodate the full group;
- classroom facilities;
- shooting ranges and fishing locations within 20 miles; and
- pleasant natural setting.

Remember, we were marketing a natural resource program to a non-traditional clientele. We wanted them to be comfortable and enthusiastic. Later, they may graduate to a primitive wilderness type experience after they have learned some basics in a comfortable setting. We didn't want to scare them away with the first experience.

Curriculum

We designed the curriculum to include one-third hunting and shooting related activities, one-third fishing-related activities and one-third non-consumptive activities that still could be related to the other categories (e.g., map and compass, and canoeing). The idea was to provide programming for the novice in a non-threatening atmosphere. Providing a broad range of choices also insured that we would have a higher level of enrollment, because the program would appeal to a broader market.

Sponsorship

We tried for a broad base of sponsors, spanning agencies, private organizations and industry. This broad base of support accomplished a number of objectives. It provided financial support to launch the program, a pool of instructors, lent creditability to the program, guaranteed a base of participants and created ownership and desire to succeed across a broad group of supporters.

Marketing

Fazio and Gilbert (1981) have suggested that resource management professionals consider the ''Five Ms of Marketing''—message, market, medium, money, and measurement.

Message

The message that we were trying to send in implementation of the ''Becoming an Outdoors-Woman'' program was actually a series of messages:

- Women can and do enjoy outdoor activities.
- There are a growing number of women participating in outdoor activities.
- Women should be considered a viable/important client base for agencies and manufacturers.
- The ''Becoming an Outdoors-Woman'' experience will be comfortable, rewarding and fun.
- The ''Becoming an Outdoors-Woman'' program will be a history-making event that women will want to be part of.

Market

At first glance, one might think the audience is obviously women. Again Fazio and Gilbert (1981) offer the wisdom of one of their seven principles of public relations: *The Public is many publics.* Rephrased, this might read: *The target market is many publics.*

Were we trying to market this to total novices or were we trying to obtain a broad range of experienced participants? Our primary audience was the novice, but we also felt it important to have veterans participate because they can provide role models, share knowledge and create an avenue for the novice to continue the activity beyond the workshop. The workshop's value to the veteran is an opportunity for her to link up with other interested women and the event status of the workshop validates her participation in an activity where she may have felt isolated.

Who actually signed up for the program? From a marketing standpoint, the bad news is that we can't pigeon-hole the participants for you. They ranged in age from 18 to 72. Some could not have attended without a scholarship, while others were very wealthy. They ranged in education level from high school diploma to multiple degrees. In Nebraska, approximately 4 percent racial minorities attended, while in Wisconsin the number was about 2 percent. There were urbanites, as well as farm women. They represented a range of careers and life styles.

Also, we were not only trying to market the program to potential participants, but also to the entire resource management community. Showing the success of this program to resource management agencies might sensitize them to a missed opportunity. Clothing and equipment manufacturers need to see that women are interested and able to buy their products. Clubs and organizations need to see that women are important to their futures. Dads and husbands need to realize that daughters and wives are potential field companions. In short, we were not only marketing a program to women, but a message to the resource management professional and all the sporting community.

The bad news is that the target market is not a homogeneous, easily defined public. The good news is that the methods described appear to work across the market.

Medium

How to get the message to the market is always a critical consideration. Agencies have told us that they have tried to do programming for women, but few or no women sign up. Where did they fail? We think in several areas. First, they probably believed they would; even wanted to fail, from the outset. No one likes change. The old clientele is a known quantity. They are comfortable to deal with. You have to have the *will* to succeed. We willed this program into existence. This took a massive amount of marketing effort to all our target publics.

Second, we believe that past efforts may have been too narrowly focused and not attractive enough. This program was conceptualized and marketed as an *event*. The participants gained much more than a skill. Participants had fun, they enjoyed camaraderie, believed they were part of a pioneering effort and generally came away with the same sort of feelings that one might have after an outdoor adventure with new and old friends.

What specific media did we use? We used a broad approach to build a mailing list. We put out an advance, one-page flier, that was circulated to various agencies, at sport shows, fairs, etc. These fliers had a tear-off piece that could be mailed in if the reader wished to receive registration information. We circulated about 2,000 of these for each event. We printed and distributed approximately 2,000 registration brochures for the Wisconsin clinics and 3,000 for the Nebraska clinic. The cost of printing and distribution was covered by the program revenue.

In addition, we worked the outdoor media. Press releases and personal letters were sent to outdoor writers. In Nebraska, a prominent outdoor writer was invited to our first planning meeting and asked to be an instructor. We sent fully written articles and black and white photos to 400 Nebraska news outlets. Particularly in Wisconsin, the articles that resulted from our efforts turned out to be very productive. When Jay Reed, prominent outdoor writer for the *Milwaukee Journal*, published an article about the program, the phone did not stop ringing for three days.

We did try paid advertising in Nebraska. This was expensive and not particularly successful. However, an advertisement caught the eye of the editor of the "Living" section in the *Omaha-World Herald*, who then wrote a front-page article about the project, complete with photographs. That story was a registration bonanza.

If Wisconsin is any example, the second time this program is run in any given state, there will be little need for publicity. We have over 1,000 people on our mailing list for this year. Last year, the program filled in just three weeks. While word of mouth quickly becomes the medium for this program, agencies will want to continue to generate publicity for projects like this one, because prospective participants are only one of the target markets that need to be reached.

Money

We have charged fees for this project that would pay the program expenses. With shrinking agency budgets, it is important to be able to demonstrate that this project will not be a cash-drain to existing programs. This is another important reason for developing a base of sponsorship. We look for facilities that will want to take the lead in this project in subsequent years. A facility needs to know that a project can make money and this one can. We have charged from $100 to $165 for registration fees. The higher fee did not slow registration at all. In fact, women have flown in for these programs from all parts of the country to participate. Women can afford to register for this program and will. We provide scholarships for those women for whom cost is a problem.

Measurement

In order to know whether you have been successful, you need to know what goals you started with. For this program we defined success in the following ways'' full enrollment; satisfied participants; positive feedback from instructors; and willingness of sponsors to continue the program.

We succeeded on nearly every count. We have turned away registrants from every program, due to full enrollment. The evaluations have been extremely high. Instructors feel very positive about the project. Several national sponsors including the National Shooting Sports Foundation, the National Rifle Association and Safari Club International have been willing to provide planning money to carry the program forward. This year, six states—Arkansas, Nebraska, Oregon, Texas, Washington and Wisconsin—will hold ''Becoming an Outdoors-Woman'' projects. We have been contacted by many other states and individuals in three other countries.

One area where we have not been successful is in attracting any fishing-related sponsorship. We have tried, but have been turned down, even though we have offered fishing programs that have been popular at each workshop. We assume that this is a function of two factors, hard economic times in the fishing industry and failure on the part of the fishing industry to view women as a potential market.

Conclusion

The ''Becoming an Outdoors-Woman'' program has been a successful example of marketing a natural resource program, for several reasons that agencies could apply to other situations:

1. We used a research base to identify a need.
2. We built coalitions and partnerships to create support, provide help and lend credibility to the project and foster ownership and willingness to succeed.
3. We provided a total, quality experience that included skill learning, a non-threatening atmosphere, a comfortable facility, a scenic natural environment and fun.
4. We worked with the outdoor media to publicize the project.
5. We believed in the project and willed it to succeed.
6. We asked participants for evaluation and feedback and incorporated many of their ideas in succeeding programs.

The world is changing. The challenges facing resource professionals in the coming decades will be enormous. If we are to maintain our programs in the face of shrinking budgets, we must recognize changes and rise to the challenge. Rising to the challenge may mean we will need to recognize the needs of a changing constituency. The ''Becoming an Outdoors-Woman'' project was conceived as a means to reach a non-traditional clientele. It succeeded because basic marketing principles were followed.

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Marketing through Interpretation: Matching Agency Goals with Constituent Desires

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Introduction

Effective natural resource management depends on funding, as well as public support for agency programs. Increasingly, resource managers must compete with a host of social and other environmental programs for limited dollars (Witter and Adams 1993). In addition, resource managers face increasing pressures from a public which questions traditional management activities such as hunting, trapping and timber harvest (Thorne et al. 1992).

Urbanization contributes to the challenges facing natural resource managers. Urban residents are more interested in aesthetic-oriented activities such as bird-watching, bird-feeding and hiking than they are in harvest-oriented activities such as hunting (Witter 1992). Urban residents participate less in hunting and fishing activities than their rural counterparts (Missouri Department of Conservation 1992a). Growing sentiments against hunting, trapping and timber harvest primarily are urban phenomena.

As agencies seek to broaden their base of support, they find themselves accountable to an increasingly diverse clientele. They must respond to the demands of aesthetic-oriented users who expect facilities and services such as nature centers, hiking trails, nature programs and other non-traditional activities (Thorne et al. 1992). At the same time, they must continue to respond to the interests of the harvest-oriented constituents on which most management agencies depend for support.

The Missouri Department of Conservation (MDC) uses market research to identify its clientele, their interests and demands. It has used the information to implement a system of conservation nature centers and related interpretive services which address some of those interests and demands within the agency's mandate.

Marketing through Interpretation

What is Interpretation and What Does It Have To Do with Forest, Fish and Wildlife Management?

Interpretation is a method of imparting information to an audience by *provoking* their attention or curiosity, *relating* the message to their everyday life and *revealing* the message through a unique viewpoint. While it contains information, interpretation also includes emotion, enthusiasm and revelation. In addition, interpretation strives to reach a strictly voluntary public with what very well may be a one-time-only message. To be successful, it must motivate the receiver to seek more knowledge on his or her own (Missouri Department of Conservation 1992b).

Interpretation can be a very effective communication tool for fish and wildlife agencies for several reasons. It brings the natural world to urban residents, many of whom now are several generations removed from the land. It increases public knowledge of the fish, forest and wildlife resources, thereby enhancing appreciation of those resources. It increases public knowledge of, commitment to and support for agency efforts to conserve those resources. And it offers a service to aesthetic-oriented constituents (Missouri Department of Conservation 1992b).

The Statewide Citizen Survey—Who Are Our Constituents and What Do They Want?

Background. In 1989 and 1990, MDC contracted with Fleishman-Hillard Research, Inc. of St. Louis to conduct a survey of Missourians' interests in conservation. Included in the survey were questions about nature centers and other interpretive services.

Selected results. Results from the survey produced five profiles of Missouri adults as they relate to the outdoors: nature enthusiasts, fishers and hunters, nature watchers, sports people, and the uninterested (Witter 1992).

Nature enthusiasts make up the largest group, consisting of about 28 percent of the population. These people may hunt and fish, but they probably would just as soon hike, jog, do nature photography or some other aesthetic-oriented activity.

Nature watchers make up 19 percent of the population. This group is similar to nature enthusiasts, but not quite as active. They enjoy wildlife around their homes and visit botanical gardens and zoos. They are less likely to camp, hike or canoe, however.

Fishers and hunters make up about 18 percent of the urban population and 33 percent of rural dwellers for a statewide average of 24 percent. They have a wide range of outdoor interests, but prefer fishing or hunting above all other interests.

Sports people enjoy jogging, walking, bicycling, and similar sports and exercise. They make up about 14 percent of the population. About 15 percent of both urban and rural populations are uninterested in the outdoors or wildlife-related recreation.

As might be expected, responses to nature center-related questions in the survey differed with each group.

Survey respondents were asked whether a need existed for more of each of the following opportunities or facilities within 20 minutes of their home: fishing, bird-watching, camping, hunting, picnicking, sightseeing, hiking and a nature center. A nature center was the top-ranking desire for the combined data set (Wallace and Witter 1991). Nature enthusiasts and nature watchers demanded nature centers above all other opportunities (78 and 62 percent respectively). While not their top choice, a majority of fishers and hunters (60 percent) and sports people (57 percent) identified a need for nature centers, as well. Even about one-fourth of the uninterested (26 percent) indicated a desire for a nature center.

Respondents also were presented with a list of 12 selected experiences and opportunities that might be provided at a nature center, and asked whether they would like to do each one. The three most popular opportunities for the combined data set were "see nature exhibits," "have nature information presented in entertaining ways" and "be alone and experience nature" (Wallace and Witter 1991).

A majority of fishers and hunters (80 percent) expressed interest in seeing nature exhibits, while two-thirds of that group were interested in having nature information presented in entertaining ways. Over a third of the uninterested group expressed interest in seeing nature exhibits (41 percent), and in having nature information presented in entertaining ways (38 percent).

Implications. According to the survey, nature centers appeal to a diverse audience. They appeal to aesthetic-oriented users as well as more traditional constituents. They even have some appeal for the 15 percent of adult Missourians who have little interest in the out-of-doors.

''Seeing nature exhibits'' and ''having nature information presented in entertaining ways,'' two of the three popular nature center offerings, provide opportunities to communicate information about conservation and resource management.

The MDC operates four nature centers, each offering interpretive exhibits, nature trails and a staff of trained interpreters that provide programs on a wide variety of topics. The exhibits are designed to be fun and inviting, while imparting basic knowledge about Missouri's forest, fish and wildlife resources and their management. For example, in St. Louis, exhibits interpret forest, fish and wildlife in the urban environment. One exhibit highlights wildlife that share buildings with people, while another shows how St. Louis was founded on the fur trade. Visitors can use an interactive computer to learn how the urban environment affects the growth and survival of trees.

In Blue Springs, exhibits focus on how conservation of forest, fish and wildlife resources can enhance urban residents' quality of life. Visitors learn some ways wildlife depend on forests, and why forests, like lawns, need to be managed. A new exhibit will allow visitors to discover how urban development can affect streams, and learn some ways to lessen the negative impacts.

Visitors to the Springfield Conservation Nature Center learn about glade, prairie and forest ecosystems in southwest Missouri. In Jefferson City, the exhibits focus on the habitats found throughout the state, and how the MDC manages those habitats for the benefit of all Missourians. Among the many exhibits is one that gives visitors an opportunity to help wildlife biologists trap wild turkeys (via video).

In addition to the nature centers, the MDC has recently installed interpretive exhibits at two service center offices. These offer office visitors an opportunity to learn more about local forest, fish and wildlife resources, and MDC efforts to manage those resources.

In addition to interactive exhibits, nature centers provide opportunities to ''provide nature information in entertaining ways.'' Naturalist staff at MDC nature centers and other facilities present a wide variety of programs to organized groups and the general public from preschool through senior citizens. Program topics reflect the diversity of our clientele ranging from programs on attracting purple martins to edible wild mushrooms to fly fishing. Programs are designed to be enjoyable as well as educational. Approximately one-fourth of the visitors to each facility attend naturalist programs.

At each facility, we find we often must start with the basics: what is a forest; what is a prairie; why aren't bats dangerous; why do birds go south for the winter and what does clearing rain forests have to do with us; what is wildlife diversity and why is it important? Our purpose in providing programs is not to recruit new hunters and anglers, but rather to educate our constituents so they can make informed decisions about conservation.

Nature Center Visitor-use Surveys—We Built It, and They're Coming, but So What?

Background. The MDC opened it's first nature center in 1982 in Blue Springs, near Kansas City, followed by centers in Springfield (1988) and St. Louis (1991). A fourth center is under construction in the state's capital and scheduled to open in July 1993.

The nature centers are popular. Visitation to the Kansas City and Springfield centers averages approximately 100,000 visitors per year each. The St. Louis facility hosted 232,000 visitors in its first full year of operation. Many visitors come on a regular basis to walk trails, attend programs and view exhibits.

In 1991, the MDC conducted visitor-use studies at the Springfield and Burr Oak Woods Conservation Nature Centers. Survey forms were sent to newsletter recipients, distributed in each nature center building and given to visitors using the trails. Respondents were asked to answer questions based on their most recent visit to the nature center.

Selected results. Responses are given here for the Springfield Conservation Nature Center survey. Responses to the Burr Oak Woods survey were very similar.

Respondents to the survey varied. Sixty-two percent of respondents were female. About half of all respondents fell between the ages of 25 and 44, though more than one-fourth (27 percent) were over age 55. About half (54 percent) were married with children, with half of those children (48 percent) living at home. About two-thirds of the respondents (65 percent) live in an urban or suburban area. They tended to be well-educated, with nearly three-fourths (72 percent) having at least some college education. Most respondents (78 percent) came in family groups, and had visited the nature center two or more times during the previous year (79 percent). Though no fees are charged, respondents indicated a willingness to pay an average of $1.74 per visit.

Most of the respondents (83 percent) spent from 30 minutes to two hours at the nature center and indicated they learned at least a fair amount (79 percent) during their visit. Nearly all (93 percent) described their visit as very enjoyable.

Exhibits were very important to most visitors (82 percent) and at least somewhat important to almost all visitors (93 percent). Most respondents (82 percent) found adult programs were at least somewhat important, as were children's programs (70 percent). Two-thirds of respondents (65 percent) indicated trails "absolutely must be there." Trails were considered at least somewhat important by most respondents (96 percent).

Respondents were asked what types of naturalist-led programs they would like to see offered at the nature center. Programs on "non-consumptive" topics were popular with most respondents: bird-watching (requested by 82 percent), gardening to attract wildlife (77 percent), wildflower gardens (84 percent) and nature photography (77 percent). In addition, interest was high in learning more about prairies, forests, wetlands and other habitats (82 percent), as well as how to create a backyard pond or manage for wildlife (79 percent). Programs on how to fish, hunt or trap were considered at least somewhat important to nearly two-thirds (60 percent) of respondents. Male and female interests varied only slightly for most topics (Table 1).

Implications. Results of the visitor-use surveys confirm that exhibits, naturalist-led programs and opportunities to experience nature, such as trails, are important to nature center visitors.

Results also indicate visitors enjoy themselves, come often and feel as though they are learning. When given an opportunity to explain why they visit the nature center, visitors repeatedly responded with phrases such as ". . . nice to touch nature in the city," "it's educational and fun," and "to enjoy and learn about nature."

In providing exhibits and nature programming at the conservation nature centers, we are meeting expressed desires. At the same time, because many visitors come to the nature centers on a regular basis, opportunities exist to foster a greater understanding of and appreciation for the resources we manage.

For example, the St. Louis nature center offers a series of programs for children ages nine and ten titled "Mysteries and More." Four topics are presented each year, and each is offered three times. Each topic revolves around a basic principle that we feel it is important for urban audiences to understand, such as predator/prey relationships, camouflage, migration and adaptations. Each session builds on information presented at the previous ones. In addition to teaching ecological concepts, sessions include team-building activities and challenges that build self esteem. At the end of the year, participants have had in-depth exposure to four important concepts.

Similar programs are available at the other nature centers and for other age groups as well. The St. Louis nature center's Golden Club provides monthly programs for adults only, and many of the participants come each month (Glenda Abney, nature center manager, personal communication). In Jefferson City, a Conservation Kids Club will offer monthly activities for children ages 6 to 12.

We might have expected a large interest in "non-consumptive" program topics such as bird-watching, wildflower gardening and nature photography. However, the high percentage of respondents interested in programs on how to hunt, fish and trap or manage for wildlife indicate additional opportunities for nature center programming. We assume these types of programs appeal to fishers and hunters whom we hope to draw to the nature centers. However, they also may have a wider appeal as indicated by the percentage of female respondents interested in that type of programming.

Nature centers offer opportunities to teach "traditional" hunting and fishing skills to a "non-traditional" audience. For example, the Springfield Conservation Nature Center recently offered an adult program on fly fishing for beginners. Response was overwhelming. Most participants had never tried fly fishing, and about half of the participants were women. Nature center staff received a lot of positive feedback from the program and several participants mentioned they would like to see a similar program just for women. Another adult program on map and compass skills drew about 80 percent female participation (Dave Catlin, Nature Center Manager, personal communication).

Interest in programs about prairies, forest, wetlands, and other ecosystems indicates visitors are interested in learning more about the natural world and offers opportunities to provide information about agency efforts to conserve those resources.

Who's Not Coming and Why Not?

Background. In spite of their popularity and effectiveness, nature centers are not reaching some segments of the population. Of particular note is the lack of involvement from

Table 1. Male and female interest in nature center program topics.

Topic	Percentage of respondents[a] Male	Female
How to fish, hunt or trap	69	56
How-to-projects (create pond, etc.)	80	78
Bird watching	80	83
Gardening for butterflies or birds	74	80
Wildflower gardens	82	85
Nature photography	81	78
Prairies, forests, wetlands, etc.	84	81

[a]Percentage of all male respondents.
[b]Percentage of all female respondents.

racial and ethnic minorities. Of respondents to the Springfield Conservation Nature Center survey, only 1.8 percent were people of color. The statewide citizen survey received a low response rate from blacks (Missouri Department of Conservation 1990).

The MDC contracted with Fleishman-Hillard Research to conduct small group research to explore the reasons for limited black participation in nature oriented activities (Wallace and Witter 1991, Thorne et al. 1992). Two focus groups of 14 black adults each were interviewed for two hours to gain insights into their recreational pursuits in general and outdoor recreation in particular.

Selected results. The focus group participants had less interest in nature-oriented recreation than in community- or group-oriented activities such as league sports, family picnicking or social clubs. Participants' lack of participation in outdoors recreation was explained by three fears. First was a fear of racial intimidation. Several participants indicated reluctance of "going where we're not in the majority." A related fear was of random violence. Security was an important issue for participants who preferred areas that were well-lighted and where authorities kept track of who went in and out. Third was a fear of the outdoors, and what they felt likely to encounter there. They expressed misconceptions about dangers in the outdoors and found little comfort in the idea of "being alone with nature" (Missouri Department of Conservation 1990).

Implications. Nature Centers would seem to offer the safe, family-oriented setting focus groups indicated they would prefer for outdoor recreation. They offer an outdoor setting in or near the city where visitors can learn about the unknown from indoor exhibits, and can walk paved trails that are clearly mapped, signed and regularly patrolled by staff.

Cultural historians warn that people of color may not perceive nature as whites do, and resource managers should not make assumptions concerning their recreational interests (Meeker et al. 1973). Focus group participants indicated, however, that nature centers had much to offer and expressed interest in visiting them. However, they indicated they would not come unless they felt invited and welcome, and knew it was a safe place for a family outing (Wallace and Witter 1991).

The MDC is making a special effort to invite black visitors to nature centers, as well as recruiting interpretive staff and volunteers that reflect the racial and ethnic diversity of the people they serve. In addition, the MDC's Interpretive Master Plan contains objectives to work with inner-city community leaders to identify ways to interpret forest, fish and wildlife resources in the city that meet the needs of both residents and the agencies (Missouri Department of Conservation 1992b).

Are Nature Centers Worth the Cost?

Nature centers are not inexpensive to build and operate. Typical construction costs for an MDC nature center range from $2 million to $4 million, with annual operating costs (including salaries) from $240,000 to $370,000 for each, and no entrance fees are charged. Operation of four nature centers accounted for nearly 2 percent of the agency's FY93 operating budget.

However, results from the public-use surveys indicate visitors value nature center services and would be willing to pay for them. Burr Oak Woods Conservation Nature Center near Kansas City has an annual benefit/cost ratio of 1.7:1 (Thorne et al. 1992).

The Missouri Department of Conservation has been actively engaged in interpretation since 1938, and interpretation will continue to play an important role in the agency. A recently approved Interpretive Master Plan provides direction for the program, setting priorities for development of new facilities and programs as well as guiding operation of existing efforts. Information from the statewide citizen survey was used in preparing the plan, which calls for additional surveys to monitor program effectiveness.

Conclusion

What Does It All Mean for Forests, Fish and Wildlife?

Market research in Missouri has shown a high public demand for nature centers and other interpretive services. The MDC has found that nature centers provide services to traditional as well as non-traditional audiences. They serve to draw visitors who might not otherwise have contact with department programs and services. This offers opportunities to foster greater understanding and acceptance of management resource practices among non-traditional constituents in ways that are enjoyable to them.

Nature centers offer opportunities to build new, less-traditional constituencies without alienating hunters and anglers who have long supported wildlife conservation. They are an effective tool to help fish and wildlife agencies make the transition to serving a broader constituent base.

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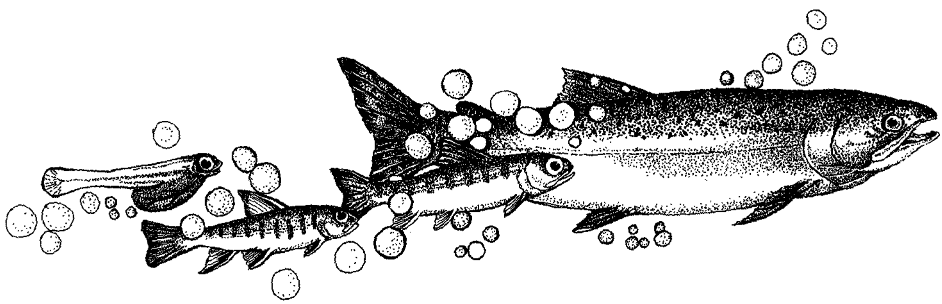

Special Session 4. *Strategies for Improving Fish and Wildlife Agency Effectiveness*

Chair
CALVIN W. DuBROCK
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Cochair
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Sharing Success: The Rationale for Management Effectiveness Research

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In the 1980s, the world discovered management effectiveness. Every respectable executive and bureaucrat scurried to: manage in a minute; search for excellence; master change; get to yes; and, along the way, mega a trend or two. A windfall to the publishing and seminar industries, management effectiveness also was a boon to the giant corporation. As those corporations swelled into bureaucracies larger and more complex than most non-industrialized nations, they had lost much of the know-how that made them great. They needed help, and management effectiveness was the prescription.

Management effectiveness is a modern offshoot of the discipline called management science—the understanding and improvement of complex organizational structure and function. A new discipline, born about the same time as fisheries and wildlife, management science has evolved repeatedly (Bozeman 1978). It emerged from political science as turn-of-the-century reformers pursued the separation of politics and public administration. It flourished temporarily as behavioral science under the tutelage of Frederick Taylor, who analyzed organizations like mechanical systems, searching for predictable responses to external stimuli. Today's approach is more individualistic, viewing organizations as unique products of their mandates, personnel, environment and prevailing culture.

Whatever the orientation, management effectiveness usually has studied large organizations. The modern corporation is the preferred client, willing to invest in analysis and experimentation; the continual—and continually changing—series of books, seminars and videotapes by Tom Peters and his colleagues typify the genre. All of the "successful companies" examined *In Search of Excellence* (Peters and Waterman 1982), for example, were Fortune 500 companies.

Public agencies also get their share of attention. Public effectiveness, however, emphasizes specific programs rather than whole agencies, generally under the rubric of policy analysis. Analysts have focused on large agencies with broad social responsibility—primary and secondary education, public health, national defense, crime prevention, and, to a limited extent, pollution control.

The Neglected Fish and Wildlife Agency

Amidst this frenzy of management studies, the fish and wildlife agency has been conspicuously ignored. And, even though general guides to management effectiveness abound, many of their ideas seem ill-suited to fish and wildlife agencies. Several conditions keep our agencies out of the spotlight, either as subjects or beneficiaries of management effectiveness.

Although fisheries and wildlife agencies are large and important to us, they are midgets relative to the organizations generally studied. The average state fish and wildlife agency spends about $32 million annually; the largest spends less than $120 million (Wildlife Conservation Fund of America 1992). Head-Start, a federally funded preschool program for disadvantaged children (and the subject of much management-effectiveness research), spends $3 billion annually; the cost overruns for one Department of Defense project may equal an entire state fisheries and wildlife budget.

Analysts study large organizations because their extensive differentiation and replication displays patterns and trends. Experiments implemented in one branch or division can be compared to outcomes in other branches. Large organizations can afford management studies, and they need to display their good work to leaders—public or private. Fish and wildlife agencies, small, poor and undifferentiated, have little to offer professional consultants, either for research or income. We seldom perform evaluative studies—and when we do, they cover technical subjects like stocking efficacy rather than administrative ones like employee morale.

In addition, the lessons from corporate studies may not fit fish and wildlife agencies. Corporations usually can narrow their goals to a few variations of "maximize profits." They know their clients, their decision-making authority is focused and instantaneous, and resource availability doesn't limit decision implementation. Corporate analysts, therefore, can prescribe sweeping reorganization, addition and deletion of products and services, or organization-wide training—and expect to see it done.

If only fish and wildlife agencies were so fortunate. Our agencies accurately have been described as "organized anarchies"—institutions with multiple goals and objectives, diverse client groups affecting isolated parts of the organization, and loose connections between inputs and outputs (Cameron 1980). Such institutions can't agree on evaluation criteria; agreement on generic prescriptive solutions for improving effectiveness is dreaming. Furthermore, a diffuse and laborious decision-making environment limits autonomy and restricts resources on all sides.

For example, a retired state agency biologist once told me that his supervisor ordered him to attend an effectiveness training course. The instructor lectured that professional effectiveness required three things—a private office, a personal secretary and a phone that didn't ring through directly. Back at work, the biologist asked his supervisor for a private office and a personal secretary to screen his calls. So ended that search for excellence.

Although such advice from the corporate sector may give some good general direction (especially if it is realistically translated), it often leaves us unfulfilled. It stops where it needs to begin—by providing clues for fish and wildlife agency effectiveness that are meaningful and acceptable to agency leaders. The study conveyed in this session was designed to do just that.

Sharing Agency Success Stories

Better agency management has been on the fish and wildlife "to do" list for decades (Nielsen and McMullin 1992). It stimulated the U. S. Fish and Wildlife Service's (USFWS) comprehensive planning program for Federal Aid projects in the early 1970s, leading to Doug Crowe's (1983) ubiquitous text on the subject. It stimulated the formation of the Organization of Wildlife Planners (OWP), now a thriving group of state and federal agency professionals dedicated to "stealing the best ideas whenever and wherever they can."

OWP members recently turned the planning process inward, looking at their own efforts. Twenty years of trying had established strategic planning as a standard management tool, but the fourth question in strategic planning—"Did we make it?"—was left unanswered about strategic planning itself. Was strategic planning producing better agencies or was it just producing paper?

The answer required knowing what really determined agency effectiveness and how some agencies were achieving it. Thus was born the Management Effectiveness Study, a joint project of the U. S. Fish and Wildlife Service's Management Assistance Team (led by Spencer Amend), the Organization of Wildlife Planners and the Virginia Tech Department of Fisheries and Wildlife Sciences.

The study's goals can be couched in management-effectiveness jargon, but they translate to this: *Share the stories of successful agencies.* Because people learn best from their peers and because experience proves applicability, we sought to learn what agency leaders believed important and how they acted on those beliefs. And because good news is always better than bad, we looked for the best in the business.

The project had two major phases. The first phase identified the elements of fish and wildlife agency effectiveness. The primary and universal answer, of course, is that the excellent agency protects and enhances the natural resources under its care. We focused one step below that goal, however, asking what characteristics of agencies allow good stewardship to prosper.

We asked that question in different ways to several groups of experienced agency observers. We facilitated brain-storming sessions with regional groups of agency directors in the West and Midwest, with USFWS Federal Aid regional supervisors, and with OWP members. We also asked agency directors from the Northeast and Southeast, fisheries chiefs nationwide, and northeastern wildlife and information/education chiefs for their input on forms we provided. The discussions and written input produced an expansive list of effectiveness factors.

These analyses produced a list of 22 effectiveness factors in six major areas—public support and awareness; conflict resolution; political skill; planning and funding; agency management; and personnel factors. As reported at the 1991 North American Wildlife and Natural Resources Conference (McMullin et al. 1991), these 22 factors provided the framework for the next project phase.

Finding Success Stories

The project's second phase was an intensive examination of selected state agencies to find common approaches and specific success stories. To select case-study agencies, we asked five groups to identify excellent agencies in each of the six effectiveness categories. The groups included staff of the Wildlife Management Institute and the International Association of Fish and Wildlife Agencies, USFWS Federal Aid regional supervisors, state agency directors, and the OWP project advisory team.

We compiled a list of agencies identified by three or more of the groups as excellent performers in each category. Agencies named in at least five of the six categories were considered for comprehensive case studies. Agencies named in two to four categories were considered for categorical case studies. Eventually, five agencies (Florida, Idaho, Missouri, Wisconsin and Wyoming) served as comprehensive case studies and four (Arizona, Minnesota, New York and South Carolina) served as categorical case studies. The Virginia Department of Game and Inland Fisheries also participated in a case study pretest.

Each comprehensive case study involved two site visits by a team of four to five professionals. Teams always included Steve McMullin, the principal investigator, and usually included Spencer Amend, the project director. Other team members changed for each visit, drawn from the OWP membership, and state and federal agency volunteers.

The first visit lasted five days, during which the team members interviewed 60–75 people, including agency staff at all levels, commissioners, legislators and public clients. All agency interviewees completed a 91-question opinion poll developed specifically for this study and a commercial instrument designed to assess organizational culture. The second, shorter visit followed 8–10 months after the first; team members investigated further the interesting topics reported in the first visit.

A categorical case study was similar to the first visit for a comprehensive case study. However, both interviews and written responses covered only those categories for which the agencies were particularly recognized.

If ever there was a team project, this was it. An advisory team of OWP members helped design the project in all stages. Forty people participated on case study teams, spending up to a week on a site visit. Agency liaisons organized the visits and assured a positive response. More than 800 people gave personal interviews for an hour or more; in total, they answered more than 100,000 written and oral questions.

But no interviews would have been held, no questions asked, if not for the enormous good will and interest of agency leaders and professionals. Studies like this depend on candidness, patience and community spirit. The success stories that this session highlights are indicative of the people who produced them—people who are eager to learn and share. We thank each of you for your help.

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Characteristics and Strategies of Effective State Fish and Wildlife Agencies

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In his opening remarks to the 50th North American Wildlife and Natural Resources Conference, Daniel Poole stated, ''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'' (Poole 1985). In this paper, I report on recently completed research that demonstrates the wildlife profession, or at least some of the state agencies in which it is practiced, has made substantial headway in dealing with social, political and organizational problems.

If the titles appearing on the *New York Times* best-sellers list are used as a trend indicator, Americans have become increasingly interested in personal and organizational improvement. Thirty years ago this week, no books of the improvement genre appeared on the list, although one book of significant interest to the wildlife profession was listed—Rachel Carson's *Silent Spring*. Twenty years ago this week, interest in personal improvement was evidenced by titles such as *Dr. Atkins Diet Revolution* and *I'm OK—You're OK*. Ten years ago this week, the trend was clearly evident in a list headed by *Megatrends, In Search of Excellence, Jane Fonda's Workout Book* and *The One Minute Manager*.

Wildlife professionals also were beginning to pay attention to principles of management (in general, rather than of natural resources) during the late 1970s. The Organization of Wildlife Planners (OWP) was founded in 1979 to promote the management-by-objective approach to management of wildlife resources. The OWP has evolved to be the leading advocate of effective agency management in the profession.

Peters and Waterman's (1982) *In Search of Excellence*, subtitled ''Lessons from America's best-run companies'' was a landmark book due to its popularity and impact on management literature. They distilled their findings down to eight basic principles they generalized as applicable to excellence in management. Their case study approach was rich in examples illustrating their eight principles. Responses to Peters and Waterman's conclusions were numerous in the literature and ranged from complete acceptance (Sipel 1984, Barbour 1984) to skepticism (Anonymous 1985) to outright rejection (Golembiewski and Kiepper 1988).

The Management Effectiveness Project reported here has been called the ''In search of excellence for fish and wildlife agencies.'' The comparison is appropriate because of the similarity in research approaches. The Management Effectiveness Project could easily be subtitled, ''Lessons from some of America's best-run fish and wildlife agencies.'' We conducted in-depth case studies of nine state fish and wildlife agencies widely recognized by their peers as effective performers relative to a set of 21 effectiveness criteria (McMullin et al. 1991). Like Peters and Waterman, we could distill our findings down to eight basic principles of management effectiveness and our data were rich in examples.

Peters and Waterman's eight principles were as follows:

1. A bias for action—identifying problems and developing answers quickly;
2. Staying close to the customer—listening intently and regularly to customers to provide quality, service and reliability;
3. Autonomy and entrepreneurship—emphasizing innovation and practical risk taking throughout the organization;
4. Productivity through people—creating awareness in all employees that they are the source of quality and organizational success;
5. Hands-on, value driven—key executives behave consistently with well-defined company values;
6. Stick to the knitting—engaging in and staying close to the businesses the companies know how to run;
7. Simple form, lean staff—simple structural form with few administrative layers and relatively small administrative staffs, and;
8. Simultaneous loose/tight properties—fostering a climate where employees are dedicated to the company's central values while allowing them much autonomy in implementing programs.

Peters and Waterman's principles were derived from observations of private corporations but nevertheless, most were directly applicable to the public sector. The major difference between the private and public sectors is the larger role of politics in public sector organizations. Our case studies of effective state fish and wildlife agencies revealed many common threads that I present here as principles of management effectiveness analogous to Peters and Waterman's principles. Table 1 presents a side-by-side comparison of Peters and Waterman's excellence principles and the management effectiveness principles generated in this study.

First, effective agencies are forward-looking and proactive in dealing with issues. They are constantly looking ahead, trying to anticipate issues. Their field staffs are the eyes and ears of the agency, but they also actively track social and political trends that may affect them. Open and honest communication between field staff and headquarters personnel facilitates agency responses to issues. Effective agencies are regional and national leaders in dealing with the major issues that face all fish and wildlife agencies, usually being among the first and most active agencies to address the issue. Their horizons extend far beyond their own state borders.

Second, effective agencies stay close to their constituents. They have developed a marketing orientation to wildlife management, using a variety of means to listen to their constituents to better understand their desires and develop programs that address them. Effective agencies also emphasize public input into decision making processes. Agency personnel are accessible and responsive to constituents. Effective information and education programs increase the effectiveness of agency constituents. While effective agencies don't hesitate to advocate programs, their openness to public input can be characterized by the attitude of one manager who told us, "We can manage fish and wildlife resources in any way that is biologically possible, sociologically desirable and economically feasible."

Third, effective agencies grant their employees much autonomy, empowering them to make decisions and try new ideas without fear of punishment when they fail. The agencies may not even be all that good at specifically encouraging creativity and innovation. However, they give employees wide latitude to do their jobs their way.

Fourth, effective agencies recognize their employees as a valuable resource. They are committed to the personal development and well-being of their employees. Effective agencies encourage employees to improve their skills through continuing education and training. They resist the temptation to reduce training opportunities at the first sign of budgets getting tight.

Fifth, effective agencies and their employees share a common mission—to manage wildlife for wildlife's sake and for the enjoyment of the citizens they serve. The high congruence of agency and personal missions results in a missionary-like zeal of employees for their work. Employees of effective agencies are widely recognized as the

Table 1. A comparison of Peters and Waterman's (1982) eight principles of excellence and the general principles of management effectiveness described in this study.

Peters and Waterman excellence criteria	Effectiveness critera for wildlife agencies
1. A bias for action—companies identify problems, develop solutions and implement them quickly.	1. Proactive action on issues—agencies are constantly looking ahead to anticipate issues, are regional and national leaders in dealing with wildlife issues.
2. Close to the customer—companies listen intently and regularly to their customers to provide quality, service and reliability.	2. Closeness to citizens—agencies use a variety of public involvement and marketing techniques to listen to public, understand their desires and involve them in making decisions. Agency personnel are accessible, open to input and responsive.
3. Autonomy and entrepreneurship—innovation and practical risk taking common at all levels. Big problems solved by "chunking," breaking company up into smaller pieces to encourage independent and competitive thinking.	3. Autonomy and empowerment—agencies empower employees to make decisions and try new ideas without fear of punishment for failures. Employees have wide latitude to do their jobs their way. Big problems addressed by teams representing a cross-section of the agency.
4. Productivity through people—companies treat employees as the source of all quality and productivity gains. Employees share in company's success.	4. Valued employees—employees are the agency's most valued resource. Agency committed to personal development of employees.
5. Hands-on, value driven—the company's basic philosophy is well defined and key executives behave consistently with company values.	5. Missionary zeal—agency and employee personal missions are highly congruent. Agencies are good planners with well defined missions, goals and objectives.
6. Stick to the knitting—companies stay close to the businesses they know best.	6. Biological base—agency credibility based on balancing biology and public opinion but bottom line of keeping the resource first is always maintained.
7. Simple form, lean staff—company has a relatively simple structure and small administrative staff.	7. Stable, respected, enlightened leadership—agencies are led by experienced wildlife professionals with good management skills. Decentralized structure and participative decision making, delegation of authority but leaders decisive when it is needed.
8. Simultaneous loose/tight properties—companies have centralist tendencies on core values but emphasize tolerance for individuality and autonomy.	8. Political/nonpolitical—agencies have strong public support and are effective in mobilizing it when needed to support or oppose policies. Open, equitable decision-making processes responsive to public. Biological basis for decisions contributes to nonpolitical image.

most dedicated, hardest working employees of state government. In addition, the agencies are good planners. Their missions, goals and objectives are well defined. Employees and constituents play a major role in developing agency goals and objectives.

Sixth, effective agencies maintain a solid, biological base. Their publics have complete faith that the agencies will always maintain a bottom line of putting the resource first. However, they never forget that agency credibility with the public and politicians is based on balancing biology and public opinion. They accommodate public opinion whenever they can and they recognize when resource allocation decisions should be driven by biological concerns or sociological concerns.

Seventh, effective agencies generally are led by experienced, enlightened wildlife professionals who know how to manage and are given the chance to do so in a politically stable environment. The average tenure of directors in effective agencies is more than twice the national average for agency directors. Effective agencies are decentralized. Leaders have participative styles, and emphasize teamwork and delegation of decision making out to the grass roots. Agency employees are only left out of decision-making processes if they choose to be left out. At the same time, leaders provide clear, firm policy guidance, make the tough decisions that rise to them and back their employees when they make decisions.

And finally eighth, effective agencies are simultaneously political and nonpolitical. They have strong public support and are effective in mobilizing it when it is needed to implement policy agendas or oppose poor policy initiatives. They have open, equitable decision-making processes and demonstrate responsiveness to public input. They are a powerful, effective force in the political arena but manage to maintain an image of sticking to biology and being nonpolitical. Politicians are regarded as another important constituent group that must be dealt with, but not favored.

Conclusions

One of the primary assumptions of the Management Effectiveness Project team was that agencies learn and improve by watching other agencies. The project should benefit fish and wildlife agencies in two ways. First, the rich data base documenting management successes of agencies widely recognized for their management effectiveness should provide benchmarks in many areas of fish and wildlife agency management. Benchmarking is the trendy word for the process of improving organizational performance by analyzing the organization considered the best at something and adapting and improving that organization's practices to establish a new benchmark (Cole 1993). The Management Effectiveness Project should provide benchmarks for many aspects of fish and wildlife agency management. Benchmarks, however, are stationary targets. Management effectiveness is a dynamic, moving target. Effective fish and wildlife agencies in the future may do many of the things the agencies participating in this study do now but they will have to improve upon these benchmarks to remain effective in the face of new challenges.

The second way in which the Management Effectiveness Project should benefit fish and wildlife agencies is through application of our data collection methods to Total Quality Management (TQM) programs. TQM is the process advocated by W. E. Deming to improve organizational effectiveness through constant monitoring of organizational outputs. Deming's disciples strive to constantly monitor and reduce variation, the root of all quality problems (Gabor 1990). The questionnaire developed for the Management

Effectiveness Project could be used as the metric to monitor variation in agency management processes.

The basic principles of TQM are (1) quality is defined by the customer and, therefore, improvement must be aimed at anticipating customer's needs; (2) the organizations must improve every system of production and service constantly and forever; (3) significant, long-lasting quality improvement can only occur when it has the firm commitment of top management; (4) everyone in the organization must be involved in continuous improvement; and (5) strong education and training programs are necessary to achieve the effective process monitoring by employees that is key to TQM. The Management Effectiveness Project questionnaire addresses nearly all the concerns of TQM. Agencies could develop similar surveys for use with constituents to measure variation in constituent satisfaction.

The Management Effectiveness Project demonstrates the wildlife profession has made significant progress in dealing with social, political and organizational problems. Benchmarks of management effectiveness have been established. However, management effectiveness, like Deming's Total Quality Management, is not an achievable goal, but a never-ending process of organizational improvement.

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Building Natural Resource Management Plans in Minnesota through Public Involvement

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Increasing demands on natural resources, inadequate budgets, and continuing fish and wildlife controversies challenge fish and wildlife agencies to improve their effectiveness. McMullen (1991) concluded from ratings of effectiveness factors by agency administrators and legislators on fish and wildlife committees that "highest priority was clearly attached to public support and awareness factors and agency management (leadership) factors."

During the last two decades, the Minnesota Department of Natural Resources (DNR) has emphasized the value of public involvement in resource management. The emphasis has a foundation in the many successful resource projects and efforts that have been driven by informed and highly motivated stakeholders.

This paper presents two Minnesota case histories—the Heron Lake Area Restoration Project and the Fishing Round Table—both built upon public support and awareness. It includes the support-building process (changing the public's role from process spectators to team players), agency climate, honing of leadership skills, a desired resource leader profile and common elements of good projects.

Case Histories

Heron Lake Area Restoration Project Case History

A classic wetland degradation problem. About a century ago, this 8,250 acre (3,339 ha) Type IV prairie wetland was a wildlife mecca. About 6 feet deep (1.8 m), its clean water supported abundant invertebrates and plants, including wild celery (*Vallisneria americana*). It attracted 50,000 nesting Franklin's gulls (*Larus pipixcan*) in the spring, up to 700,000 canvasbacks (*Aythya valisineria*) in the autumn, and duck hunters nationwide.By 1990, diking along Heron Lake to reduce flooding of crop land decreased its size to 6,400 acres (2,590 ha), and wetlands and prairie in its 472-mile^2 (1,222 km^2) watershed were drained and converted to cropland. The increased flow in the many channelized tributaries caused Heron lake to rise as much as 5 feet (1.5 m) in 24 hours. Sewage and fertilizer caused pollution, while runoff increased sedimentation. Carp (*Cyprinus carpio*), bigmouth buffalo (*Ictiobus cyprinllus*) and black bullhead (*Ameirus melas*) increased turbidity and nutrient loading. Secchi disk readings decreased to less than 1.5 inches (3.8 cm), plant abundance and diversity declined, Franklin's gull use declined 98 percent and canvasback use almost ceased.

Regardless, discord among local governments, watershed board members, farmers, hunters, anglers and others, plus mistrust of DNR, stalled improvement efforts. Riparian farmers sought low water to prevent cropland flooding while hunters wanted it deeper to ease boat travel. Anglers and hunters debated Heron Lake's uses (fish or wildlife). Private riparian ownership on a part of Heron Lake prevented access. Persons unknown illegally dynamited the Heron Lake dam. A DNR public access and establishment of a waterfowl feeding and resting area were controversial. And, a 1979 $200,000 water-level management project couldn't be implemented due to discord.

Bringing people to the table. The first step was to provide information and improve communication, a requirement before identifying common goals. About 1980, local and regional DNR personnel began attending more local government and conservation club meetings.

Building trust. The second step included a continuing DNR presence, tangible accomplishments and diffusion of the agency "control" issue. Four meetings held in 1984–85 by DNR and the Middle Des Moines River Watershed Board (Board) (Heron Lake's watershed) led to a legislatively funded $380,000 Heron Lake dam repair. An agreement signed between DNR and the Board delegated them authority to operate the state dam. Next, DNR and landowners agreed on the removal of their private dam and other upstream flow restrictions.

In 1987–88, DNR attended a local angler-oriented club's meetings to discuss Heron Lake. Two contentious club-hosted public meetings were dominated by negative and vocal antagonists. The public recognized that Heron Lake's problems were a product of the watershed and DNR provided input and was asked to draft a watershed restoration plan.

Planning. The third step was a written plan. In 1989, a regional wildlife manager and DNR co-workers prepared a *draft* integrated resource management (IRM) plan. It was widely distributed prior to a DNR-hosted public input meeting attended by 125 hunters, anglers, farmers, lake shore owners, county board members, city councilors, watershed board members, birdwatchers and attorneys for clients. About 75 percent of those present voted to form a local plan review group.

The review group hosted the next public meeting and presented their "locally owned" 20-year, 15-page consensus IRM plan (sent out in advance), focusing on water quality, plus erosion control, flood control, fish and wildlife, recreation, education, and economies. It was aproved by 59 of the 60 participants (one abstained).

Formalizing local support. The fourth step was formalizing the support. The Heron Lake Area Restoration Association (HLARA) was formed. Its 14 voting members included commissioners from four counties, watershed board members, a city councilor, and representatives from hunting and fishing groups. The members of the nonvoting resource team (comprised of the U.S. Fish and Wildlife Service [USFWS], Pollution Control Agency, Soil Conservation Service, University of Minnesota, a local club's wildlife biologist, state and national organizations; and DNR disciplines—wildlife, fisheries, parks, enforcement, waters and support bureaus) attended monthly meetings as each was needed. The resource team leader (regional wildlife manager), who emerged during the earlier steps, attended all HLARA meetings and provided continuity. The total dynamic partnership (HLARA, resource team, organizations and others) approaches 50.

Implementation. Obvious and substantial accomplishments signal success, fuel public support and calm the critics. A pivotal point was the 1991 completion of a $431,000 electric fish barrier, funded by the Legislative Commission on Minnesota Resources (LCMR), DNR, USFWS, The Nature Conservancy and Ducks Unlimited. Preventing upstream migration of fish into Heron Lake and its watershed helped increase Secchi disk readings to 5 feet (1.5 m). Other accomplishments: over 2,000 acres (810 ha) acquired since 1989 by DNR aand USFWS, including 350 acres (140 ha) of wetlands and 500 acres (200 ha) of restorable basins; $360,000 Clean Water Partnership to identify pollution, wetland restoration sites and flows; watershed board will hire a watershed ecologist in 1993 (first Minnesota board to do so); 1993 research and visitor's center; and LCMR-funded high school ecology bus. Total funding from 1990 through 1993 approaches $7,000,000.

Impacts of partnership. A commonly found resource problem was addressed by a diverse public/private partnership that produced an IRM consensus plan and implemented substantial watershed improvement actions. A century of watershed degradation and human conflict ended and a strong restoration effort began.

Fishing Round Table Case History

The problem. Angling has great economic and social value in Minnesota, with two million anglers annually spending over $1 billion on their sport. Recently, they felt the quality of their recreation was decreasing and too much time was passing between bites. Studies verifying their concerns showed a long-term decline in large game fish and increasing angling pressure and effectiveness (Olson annd Cunningham 1989) Osborn and Schupp 1985).

During this time, input was solicited through public meetings which lacked a postive focus. They were dominated by a few vocal negative people who minimized the majority opinion, maximized bias, hid the diversity of interest groups and had few solutions (Hans and Anne-Marie Bleicker personal communications: 1986).

A new approach. To better identify fishing quality threats and develop strategies, DNR's Section of Fisheries invited 50 stakeholders to the 1990 Fishing Round Table. Included were interest groups with a diversity of economic, political, social and resource perspectives (angling business people, resorters, legislators, angling groups and DNR personnel). To promote participation, DNR paid for lodging and meals. To minimize bias and produce trust, trained non-DNR facilitators organized and ran meetings, and reported outcomes.

Participants, recognizing the common commitment to improving fishing regardless of conflicting strategies, agreed to respect all views. Facilitators, guiding four smaller concurrent sub-groups, maximized discussion and controlled opinionated participants.

Discussions at the Fishing Round Table included long-term vision, major barriers to quality fisheries, expanded or new initiatives for the 1900s and holding more Fishing Round Tables. This group's three most important issues, supported at eight public meetings statewide, were: habitat improvement and protection; enlightened fisheries (individual waters) management; and new values education.

The second Round Table. The focus was on strategies from the first Round Table, and generated consensus on the three identified issues. Implementing special regulations requires caution, early involvement by all stakeholders, conflict resolution strategies, statewide approaches to reduce opposition and evaluation. Participants felt the Round Table showed DNR's responsiveness and improved relationships among all interests.

The third Round Table. The focus was on how participants could help DNR implement strategies and remove barriers. It reiterated that implementing special regulations requires early local involvement and demonstration of a biological need for a new regulation. It concluded that priorities for establishing habitat enhancement and protection are essential, especially when budgets are short.

Impacts of Round Tables. Input was incorporated into the Section of Fisheries Long-range Plan; it caused budget allocation (Operational Planning) changes to meet long-range plan objectives, identified several necessary research projects and refocused priorities on the three work areas identified by the first Fishing Round Table. It has been well received by the legislators who appropriate funds and pass statutes needed to meet objectives.

Discussion

The Heron Lake project and Fishing Round Table have moved the Division of Fish and Wildlife beyond forums for vocal minorities to broadly based mandates on controversial issues. Open dialogue, and consensus goal and strategy setting improve relationships by creating trust, generating ownership and reducing ''surprises'' and false rumors. Even vocal critics have ownership of consensus strategies and do not perceive resource decisions as foregone conclusions. DNR credibility with legislators improved because of the opportunity for public consensus building before issues reached them.

Seven Elements for Success Shared by the Case Histories

1. A critical and visible environmental threat, such as the degraded water in Heron Lake or a declining fishery. The public is more likely to support solutions to obvious and appalling problems.
2. Earliest possible public involvement. Early public input in defining problems, scope of efforts, priorities and objectives creates public ownership, diffuses the agency control issue and increases trust. Local partners must enter any management effort at its beginning as participants and not spectators.
3. A skilled full-time resource leader, trusted inside and outside the agency, and using ''legitimate power'' (Covey 1990). Effectiveness depends on timing, flexibility, honesty, openness, integrity, dedication, innovation, consensus building skills, being a catalyst, using a ''lead from behind'' style and making it obvious that the effort is locally and not agency controlled. Leaders hone skills by leading a series of increasingly complex public/private efforts. While all have team value, fewer have the ability and background to be effective leaders. Filling in behind the seasoned resource leader makes a full-time effort possible. In IRM efforts that stall due to poor leadership, an agency tempted to tighten the process should replace the leader instead (Pinkerton 1991). Effective leaders emerge during the process.
4. An agency climate of empowerment and independent decision making. Resource leaders must have the authority to take risks and make timely decisions in a shifting continuum of opportunities.

5. A diverse support group. Like ecosystems, diversity is a key to stability and strength in a partnership. Everyone should be welcomed because of their individual and team contributions. Their suggestions often are similar to those of resource managers.
6. A brief, straight-forward and practical consensus plan with broad and easily understood objectives. Lengthy "cookbook" or confusing plans may be shelved, difficult to implement or result in no management "on the land." It must address controversial aspects. The "planner" (resource leader) must be close to the effort prior to helping draft the plan and avoid wasting time on management term definitions (IRM, holistic, ecosystem, landscape, etc.). A clear plan is a most important future reference, especially during implementation of controversial strategies.
7. Early and continuing tangible accomplishments. These daily reminders of success maintain, gratify and inspire partnerships.

Conslusions

The Heron Lake Project and the Fishing Round Table were built on solid foundations of public support. At Heron Lake, awareness had to be created before prospective partners "came to the table" and found a common thread (water quality). The Fishing Round Table became a forum for stakeholders and resource managers who had common goals. The dialogue between agencies and stakeholders resulted in strong public/private partnerships. Resource leaders were effective guides because of skills honed in a series of increasingly complex "on-the-ground" IRM efforts and an agency climate of empowerment and field decision making. The case histories provide valuable process models for other IRM efforts.

Rebuilding a fishery or ecosystem takes time but fish and wildlife populations will signal the success. Signals in these cases will be improved fishing and 50,000 canvasbacks on Heron Lake each autumn.

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Paying Attention to Internal and External Publics in Idaho

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Introduction

One of the more critical aspects of improving agency effectiveness is attention to the various publics we all must deal with on a regular basis. This first requires identification of the publics, followed by a strategy to communicate with and involve those groups.

While a casual or irregular communication may be better than nothing at all, the more productive approach is a planned strategy which provides for regular contact and communication.

It is critical not to overlook our internal public—our own employees. Ignore them and no amount of effort with the external publics will compensate.

Internal Publics

Recognition

The Idaho Department of Fish and Game employs a variety of strategies to recognize employee performance, either sustained, high-level performance, or that single, special, outstanding effort by an individual—the ''leaping the building with a single bound'' factor.

Employee-of-the-Year Awards are made annually in each of four categories. They include enforcement, professional/technical, administrative and clerical. Nominations for each category are solicited from coworkers, then reviewed and selected by the director and two assistant directors.

Special effort is made to present the awards in front of the employees' peers. In addition to the ''ceremony,'' a plaque is presented and a permanent 5-percent salary increase is included. Needless to say, the awards are both prestigious and appreciated.

Another special award, entitled the ''Image Enhancement Award,'' also is presented annually. This award, as the name implies, is presented to the individual employee who has done the most to ehance the image of the agency with the general public. Once again, a plaque and a 5-percent salary increase are awarded. This is a *very* prestigious award and reflects the emphasis Idaho Department of Fish and Game places on communication and public image.

Salary

There are few, if any, ''perks'' when working with a public agency. Outside of special awards, one of the few things that can be done to recognize performance and to express our appreciation for a job well done is to adequately compensate our employees.

Merit increases are a tool which is available to state agencies in Idaho. They can consist of short-term (6 pay periods), medium (13 pay periods) or permanent increases. They can be for 2.5 percent or 5 percent.

We devote a great deal of effort to the administration of merit increases. Field supervisors make initial recommendations to upper-level supervisors, all of which eventually end up on the appropriate assistant director's desk.

Each assistant director carefully reviews these individually and consultation between the two assistant directors also occurs, in order to assure equality and balance throughout the process.

Finally, the two assistant directors review them with the director, decisions are finalized, the Personnel office is advised and employees are notified of their increases.

We strongly believe merit increases are a good tool to reward performance and create, or maintain, high employee morale.

Planning Teams

Planning is an important endeavor. We utilize an interdisciplinary approach when developing our five-year species management plans. For example, a planning team for a wildlife species, such as elk, may include enforcement, and information and education personnel, in addition to wildlife professionals.

We feel the interaction between the disciplines is healthy and, by providing different perspectives, results in a more balanced and well-rounded final product.

Slick, four-color, easy-to-read popularized versions of the plans are printed and distributed to the public.

Special recognition was given to the planning teams by the Commission by giving plaques and cash awards.

Physical Fitness Program

We recognize that a physically fit employee will be safer and more productive on the job, and also will have ''something left'' when he/she goes home after work to enjoy families and hobbies.

With this in mind, several years ago we instituted a physical fitness program. It is mandatory for all field personnel and many of the administrative positions. Many other personnel participate voluntarily, as do many employees' spouses.

Fitness is encouraged in regular newsletters dealing with exercise, conditioning, stress management, proper nutrition and a variety of other issues. Participating employees are provided a free medical exam. Also, we will pay (one time) for an employee to attend a smoking cessation class. This costs about $40.00 per employee and has provden highly successful.

Fitness assessments are conducted twice a year, measuring dynamic strength, flexibility, endurance and aerobic fitness.

Incentive awards in the form of cash bonuses are provided for those scoring above a certain percentile, as well as plaques for the highest overall score for a region, a bureau and the entire Department.

The program has proven highly popular, with much good-natured competition between bureaus, regions and individuals, and a great deal of prestige given to the top award winners. The overall benefit has been an increased awareness of the importance of physical fitness and a healthier and more physically fit work force.

External Publics

The Department does a wide variety of things to inform, educate, communicate with or ''manage'' the external publics.

"Fish and Game News"

Our primary external constituency is, of course, our hunters and anglers. We attempt to keep them up-to-date by printing a "tabloid" publication we simply call the "Idaho Fish and Game News." This eight-page publication contains up-to-date information on seasons; potential for regulation changes; a schedule of upcoming events, such as season openings and closings, public hearings, and Commission meetings. It also includes a column written by Director Jerry M. Conley.

We print about 85,000 copies four times a year and provide them free to the public by distributing them through our 600 license vendors and all of our offices. Each issue costs about $7,000 to produce and deliver to license vendors statewide.

Last year, we also made two special mailings to individual license holders (one to anglers at a cost of approximately $67,000 and one to hunters at a cost of approximately $52,000). The costs included printing and postage and the license-holders were screened so that only one issue went to each household, to hold down expenses.

"Wildlife Express"

We also work with school children. We presently produce a "weekly reader" type of publication entitled "Wildlife Express," which is sent free to all fourth, fifth and sixth graders in the state every month during the school year. It contains articles on featured species, as well as introductory material on management issues, such as predator/prey, carrying capacity or why we hunt. We print approximately 67,500 copies each month, at a printing cost of approximately $6,100/month. So far, it has proven popular with the teachers, as well as the students. (It may be useful to note that 70 percent of Idaho's teachers have been certified through Project WILD.)

Idaho Wildlife Magazine

We also produce a slick, four-color, bi-monthly magazine, *Idaho Wildlife*, which is aimed at more of a *general* fish and wildlife audience. It is costly to produce (about $224,000 per year, including the editor's salary), but we feel it serves a useful function. About 9,500 copies are printed and distributed to libraries and Project WILD teachers, as well as the 7,400 subscribers (nearly half are nonresidents). It is estimated that each magazine is read by approximately three people, making a readership of approximately 30,000 people.

Sensitive Issues Policy

It is not uncommon in the fish and wildlife field for situations to occur which are both high profile, very sensitive and require a consistent, thought-out and planned approach when dealing with the media and the general public. These could be anything from a fish treatment project that "got away from us" to high-profile wildlife depredation or winter feeding activities, to the tragic loss of an officer. (Sadly, we have had to deal with the latter.)

Our policy manual outlines steps to be taken when the Director's office deems an issue to be of sufficient sensitivity.

It provides for a lead spokesperson to handle *all* media contacts, so everyone is being told the same thing. The "message" is coordinated with the Director's Office and appropriate personnel. This eliminates conflicts, contradictions and misunderstandings, and results in an organized interaction with the media and the interested public.

Wildlife Congress

Several years ago, we realized that our hunters and anglers were becoming more specialized, forming their own groups and sometimes working at odds with each other, rather than focusing on the big picture. Bird hunters versus trappers, fly fishermen versus bait fishermen, archers versus muzzleloaders, rifle hunters versus archers and muzzleloaders, and so on.

These groups were forming rapidly—all with excellent people and laudable goals—but while their individual efforts were useful, they still were working separately. We felt there would be more strength in their efforts if they had a way to combine their goals and their efforts.

In an effort to bring together *all* these interests, along with the hunters and anglers who were not associated with any group(s), the concept of a Wildlife Congress was born, where *all* sportsmen in the state would be invited to meet and discuss issues.

The Wildlife Congress was to have two major goals; first, to learn which issues were of paramount importance to the attendees and second, to create some kind of a statewide organization that would represent those views in an effective and coordinated way to the Department, and Commission or the legislature.

After a great deal of groundwork, the Wildlife Congress convened in Boise in November, 1988. Over 1,200 sportsmen and women attended, far beyond anyone's expectations. It was opened by several dignitaries, including Governor Cecil Andrus, an avid outdoorsman. After a stunning, wide-screen slide show entitled "Thank God I Live in Idaho," 1,200 people jumped to their feet with a thunderous affirmative response to Director Jerry M. Conley's question: "I'm glad I live in Idaho—how about you?" This set the stage for an enthusiastic and productive working meeting.

After a general session, the crowd was broken into smaller working groups, each with a trained facilitator, to identify issues and develop strategies to resolve those issues. We also provided lunch, so no momentum was lost by attendees leaving the building. A clerical crew worked through the night to prepare a typed final report of nearly 50 pages which summarized the previous day's discussions and recommendations and was passed out to every person the next day.

The group then formed regional wildlife councils, which included representatives from all the different sportsmen and natural resource groups in that area. Each regional council since has elected a slate of officers, written charters and by-laws, and selected a representative to serve on the Statewide Wildlife Council, which was formed to serve as as overall coordinating body.

As one might expect, all has not gone entirely smoothly, and some councils are more active and productive than others.

But the original purpose was to get everyone to pull together for fish and wildlife in an organized fashion, and that was accomplished!

The total cost for the Idaho Wildlife Congress, including salaries, after $18,000 in revenue and donations, was $62,851.

Weekly Live Call-in Radio Show

In order to maintain contact with the general public in Idaho, Director Conley hosts a weekly hour-long live call-in radio show called "Inside on the Outdoors." The program is co-hosted with a local radio personality and is broadcast to most parts of the state.

As you might expect, it produces a wide range of subjects and opinions from callers.

The program airs from 6:10–7:00 p.m. each Monday night and has proven to be extremely popular, eliciting many positive comments.

Morrison-Knudsen Nature Center

Another effort to communicate with the general public has been the development of a natural area adjacent to the Boise headquarters office. Named the Morrison-Knudsen Nature Center because of a major $350,000 donation from that corporation, the four and one-half acre site includes a variety of demonstration habitat sites, as well as an artificial stream, complete with viewing windows which look into the water from the side of the stream.

Aquatic insects, egg hatching and different types of aquatic habitat are featured at each station, along with interpretive signs to aid the visitor. A variety of wildlife also inhabits the area.

Extremely popular, the Nature Center already attracts over 200,000 visitors annually, including over 10,000 school children, most of whom are given guided tours.

In addition, an indoor facility will be nearly complete by this May, containing exhibits ranging from aquariums with P.I.T.-(Passive Integrated Transponder) tagged fish; hands on exhibits with hides and antlers; sand-filled boxes with tracks of animals; computer interactive exhibits; etc.

The 4,000 square-foot building, which includes a fully equipped audio-visual room, was constructed by a local high school vocational education class.

When all is complete, nearly two million dollars will have gone into the Nature Center (almost entirely from donations), along with countless hours of volunteers' work time.

At its dedication, Governor Andrus predicted it will be the most popular tourist attraction in the state, a prediction sure to come true if present trends are any indication.

Closing

In short, we have found it takes planning, coordination and effort to deal successfully with all our publics. But when goals are reached and ideas successfully accomplished, it is all worth the effort!

Comprehensive Management through Teamwork in the Wyoming Game and Fish Department

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Introduction

The year 1993 finds wildlife conservation in America in a curious situation. Never before have our challenges been so great. Our constituencies are changing, splintering and growing increasingly diverse and contentious. Issues of global significance lie before us: loss of biodiversity, species becoming extinct at an unprecedented rate, deforestation, acid rain, . . . the list goes on and on. At the same time, never before have so many people been so vitally interested in wildlife and wildlands. Recent polls in 20 countries suggest that most people believe environmental protection is more important than economic growth. The 1992 Environmental Summit in Rio de Janeiro marked the beginning of a new age of environmental awareness and concern on a global scale.

Clearly, we are faced with a dilemma. The expectations of our constituents are higher than ever. The issues facing us are more serious and complex than ever. At the same time, most of us are faced with limited fiscal and human resources to meet these challenges. How are we to meet these challenges as we face the 21st century? The answer is simple, but not easy: *We must become more effective.*

On July 23–24, 1992, an historic meeting of leaders from nine of the most effective fish and wildlife conservation agencies in the United States was held in Estes Park, Colorado. These senior administrators gathered to discuss their successes, concerns and needs for the future. Among the identified needs were:

- a need to more effectively involve our constituents;
- a need to involve agency personnel in agency management;
- a need to improve communications, both internal and external; and
- a need to develop broader agency philosophies.

The Wyoming Game and Fish Department (WGFD) has sought to meet these needs through teamwork within the context of a comprehensive management system. While it is certainly too soon to tell if this approach will be successful, the results to date have been encouraging.

The Comprehensive Management System

The Wyoming Game and Fish Department has long been considered a leader in the development and implementation of comprehensive management systems (CMS). The Wyoming system is a mature one, having been continually refined and adapted since 1975.

As described by Crowe (1983) this system is based around four simple questions:

1. Where are we?
2. Where do we want to be?

3. How do we get there?
4. Did we make it?

As noted by Guynn and Youmans (1989) "Where are we?" constitutes an inventory, including biological, social and environmental parameters. It also includes identification of issues and challenges facing the agency. "Where do we want to be?" describes strategic planning, or the development of mission, goals, objectives, and identification of challenges and opportunities for each agency program. "How do we get there?" includes operational planning, or linking the allocation of fiscal and human resources to achieving the objectives and meeting the goals developed. "Did we make it?" is evaluation, analyzing outputs and benefits provided to the resource and to the constituents. The overall mission of a comprehensive management system is to increase the effectiveness of the agency.

Teamwork

In his book, *Managing the Nonprofit Organization* (1990), noted management authority Peter F. Drucker wrote: "The more successful an organization becomes, the more it needs to build teams. In fact, nonprofit organizations [like fish and wildlife conservation agencies] most often fumble and lose their way despite great ability at the top and a dedicated staff because they fail to build teams."

In the WGFD, team-building exists at a number of levels. External team building links the Department to its constituents, to other entities of government, and to nongovernmental organizations. Internal teambuilding may link co-workers within the same work unit, interdivisional teams assigned to a specific project or interdisciplinary task forces charged with solving a specific problem. Regardless of the context, the goal of teambuilding is to increase agency effectiveness.

Involving the Constituents

Constituent involvement in agency management takes place at each phase of the CMS. In the inventory phase ("Where are we?") efforts are directed toward developing a thorough knowledge of the constituents by answering the following two questions:

- Who are the constituents?
- What do they want?

A variety of techniques are available for conducting constituent inventory. Perhaps the most technologically advanced has been the use of the Constituent Inventory Package (CIP) through Responsive Management. WGFD has been an active user of the CIP since its initial pilot testing and has found it to be a very important tool. It has provided statistically valid data on demographics and constituent attitudes and preferences at a reasonable cost. Further, it is sufficiently flexible to allow managers to focus on whatever level of detail is needed on any given issue. This is not to say that the most technologically advanced is always best. Much of the most important constituent inventory information collected by the WGFD is collected through person-to-person, one-on-one networking at the grass-roots levels between local agency personnel and constituents. This data, while admittedly subjective and qualitative, often is as valuable as more quantitative data produced through mail or telephone surveys.

Constituent involvement is extremely important in the strategic planning ("Where do we want to be?") phase. This phase of the CMS is characterized by the establishment of management objectives for all agency programs. While the range of management objectives may be constrained by biological factors, the final decision on objectives for population size, number of hunters or anglers, success rates, etc. will be a social decision, not a biological one. Further, since these quantifiable targets will form the foundation for all agency management programs, they cannot be just agency objectives. There must be constituent ownership in all management objectives.

Again, developing constituent ownership in objectives requires teamwork between the constituents and the agency. There are a variety of public involvement tools available to assist in forging this teamwork. The traditional public meeting is one used less frequently by the WGFD. We have found these meetings to be confrontational and designed to produce "win-lose" situations. More frequently, we have begun to conduct "open houses" where constituents can speak one-on-one with local WGFD personnel involved in the management of the population or program in question without confrontation. Recently, we have begun to use facilitated group sessions, task forces and other public involvement tools. Focus groups are a tool which we will be experimenting with in the near future. Whatever the mechanism used to assist in developing teamwork with the constituent in establishing management objectives, it is important that the process be done at the local level and that it be completely open and honest.

Constituent involvement in the third phase of the CMS also hinges on teamwork. In this phase, the operational planning ("How do we get there?") process is designed to involve the constituent in the allocation of budget and development of work schedules. Again, a number of ways exist to bring about the teamwork between agency and constituent necessary to complete this phase. In Wyoming, the ranking of projects within the annual budget is very important. Using the CIP, we annually ask the constituents which agency programs are most important and which problems identified in the strategic plan are most in need of solution. These rankings become part of the project ranking criteria for prioritization in the annual budget. Thus, projects within the budget which deal with highly ranked programs and problems are funded before projects which deal with lower-ranked programs and problems. In this way, the constituents have a direct role in the formulation of the annual budget, becoming a part of a team with the Department and the Game and Fish Commission in linking constituent dollars to meeting mutually developed "team" objectives.

The fourth phase of the CMS is evaluation ("Did we make it?") in which progress in achieving objectives and solving problems is measured. Again, the process involves teamwork between the agency and the constituent. While some measures of progress are measured objectively (population size, harvest, numbers of hunters or anglers, recreation days, expenditures, etc.) other important measures involve subjective parameters. In practice, the agency must go back to the constituents and re-inventory attitudes, preferences and satisfaction with the products and services provided, in effect asking the question "How are we doing, folks?" The same tools which served in the inventory phase are used in evaluation. This evaluation then forms the inventory for the next annual iteration of the four-phase planning process.

Involving Agency Personnel in Agency Management

The concept of teamwork within the structure provided by a CMS gives rise to an environment conducive to involving agency personnel in agency management. Fundamental to this involvement is a recognition by agency leaders that personnel are in fact constituents. Naisbitt and Aburdene (1987) cited the qualities people most desire in a job. Factors such as mutual respect with co-workers, interesting work, seeing the end results of work and feeling involved were much more important than job security, high pay or good benefits. In wildlife conservation agencies (including the WGFD) these factors may be even more important than in the private sector. Most agency personnel were not attracted to their profession by economic incentives, but by deep-seated values and attitudes about fish and wildlife conservation. They can constitute a tremendous force for development and implementation of management decisions in which they share ownership or a formidable force in opposition to decisions from which they were excluded. As such, the reason behind involving agency personnel in these decisions is not to produce a "warm and fuzzy" feeling, but to make the best management decisions possible and implement them in the most effective manner possible.

Each phase of the CMS provides the opportunity for teamwork within the agency leading to involvement and ownership. In the inventory phase, teamwork is involved in the collection of biological, social and environmental data. At the local level, distribution data may be collected by a wildlife biologist from one division, habitat data collected by a habitat biologist from a second division, and social data by an education specialist from a third division or game wardens from the first division. The teamwork between these professionals will determine the quantity and quality of the inventory data for the population for which they share responsibility.

In the strategic planning phase, this teamwork becomes even more important. The process of establishing objectives essentially is a process of public involvement. The team of professionals responsible for a given population are charged with coordinating this process, presenting the inventory information and resolving the conflicts which may arise between constituents over proposed objectives. In practice, teamwork at the local level in data collection and public involvement determines the success of strategic planning. Further, teamwork plays an important role in the development of trends forecasts and "futuring" efforts carried out by the WGFD. In 1987, the agency convened "Task Force 2000," its first interdisciplinary team devoted to trends forecasting and planning. Subsequent task forces have been designated to address a host of strategic planning issues.

Teamwork carries on in the operational planning phase of the CMS as projects are proposed to achieve management objectives. These projects may involve personnel at multiple levels from several divisions. While the budget associated with the project may be credited to one division, the involvement of other divisions forms an integral part of the administration of what is essentially a "team" project.

Evaluation also is a team effort in the WGFD. As noted above, this phase of the CMS is often a revisitation of the inventory phase. The same tools are often used in the same team context. An interesting addition to this phase has been the recent success of teams charged with evaluation of specific functions or projects. In 1992, an interdisciplinary task force evaluated the WGFD system of license sales and issuance in light of identified trends and problems developed in strategic planning. The recommendations of this task force will form the basis of future licensing of hunters and anglers by the agency.

Our experiences suggest that involving agency personnel in agency management is both very important and very challenging. The responsibility given any team should be clear to all at the outset. If training is needed in order to carry out that responsibility, it must be provided. The resources necessary to carry out the responsibility must be provided. Perhaps most important, any rejection or alteration of the team's recommendations made by an agency administrator should be accompanied by supporting rationale. Nothing is so devastating to the nurturing of teamwork as an unexplained veto at the executive level.

Improving Communications

The process of communications seems simple: information transferred from a sender to a receiver. Why then is the challenge of improving this process facing every fish and wildlife agency? Certainly the WGFD is no exception. One of the most important problems listed in the agency's strategic problem states: "Many management programs suffer from inadequate internal and external communications." The challenge of effective communication with internal and external constituents is endemic to wildlife conservation in the 1990s.

Still, teamwork within the context of a comprehensive management system provides some opportunities to effectively address this challenge. The inventory phase provides the setting for communicating the results of ongoing inventory efforts to both internal and external constituents. A variety of tools are available. Certainly, the traditional report is a valuable tool, but few constituents have the time or the desire to pore through voluminous reports to find out how many elk (*Cervus elaphus*) are in the South Wind River Herd or if anyone has seen a snowy owl (*Nyctea scandiaca*) in Wyoming this winter. A more concise and user-specific approach to communications is called for. The WGFD has developed a host of targeted publications to meet specific constituent needs. The agency publishes two separate newsletters for employees, another one for landowners, one for children, another for nongame enthusiasts, and yet another for hunters and anglers. In addition, WGFD news releases and radio and tv spots are directed to specific constituents through timing and spatial distribution. In essence, this targeted approach is an effort to build unique relationships with specific constituent groups, thereby promoting the teambuilding process.

The same tools used in the strategic planning phase are used to aid in the development of public involvement in management objectives. The process of communications within this phase is largely an application of developing informed consent. This approach mandates the identification of all constituents who will be affected by the objectives and the design of communication strategies which will most effectively reach each of these constituents. While a simple news release may fit the bill in one instance, a facilitated meeting may be necessary in another. A host of potential vehicles for communications is available. The ones which will most effectively assist in forging the bond between agency and constituent are chosen by the managers involved.

The operational planning phase of the CMS provides further opportunities for communicating effectively with both internal and external constituents. The active involvement of external constituents in the ranking of programs and problems as part of the budget process is an important tool in fostering communications about agency priorities. Perhaps as important has been the opportunity to discuss the budget process and the CMS with a variety of constituents. This process is unique in Wyoming state government and has provided the credibility needed to establish relationships with many constituent groups, including the joint appropriations committee of the state legislature.

Perhaps the most important part of the evaluation phase has been the communication of results to the constituents. Again, the medium of choice for communicating these results varies. The traditional annual report is an important mechanism. But more recently, the WGFD has begun providing information to constituents on specific projects, and the benefits to wildlife and the constituent with a more user-specific approach, using many of the tools noted above.

Developing a Broader Agency Philosophy

The concept of a fish and wildlife agency as more than the guardian of hunting and fishing is not a new one. As Aldo Leopold noted in 1930 at the 17th American Game Conference (Wilson 1984):

''The public, not the sportsman, owns the game. The public (and the sportsman) ought to be just as interested in preserving nongame species, forest, fish and other wildlife, as in the conservation of game. In the long run, lop-sided programs dealing with game only, or fish only, will fail because they cost too much, use up too much energy in friction, and lack sufficient volume of support.''

More recently, fish and wildlife agencies have struggled to broaden agency mission and to develop nontraditional programs for nonconsumptive use, nongame and biodiversity without sacrificing traditional programs or alienating traditional users. The WGFD has been active in developing such nontraditional programs. Perhaps the best known has been ''Wyoming's Wildlife—Worth the Watching'' (Kruckenberg 1988). Last year at this conference we provided an update on this innovative and exciting program (Kruckenberg et al. 1992). Teamwork within the CMS provided the environment necessary for developing and nurturing this effort.

Like any other program, the development of ''Worth the Watching'' required sound inventory information. Collecting data on the demographics, preferences and attitudes required teamwork between several divisions within the WGFD. Perhaps more important, this inventory led to understanding and a closer relationship with constituents we had previously ignored. For example, we learned that many of our constituents were females, and that their participation (or lack of participation) in hunting was not a major factor in their appreciation of wildlife.

Developing objectives for this program was even more a team effort. Since the ''Worth the Watching'' program includes elements of education, marketing and interpretive services, objective setting by necessity involved team members from throughout the WGFD. This involvement was crucial to the development of internal support for the program. As Larry Kruckenberg noted in his paper at this Conference last year: ''. . . internal support for the ''Worth the Watching'' program has grown significantly since inception. This strengthened support can be attributed to several factors, most notably: (1) program emphasis on education outreach; (2) the involvement of field personnel in project planning and interpretive development; (3) intensive and extensive coordination with all divisions; (4) the development of interpretive educational materials . . . and (5) structured workshops for employees which enable them to get more involved in agency and community communications efforts.''

This ''team'' concept carried through with both internal and external constituents in the operational planning and budgeting phase. The high public profile of the program generated interest and support from businesses, communities and the legislature because of the strong tie to the tourism industry in Wyoming. As such, local constituents began to develop ideas with local WGFD personnel for ''Worth the Watching'' projects in their own areas and these projects began to appear as proposals for funding in the agency budget. Subsequent funding of some of these projects served to increase this interest and support.

Evaluation of this program to broaden agency philosophy must be a team function. Because the various components of the program involve multiple agency functions, evaluation must be a cooperative effort. Surveys to monitor nonconsumptive use at the statewide level may involve Planning Section personnel, monitoring visitor use at interpretive sites may involve Education Section personnel, tracking sales of "Worth the Watching" products may involve portions of the Fiscal Division, while the responsibility for program administration falls to the Information and Education Services Division. Still, the factor which holds the effort together is the ability for these personnel to work as a team to evaluate the outputs and benefits produced by the whole effort.

Other WGFD programs also serve to broaden the agency's mission and philosophy: "Fish Wyoming" has brought about fisheries access and habitat development, the Wildlife Land Use Plan has tied biological values to property rights management, the nongame program and management of several high-profile threatened and endangered species have experienced major success. But in each case, the keystone of all these programs has been the ability of agency personnel to work effectively in cooperation with internal and external constituents within a comprehensive management system.

Conclusion

Agency effectiveness can be measured in many ways. The principals involved in the Management Effectiveness Study can cite criteria and support them with data from case studies involving nine diverse fish and wildlife conservation agencies. Different ecological, social and political environments have led to the evolution of a variety of innovative and successful approaches to the challenges of the 1990s.

For our agency, the strength and imagination of our personnel, and the cooperation and focus brought about by teamwork within a comprehensive management system have been of paramount importance. They have enabled the agency to successfully meet the challenges of involving our internal and external constituents, improving our ability to communicate and developing a broader agency philosophy. We have been successful in building strong constituent support, implementing innovative programs, nurturing excellent working relationships with other governmental and non-governmental organizations and maintaining a sound fiscal posture through troubled economic times.

This is not to say, however, that these successes of the past will serve to answer all the challenges of the future. The effective fish and wildlife agencies of the future will be those who can adapt rapidly to change. Over 2,500 years ago, the Chinese general Sun Tzu said: "... just as water retains no constant shape, so in warfare there are no constant conditions. He who can modify his tactics in relation to his opponent, and thereby succeed in winning, may be called a heaven-born captain."

May we all seek to develop heaven-born agencies. Fish and wildlife deserve no less.

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Communication Strategies to Improve Conservation in Missouri

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Effective fish and wildlife conservation hinges on good communication between managing agencies and their clientele. Clear communication can buffer threats to agency effectiveness such as faltering revenues, rising costs, increasing responsibilities and contentious anti-management activists. An agency's relationship with its clientele will be marked by either cooperation or confrontation, depending on the nature and extent of communication.

Two basic communication tasks face wildlife management organizations: (1) disseminating conservation information and (2) obtaining constituent feedback (Witter and Sheriff 1983). All agencies do these jobs to some extent. The challenge facing organizations is to be vigilant for opportunities to innovate communication, increasing the numbers and types of citizens contacted, and improving the clarity and consistency of contacts. Following are selected strategies used by the Missouri Department of Conservation (MDC) to improve communication and enhance conservation services provided Missourians.

Non-traditional Funding

Background

Communication between an agency and its constituency is expensive, demanding time and staff, both of which require adequate funding. The one factor that can most dramatically and immediately enhance communication between an agency and its clientele is hard cash. Moreover, if funding sources other than traditional revenues from hunting and fishing can be exploited, an agency can make the bold leap into the vast realm of aesthetic-oriented programming in fish, forests and wildlife.

Opportunity

In the early 1970s, MDC developed a master plan for mitigating the adverse impacts of modern development on the state's fish, forests and wildlife. A highlight of the plan was the long-term acquisition of about 300,000 acres to be added to the 300,000 acres MDC already owned. Additionally, a wide range of new or expanded services and facilities were promised, including new nature centers, more community lake and stream accesses, additional emphasis on conservation education in schools, broadened biological and social research, and a new nongame division for MDC.

Innovation

Funding this master plan required revenues far beyond the traditionally unwavering but financially limited support of Missouri anglers and hunters. The funding mechanism proposed was a unique 1/8 of 1 percent sales tax, with revenues earmarked for MDC. The tax, however, had to go before voters as a proposed constitutional amendment. The MDC informed voters that it would use the new revenues in the same responsible and productive way that the agency had managed fish, forests and wildlife since its establishment in 1936.

In one of the most extraordinary stories of coalition-building and citizen initiative in U. S. conservation history, Missouri's electorate approved the amendment in 1976 (Brohn 1977, Keefe 1987). The Missouri Conservation Sales Tax since has generated over one-half billion dollars in support of MDC's fish, forest and wildlife management programs (Thorne et al. 1992). Sales tax income now accounts for about half of MDC's $113 million annual budget, with sales of hunting and fishing permits and federal aid constituting most of the balance (Missouri Department of Conservation 1992a). Missourians' annual expenditures on fish and wildlife recreation now generate sales tax revenue equal to income flowing to MDC from the Conservation Sales Tax (Brown 1992), demonstrating how fish and wildlife recreation can support itself in a way that dramatically supplements traditional license revenues.

Significant non-traditional funding has allowed MDC to pursue a comprehensive conservation program, appealing to a wide range of citizen interests in fish, forests and wildlife. However, attention given traditional folkways of hunting and fishing has been maintained. Expressing the conservation message in both harvest-oriented and aesthetic-oriented activities, while simultaneously demonstrating MDC's commitment to each through allocation of staff and fiscal resources, has produced unprecedented political and financial support for the agency. The MDC is now acknowledged as a state conservation organization that has gone far ''beyond the hook and bullet'' (Arrandale 1993).

Missouri Conservationist Magazine

Background

Every state fish and wildlife agency in the country has some periodical to help spread the conservation message and report opportunities, problems and progress. Some publications are glossy; others, not so sophisticated. Many are based on paid subscriptions, while others are distributed free.

The MDC began publishing the *Missouri Conservationist* on July 1, 1938, with a run of 10,000 copies. Though a $0.25 fee per magazine was requested in the early years, collection of the fee was inconsistent, and the charge was dropped in 1942. The *Conservationist* has remained free to Missouri residents since then (Keefe 1987).

Today, the magazine is distributed monthly to about 400,000 Missouri households—roughly one-fifth of the state's total. Over the years, letters to the editor and readership surveys have revealed that the magazine has developed a loyal and appreciative clientele (Keefe 1983, Missouri Department of Conservation 1991). The magazine is a powerful voice for conservation in the state.

Opportunity

The sheer number of *Conservationist* magazines distributed is impressive. But a survey of Missouri urbanites (Missouri Department of Conservation 1990) revealed inequities within certain populations. About 30 percent of white households in urban Missouri received the *Conservationist*, compared with 10 percent of non-white households. Moreover, outdoor participation varied significantly between white and non-white urbanites. The MDC sought a way to increase the number of magazines sent to non-white households, hoping to encourage minority interest in conservation over time.

Innovation

In 1992, MDC purchased addresses of inner city households with children 15 years of age and younger. Inner city ZIP codes were selected to identify residents who might not possess the economic means for other MDC exposure. Starting in December, 1992, approximately 20,000 inner city households began receiving the *Conservationist.* The subscriptions will continue for a year, at which time each household will be asked if it wishes to continue receiving the magazine. Recipients need only return a pre-addressed card to become permanent subscribers.

Flyers depicting a black father and son fishing also were produced to promote the *Conservationist.* About 20,000 were distributed in 1991 through African Methodist Episcopal churches, minority fraternal organizations and the NAACP. In spring, 1993, nearly 50,000 flyers will be included in black and Hispanic newspapers distributed throughout Kansas City.

Conservation Advocacy Plan

Background

The International Association of Fish and Wildlife Agencies began its Proactive Strategies Project (PAS) in 1989. The primary objective of PAS was to develop communication and information tools for use by natural resource agencies to offset the effects of the contemporary anti-management movement (Race et al. 1991).

Opportunity

The MDC directorate understood the benefits of PAS, and in 1991, organized a task group within MDC to develop a plan and program for MDC analogous to PAS. The MDC's task group recognized there was no need to duplicate the proactive strategies that would be forthcoming from PAS. Instead, the task group concluded that MDC could be most creative by tailoring a plan for Missouri that would accentuate conservation strategies appealing to the outdoor interests of the state's citizenry at large.

Innovation

A plan called Conservation Advocacy for Missouri (Missouri Department of Conservation 1992b) was formulated by the task group. The document consisted of 81 objectives selected from the operational plans of MDC's 13 divisions. These objectives—such as development of nature centers, increased opportunities for aesthetic-oriented wildlife recreation and new services to anglers and hunters—provide broad-based resource opportunities. These services and products appeal to a wide range of public interests in the outdoors, and represent a powerful foil to emergence of anti-management sentiment in Missouri.

Constituency Research

Background

Agencies must understand citizen expectations for fish, forest and wildlife management by monitoring public participation in outdoor activities, sentiment toward resource issues, values attached to recreational experiences and public awareness of agency efforts. As early as 1939, MDC elicited public opinion of wildlife and forestry regulations through public meetings. The MDC's first public opinion survey was conducted in the early 1940s to help resolve a dispute between trappers and houndsmen (Keefe 1987). Prior to 1978, research focused on harvestable fish and wildlife species and populations, though some studies regularly assessed types and levels of resource use, and occasionally participant characteristics and attitudes (Brown 1992).

Opportunity

Although MDC benefitted from the results of human dimensions research prior to the late 1970s, the agency could not afford a long-term and comprehensive social research program. Recognizing that social change and the rapidly emerging information age warranted staff devoted to such studies, a portion of the Conservation Sales Tax approved by Missourians in 1976 was committed to social research in natural resources.

Innovation

MDC now maintains a staff of three social scientists who collect and analyze human dimensions on market data related to fish, forests and wildlife. These staff—a bioeconomist and two social researchers—are cross-trained in social and natural science disciplines at the doctoral level and work with the agency's administrators, managers, biometricians and planners in program development, program evaluation and, if need be, crisis management. Housed within MDC's Planning Division, the social researchers are accessible to all other divisions in the agency. Social research results are primarily reported in an in-house Public Profile Series, and secondarily at professional symposia and conferences.

The Future

Even a well-funded fish and wildlife agency will maintain the public's trust only so long as it hustles to serve its citizenry and seeks new opportunities for cooperation, partnerships and citizen input. Agencies should see citizens as valued customers, first trying to determine what constituents expect from fish and wildlife management, and then trying to develop products and services that meet citizens' expectations. Natural resource agencies unwilling to market their programs might find public interest in fish and wildlife conservation eclipsed by other pressing social needs (Witter and Adams 1993).

During 1993, MDC will begin writing a new five-year strategic plan. The first five-year plan, 1990–1994, was effective in guiding agency management and promoting intradepartment communications. The MDC learned, however, that the strategic plan should be the starting point for increasing communication outside the agency, especially with the public.

In developing the new strategic plan, MDC will seek more citizen input than in the previous plan, escalating the agency's commitment to listening and being responsive. Citizen participation techniques will be expanded, analysis of social and cultural issues will be intensified, and better trend data will be sought. A "Conservation Monitor," or public poll, currently is being planned that will be repeated annually to gather data on agency image, effectiveness and responsiveness over a 10-year period.

Concluding Remarks

Disseminating conservation information and obtaining constituent feedback are the two communication tasks facing natural resource agencies. Both are facilitated by an adequate funding commitment that allows innovation in communication. But even in the absence of a new or large funding base, a long-term staff commitment to creativity in public service can have a profound effect on improving the relationship between an agency and its clientele (Keefe 1987). The greatest challenge facing agency staff is to avoid communication complacency, or being content with traditional strategies for interacting with the public.

Over the years in Missouri, the dogged commitment by staff to communicate the importance of fish, forest and wildlife conservation has led to a profusion of communication strategies: conservation education materials for teachers and students, kindergarten through college; conservation assistance programs for private landowners; nature centers; movies, video, tv and radio productions; outdoor skills training; books; volunteer training; public involvement and input; and others.

But prerequisite to any strategy is a creative and committed staff. There is no substitute for personal dedication by agency staff to public service through innovative communication. Staff must be devoted to serving a diverse clientele, and to exploring innovative programming while maintaining traditional harvest folkways.

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Managing for the Future in Wisconsin through Strategic Thinking, Customer Focus and Employee Training

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Introduction

Managing a major state natural resources department in today's era of accelerating change is difficult at best. Trying to position the agency for an uncertain future sometimes seems impossible.

Environmental and resource management issues evoke powerful and often conflicting emotions. The issues seemingly affect everyone, and their reach goes well beyond the borders of any one state. With a global economy, many of the decisions we make are impacted by national or international concerns and, in turn, affect others outside of our own state.

Expectations of government management run high. The public is demanding better service at less cost and is increasingly vocal about efficiency and effectiveness expectations. Good customer service is as important for government responsiveness as it is for private industry competitiveness. And, employee expectations of management also are increasing. They expect a progressive management climate which nurtures a sense of worth, creativity and teamwork enabling them to fulfill public service needs.

Given this turmoil, no one organization is going to have all the answers. So it's important for each of us to share our best ideas, and even our failures, with our counterparts. This paper highlights three facets of the Wisconsin Department of Natural Resources' (Department) management approach to try to stay on the cutting edge of change; namely—strategic thinking, customer-based focus and progressive management training.

Strategic Thinking

Our basic mission is to ensure adequate quality resources for future generations. So strategic thinking is essential. In Wisconsin, we've developed two approaches to foster future oriented thinking. The first approach, an informal one, is TRENDS ANALYSIS, an attempt to anticipate emerging patterns which will impact how we do business and even what type of business in the future. The second approach, a more formal one, is STRATEGIC PLANNING, a rigorous planning process which utilizes the results of trends analysis to direct strategic change within the agency and its programs.

Trends Analysis

Trends analysis is the fuel that fires strategic thinking. It's a systematic search for indicators of fundamental social, economic and technological change beyond our normal programmatic thinking. The goal is to get managers to step outside their traditional sandboxes and think broadly about how the world is changing before they attempt to embark on strategic planning for their programs. For example, how will an aging population and changing family structures affect recreation facility needs and license sales.

In 1983, we created a team of free spirited thinkers called the Trends Analysis Group (TAG). These are professionals from a variety of disciplines and representing diverse viewpoints who enjoy doing research and brainstorming on widely varying topics. It's an informal volunteer group selected by the Deputy Secretary, and the membership has changed with some regularity over the years. Their efforts are part-time, in addition to normal work assignments to keep them from completely losing touch with program realities.

TAG does a lot of reading, interviews with varied experts, communicating with other futurists and brainstorming with each other to form opinions on leading trends. Initially, they produced thought provoking briefing papers for our top management team. However, their trends advice became so popular that they were regularly invited to staff meetings to help programs initiate strategic planning. In addition to this research and consulting role, most of their output now is shorter "think pieces" published in our regular employee newsletter. The success of this informal approach underscores the need to keep it free of bureaucracy to assure expanded horizons of thinking.

Strategic Planning

After trends analysis loosens up the thinking of the organization, you're ready to start strategic planning. The goal is to establish a strategic vision for the organization and specific directions or goals to achieve that long-range vision. To be successful, it requires a high level of commitment and an unusual degree of flexibility and creativity. A good place to start is by examining your overall mission and philosophy or articulating them if you haven't previously done so. The trends may point to a need to make fundamental changes in both the mission and your philosophical approach. In Wisconsin, it identified the need to do less hands-on management of resources and more assistance to others, such as private property owners, as well as the need to focus more attention on preventing environmental problems rather than more expensive reactive solutions.

Establishing the strategic vision and directions in the Department was a very interactive process involving all facets of the organization and affected publics. An overall plan first was crafted for the whole department by the upper management team. Then the Divisions and subsidiary Bureaus were charged with preparing their own strategic plans compatible with the Department's strategic directions. For example, specific plans were crafted for the future of the forestry program, fish management and wastewater management. Public involvement was prevalent at all stages but intensified with the more specific Bureau plans because it was easier for affected publics to identify how they would be impacted.

We now are beginning a new round of strategic plans which attempt to integrate related program efforts across organizational lines. Water 2020 addresses all water quality, water quantity and related land-use issues affecting many of our Bureaus in each of our major Divisions. Land management and biodiversity issues also may be candidates for an integrated planning approach.

Keys to successful strategic thinking for us have been: (1) loosening up our overall management approach and using informal brainstorming techniques to encourage creative thinking; (2) using trends analysis to fuel strategic planning; (3) keeping the plans brief and the process simple, not mandating specific procedures and formats; and (4) encouraging broad interaction with affected publics throughout the process.

The results have been impressive. Our $250 million Stewardship Program offers several innovative examples drawn from our strategic thinking. A 92-mile Lower Wisconsin River management area was created utilizing a regional commission of local citizens in charge of protecting scenic river zones. A regional Habitat Restoration Area approach was created emphasizing landscape scale management combined with private landowner involvement. Financial grants were created to encourage nonprofit group protection of priority habitats. A wetland reserve program for private landowners was created to encourage the preservation of small but critical wetlands.

Customer Focus

The key to working successfully with our many publics is to involve them openly throughout planning, administrative rule making and program implementation. Citizen involvement is a way of life and normal business in the Wisconsin Department of Natural Resources. This philosophy is reflected in our mission, strategic plans and citizen policy board. The philosophy is carried out through specific citizen involvement plans and a variety of techniques tailored to meet specific project needs.

One approach is to form true partners, sharing work and responsibility as appropriate. Out state's recycling program is a recent example. The Department has formed partnerships with local governments across the state, providing them with grants, technical assistance, public information and other tools to help them implement recycling programs in their communities.

Historically, one of the most common involvement tools has been the public hearing. Such hearings are mandated by law in Wisconsin for administrative rule making. While potentially a useful legal tool, it often proves to be a frustrating public involvement tool. Relatively few people testify and the process often is intimidating to individuals who are not used to public speaking. For this reason, we have been redesigning some of our hearings, to a more useful open-house format, particularly on controversial topics such as mining. The open-house hearing generates more useful comments because the public can participate at their convenience, get information and questions answered, and leave their opinions in the format most comfortable to them.

Another common technique for involvement in Wisconsin is citizen advisory or work groups. We have literally dozens of specific continuing advisory committees created by statute or by the Department to provide input from affected interest groups on specific ongoing needs. For many of our larger state properties, such as state parks and wildlife areas, we created ongoing advisory groups or ''friends groups'' to help advise us on master plans for the property, solicit donations or run concessions to fund needed projects, and simply help generate a feeling of involvement by property users and neighbors.

One of the more complex advisory groups we have in Wisconsin is the Conservation Congress, established nearly 60 years ago by statute to advise the Department on fish and game programs. The Conservation Congress members are elected, five from each county of the state, at Spring public hearings conducted in each county. The Congress addresses specific fish and game proposals through these Spring hearings, an annual meeting of Congress members, and several standing committees appointed by the Congress Chair to meet regularly with specific Department program staff.

We also create short-term work groups frequently to address specific problems or to help us craft new administrative rules. Contrast the formality of the Conservation Congress approach to the advisory team we assembled to help us write a rule addressing problems of public access to our lakes and rivers. In this case, members of varied interest groups and legislators were invited to participate in a series of workshops where we used focus groups and other small group techniques to actually write the rule, starting virtually from a blank piece of paper. Many of the same people kept up an active interest throughout the rule-making process, continuing to help us refine and improve drafts.

Involving people at the very beginning of a process can be critical as demonstrated recently when we developed a statewide plan for our recreational trails. The agency's team started by carefully identifying all affected stakeholders. These people then were interviewed through individual sessions and focus groups. This input gave the team a skeleton of the plan. Along the way, drafts and executive summaries were mailed out to hundreds of participants. The project then went through a series of reviews, comments, and redrafts, incorporating such techniques as call-in radio shows and 24-hour hotlines. The project team kept a running list of all comments and responded to them.

Similar approaches have been or are being taken on a wide range of projects including plans for state properties, reintroducing wild turkeys, making long-range plans for Great Lakes fisheries and remedial action clean ups, and changing hunting season frameworks. Critical to success is a sincere belief by the project staff or team that the public has a legitimate and useful role to play in natural resources planning and management. This attitude is fostered at all levels of the agency through training and management actions.

Progressive Management Training

A progressive management climate is vital to encourage creative thinking, innovation and employee satisfaction. The collective actions of all our managers is the key to creating and maintaining a progressive work climate speaking far louder than any messages we can send. Therefore, we have focused much of our management training over the past decade on reinforcing participative management behaviors.

In the early 80s, we created, with the help of University Business School consultants, a two-week management course to help Department supervisors understand and apply participative management. Since this was a major philosophical change for many supervisors used to traditional command and control methods, we put all of our managers through the training, including the Secretary and his upper management staff. We hired quality professional educators to do the training and it was well received. However, an interesting phenomenon developed. Even though we used quality trainers and supplied them with Department examples, students were not satisfied there was enough discussion of the real world in the Department. In response, some of the upper level managers began to host unscheduled night sessions to share their experiences and thoughts. Those impromptu sessions eventually became the highest rated portions of the training.

As we worked our way through all the management layers, the course was gradually reduced to one week because of cost and time commitments. However, the course results continued to be good based on supervisors reactions. And after we reached our goal of training all supervisors, we eventually replaced it with one- and two-day refresher courses on specific management skills such as management by objectives, team building, effective delegation and perceptive communications.

In the late 80s, as we began to implement our new strategic directions, we sensed the need for additional training to reinforce the strategic directions and the management philosophy around which the plan is built. To do justice to the topics involved, we felt it would take a week-long intensive course. Because the topics were so vital, we felt the upper management team should not only design it but also teach it. That was a risky decision because only a few of us had done management training before. But we felt what we lacked in technique would be offset by the sincerity and credibility of the presentation.

With some initial help from a consultant and continued guidance from our training officer, our upper management team held a retreat at which we reached consensus on the overall course content and objectives. We then divided into smaller teams to craft the individual subject blocks and decide appropriate delivery strategies. We held another retreat to practice and critique the results and to see how it all fit together. With some refinements, we were ready for prime time. We chose as our pilot group 30 of the next level of managers in our organization, feeling they would be more comfortable in critiquing their bosses' efforts. They were frankly astounded at the level of effort and commitment we put into the course and had good suggestions to improve the interactive course techniques. They enthusiastically recommended it for all managers in the department, indicating it was the most significant management training they had ever received. Since March 1990, we have held two courses a year (spring and autumn) training about 30 managers at a time plus one or two outside observers.

We designed the course to achieve the following objectives:

- stimulate broad-based, future oriented thinking and the need to deal with constant change;
- build consensus on our management approach and philosophy;
- articulate and reinforce our strategic themes;
- build trust and shared values amongst our managers;
- share management experience and ideas with our Secretary's staff;
- strengthen our sensitivity and approach in dealing with employees and customers; and
- create time for managers to focus on the managerial part of their jobs.

The specific course content includes: traditions; creative risk-taking; strategic planning; management philosophy; our management system and how it is used in decision making; policy setting; human resources; change; and customer service. The teaching techniques are highly interactive, evoking lots of group, small team and individual involvement. A night of open discussion in mid-week allows the course participants to pursue any previously unanswered questions or subjects in more depth with the instructors.

Following the course, we do follow-up questionnaires to determine what facets have been most useful to them in their day-to-day management. The management concepts continue to be reinforced through a management newsletter, regular staff meetings and other communication techniques including electronic mail. Current management problems raised by course participants in discussions during the course are addressed by special management teams usually including volunteers from the course participants who recommend solutions to the Secretary's staff. Action on those recommendations speak louder than any words on our commitment to participative management.

The management course is a very time intensive and demanding effort. But the results, as judged by both participants and instructors, have been well worth it. It has given all managers more opportunity for quality time with upper level management in a setting conducive to constructive evaluation on how effectively we are managing. It has enabled us to more effectively and consistently communicate important management philosophy messages. The participants have learned some broad management concepts which have made them more effective managers. It has brought the upper level management team closer together, helped us crystallize our own management approach and brought us a huge amount of respect from other department managers as a team and as individuals.

Plus, it has earned the Department lots of praise from outside observers including other state agencies, professional trainers and the press.

Summary

The nature of our functions demands a strategic look to the future. Trends analysis is the fuel that fires strategic thinking in the Wisconsin Department of Natural Resources, helping us to be more creative in our thinking. Keeping our strategic plans brief and our process simple has been critical to successful implementation. Equally important is encouraging broad interaction with affected publics throughout trends analysis, planning and implementation.

Citizen involvement is a way of life in the Department. This philosophy is reflected in our mission, strategic plans and citizen policy board. We utilize specific citizen involvement plans and a variety of techniques tailored to meet specific project or issue needs. Continuing advisory committees and short-term work groups are a mainstay supporting many of our programs. However, we are successfully using newer focus group, workshop and electronic call-in techniques for controversial issues. Critical to this success is a sincere belief by staff that the public has a legitimate and useful role to play, an attitude fostered agency-wide through training and management actions.

Our progressive management climate is vital to encouraging creativity, future oriented thinking, customer oriented service and employee satisfaction. The collective actions of all our managers is the key to creating and maintaining a progressive work climate. We have focused much of our management training over the past decade on defining and reinforcing participative management behaviors. The centerpiece for our management training is our week-long "Managing for the Future" course, a unique advanced management course designed and taught by the Department's senior management team. It's given all managers an opportunity for quality time with upper level management, helped us communicate a consistent management philosophy message, brought the management team closer together and earned a great deal of respect from within and outside our agency for our progressive management approach.

Future oriented thinking, customer focus and management training are key elements to the Wisconsin Department of Natural Resources' progressive management approach which is consistent with well known quality management principles. Each of them together are necessary ingredients to maintaining a progressive management climate and staying on the cutting edge of change.

Values, Mission and Vision: A Recipe for Success in the Twenty-first Century

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Introduction

The New York State Division of Fish and Wildlife is a part of the Office of Natural Resources in the Department of Environmental Conservation. It employs about 540 members and is organized in several Division staff units and three operating bureaus—Fisheries, Wildlife and Environmental Protection.

About two years ago, the Division Director, Assistant Director and three bureau chiefs spent three days on a remote Adirondack lake discussing where we were going and how we were going to get there. They came to the realization that the old saw, "We might be lost, but we're making good time" was getting painfully close to an accurate description of the Division. Because of budget, program and political crises, we often were plodding along and not looking forward to see where we were headed.

At the end of those three days, our leaders made a commitment to themselves and our Division members to establish a focus on the future. They also committed to do their best as individuals and as a team to lead the Division to achieve that future. We have learned a great deal about values, mission and vision while trying to fulfill those commitments.

Our Division began a Strategic Management Initiative composed of three elements: (1) a strategic planning process; (2) an enhanced public participation program; and (3) a staff and organizational development program.

Strategic Planning

Division Director Ken Wich set up a Strategic Management Team (SMT) of 12 Division members to lead the strategic planning effort. The team, frequently referred to as the "Dream Team," included the top leadership of the Division and seven members drawn from throughout the Division. The SMT was charged with three tasks: (1) develop a statement of organizational values for the Division; (2) develop a Division mission; and (3) describe a vision of what we wanted our future to be in the year 2010.

The SMT used "Shaping Strategic Planning" by Pfeiffer et al. (1989) to guide their efforts. They picked that model because it emphasizes the importance of values in strategic planning and organizational management. The first task, and the most difficult, the SMT addressed was developing a statement of organizational values. After several intensive, and intense, working sessions the team produced a draft values statement for internal member review. Every member of the Division was provided a copy and the team conducted 22 facilitated review sessions around the state to solicit member feedback. The SMT completely rewrote the values statement based on our members' input.

The SMT then drafted a mission statement for the Division and circulated it to all members for review and written comment. The mission also was substantially revised based on staff comment.

The Human Dimensions Research Unit of Cornell University surveyed our staff to determine the degree of acceptance of and commitment to the revised values and mission statements. Using a direct mail survey of all Division members, Brown and Proud (1992) found about two-thirds of our staff endorsed the values statement and were strongly committed to it. About 3 percent of our members were strongly opposed to some aspect of the values statement. The rest were neutral. The levels of endorsement, commitment and opposition to the mission were similar. Brown and Proud (1992) identified the lack of acknowledgement of intrinsic resource values in the statements as the only significant issue preventing even higher levels of endorsement and commitment.

The SMT revised the values and mission statements a final time to address the issue of intrinsic values. The final statements have been formally adopted and read as follows:

OUR VALUES

New York's fish and wildlife are held in common by the citizens of the State. The citizens have entrusted us with the care of their fish and wildlife. We will work to manage and perpetuate the State's fish, wildlife and ecosystems.

The most important asset of the Division of Fish and Wildlife is its members. Individual competence, creativity, commitment and diversity are vital to meeting people's needs. Division members will be open, honest and innovative; respect differing ideas; make decisions; take risks; and be provided opportunity to develop technically, grow personally and pursue career choices. We will treat each other with the mutual trust and respect for human dignity that we expect for ourselves.

Our program is delivered to serve the interests of all the people of the State. We will work with all segments of the public to identify their needs and interests in fish and wildlife. Effective communication with the public is essential for honest exchange of information and mutual education. We support and will provide for a free and open exchange of information so we may listen and learn as well as speak and teach. We advocate human use of fish and wildlife, including observation, study, hunting, fishing and trapping, all conducted in a humane manner without threatening the continued existence of a species.

We value achievement of attainable and measurable objectives developed with public participation. Decisions will be founded on the best physical, chemical, biological, social and economic information available. Division members responsible for achieving objectives will be delegated authority to make decisions. We will equitably allocate adequate resources to achieve our objectives. No Division member will be responsible for an objective unless adequate resources are provided to achieve it.

We welcome being held accountable for our behavior and performance by each other and the public.

OUR MISSION

The mission of the Department of Environmental Conservation's Division of Fish and Wildlife is to serve the interests of current and future generations of New Yorkers by using our collective skills, in partnership with the public, to describe, understand, manage, and perpetuate a healthy and diverse assemblage of fish, wildlife and ecosystems.

Concurrent with finalizing the values and mission, the SMT analyzed a series of issues we believed would affect our future. The issues included: environmental quality; demographics; staff recruitment; public participation and accountability in government; land ownership and use; management science, technology and tools; economic trends; and human values for fish and wildlife. Based on that analysis and consistent with our values and mission, the team described our desired future for the year 2010 and proposed five goals we must achieve to attain that future. Again, this work was reviewed with staff through facilitated meetings and rewritten.

This vision of the future has become a high-order strategic plan. It contains five high-priority goals, general strategies for pursuing the goals and a characterization of what we expect success to look like. It is the foundation on which we can build detailed operational plans. The five goals of our vision include: (1) protect, enhance and restore New York's fish and wildlife and the ecosystems that support them; (2) help provide New York residents with the knowledge to appreciate and understand fish and wildlife and their habitats; (3) provide a wide array of opportunities to enjoy the benefits associated with fish and wildlife; (4) provide a public role in planning, implementation and evaluation of fish and wildlife programs; and (5) foster and maintain an organization that efficiently achieves our mission.

While beginning our strategic planning process our Division recognized two issues that we had to address immediately. First, our publics were demanding a larger and more interactive role in shaping our program and making decisions. Second, we needed to help our staff deal with increasing demands and diminishing resources by providing some new skills.

Public Participation

Like many northeastern states, New York manages its white-tailed deer population by recreational hunting of does. Our statutes provide for a one hunter, one buck opportunity and control of populations through deer management permits (DMP) issued to individuals or groups. The DMP allow the hunter or hunters to take an additional, usually antlerless, deer. The statute governing buck hunting is permanent. The statute that provides for issuance of DMP is of fixed duration and must be periodically extended, usually every three years.

In early 1989, several groups of organized hunters formed a Coalition for Sensible Deer Management. This coalition alleged that we were issuing too many DMP and reducing deer populations to unacceptably low levels. The allegation coincided with the expiration of our statutory authority to issue DMP for population management purposes. The coalition captured the ear of several key legislators including the chairs of the committees that would pass judgment on extension of our DMP authority. They also won our full and undivided attention.

We were able to convince the legislature to extend our authority to use DMP, but only for one year. Their message to us was clear, "You may be the professional resource managers, but you must institute a process to fairly accommodate public input or this one-year extension is your last." We immediately commenced a process to review our deer population objectives for each of our deer management units (DMU) in consultation with the stakeholders affected by our management decisions.

In autumn 1989, we set up Citizen Task Forces on Deer Management (CTF) in four DMUs. We selected members for each CTF by working with the local Cooperative

Extension Agent to identify representatives of the major stakeholders affected by deer management decisions. The stakeholders included farmers, hunters, motorists, rural landowners, tourism and small business representatives, and others. We then asked the agent to facilitate a series of three meetings of the CTF.

At the first meeting, our biologists reviewed our approach to deer management and the current population objective for the DMU. We asked each CTF member to work with the people they represented to decide if the current deer population was too high, too low or about right. The CTF members discussed their views about deer populations among themselves at the second meeting. Our only role was to respond to questions. At the third meeting, we asked CTF members to give us a consensus recommendation on what the deer population should be in the DMU. All CTF were able to achieve consensus.

We have continued to utilize the CTF approach in the remainder of our DMUs. We have completed review of population objectives in about 40 DMUs. In nearly every case, the CTF has been able to achieve consensus on a population objective. Many CTFs achieved consensus in only two meetings. We have implemented each consensus recommendation we've received. Each has been biologically sound and achievable.

In 1990 and 1991, the legislature extended our authority to issue DMP for one year. In 1992 the authority was extended for another year and expanded to provide us with new flexibility to regulate seasons, bag limits and manner of taking. The new flexibility was specifically tied to the need to meet CTF recommendations. For 1993, the legislature has proposed to extend this broadened authority for three years.

Our experience with an expanded role for stakeholders in making deer management decisions has been extremely positive. We have since provided a larger public role in decisions about coyote management, moose restorations and Lake Ontario fishery management.

Staff Development

The Division renewed its focus on staff development in 1990. We established a full-time staff development coordinator and charged him with accomplishing several objectives, including: (1) foster communication, cooperation and cross fertilization among bureaus, field offices and individual staff; (2) reestablish staff confidence in the Division and the Division's interest in staff; (3) develop greater openness among staff to deal with today's diversity of public interests in fish and wildlife; and (4) provide skills and concepts useful for tomorrow's administrative and program responsibilities.

Working with the Division leadership, our staff development coordinator designed a series of four workshops called "Professional Skills for the 90's." Three workshops presented principles and technical skills to all levels of scientific and technical staff. The fourth covered the leadership, supervisory and managerial skills supervisors would need to empower a well-trained staff to act. The first three workshops were designed as two- and a half-day, in-residence sessions. The fourth included one two-day session and two three-day sessions.

The first workshop presented a disciplined approach to problem solving similar to that described by Crowe (1983). This was familiar ground for many Division members, but was a positive review and endorsement of this approach. As important as technical content, this workshop helped win over pessimistic and doubtful staff who had not been provided any training opportunity for several years. The primary objective of the workshop was to institutionalize a systematic process for planning and managing projects or solving problems.

The second workshop was more technically challenging in that it included communication concepts that few of our scientific and technical staff were familiar with. It analyzed personal values and how everyone's beliefs are rational and appropriate to them. Many staff were surprised to discover that values are just as important to our decision-making as to any of our publics. The objectives of this workshop included learning new communication concepts; mastering some basic methods for oral and written communication; and gaining some understanding of the importance of personal values to communication.

The third workshop was designed to expose staff to the advantages of win-win outcomes and how to achieve them. This course exposed staff to techniques for negotiation and litigation. The objectives were to acquire new skills based on unfamiliar principles; develop appreciation for and stimulate pursuit of win-win outcomes; inhibit competitive, judgmental styles in negotiations with our publics; and develop good expert witness skills.

The final workshop emphasized the interpersonal skills required to be a successful leader. The role of the leader in shaping organizational culture and building teams was stressed. The primary objective of the workshop was to motivate supervisors to give up the reins and empower staff in technical areas while concentrating more on focusing direction, supporting staff needs, team-building and coaching.

Our members generally have acclaimed this series of workshops as: "the best thing the Division has done in ten years." We believe that response is based on the intra-Division communication benefits of the workshops as much as the technical content.

Summary

We believe our three-part Strategic Management Initiative has helped us establish a focus on the future. It also has produced a fundamental change in the way we view our business and the basic business model we employ. In the past, fish and wildlife agencies, including ours, have been accused of using a simple, linear model to change public attitudes and behavior associated with fish and wildlife resources (Figure 1). We characterize that approach as the "Missionary" model.

Today, the New York State Division of Fish and Wildlife is using a more complex model that includes a central role for the public, our customers (Figure 2). We believe this approach is more closely in tune with long-term stewardship of natural resources

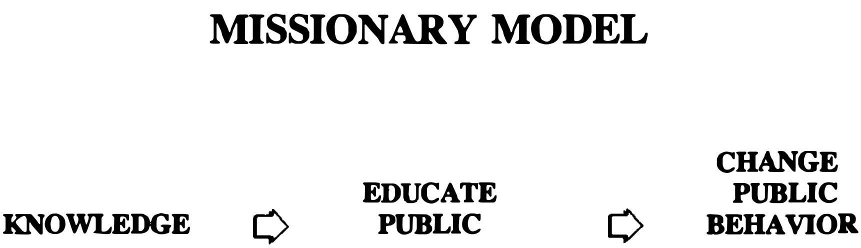

Figure 1. A simple business model that relies on transfer of knowledge to affect public behavior.

and stewardship of the public's trust of us. We title this approach the "Stewardship" model. It is our vision of how to be successful in the future.

The difference between the two models is the difference between selling and marketing. Selling is convincing the customers we have what they want. Marketing is producing the product our customers truly do want. We are confident our strategic management initiative and the Stewardship model will help us market in rapidly changing conditions and within the context of long-term resource protection.

In this process, we made several mistakes from which others may choose to learn. Our Strategic Management Team was too large and yet not diverse enough. If we had it to do over, we would limit the number to nine or fewer people that better represented the diversity of our Division. Our strategic planning process has taken far longer than we thought it would. The time required was partly because we provided many opportunities for staff participation (very worthwhile), but more because we avoided dealing with some seminal issues early in the process and had to keep going back to them. We also suffered from lack of a full-time person to manage the process. Finally, you can never have too much support from top management for an effort like ours. We sometimes failed to view and treat the big guns as customers.

The degree of participation we have enjoyed from fellow Division members has been truly rewarding. We are fortunate to be associated with an outstanding and uninhibited staff. We also have learned that most of our customers are reasonable people who can help us make sound, sustainable decisions when we provide good information and opportunity to be involved.

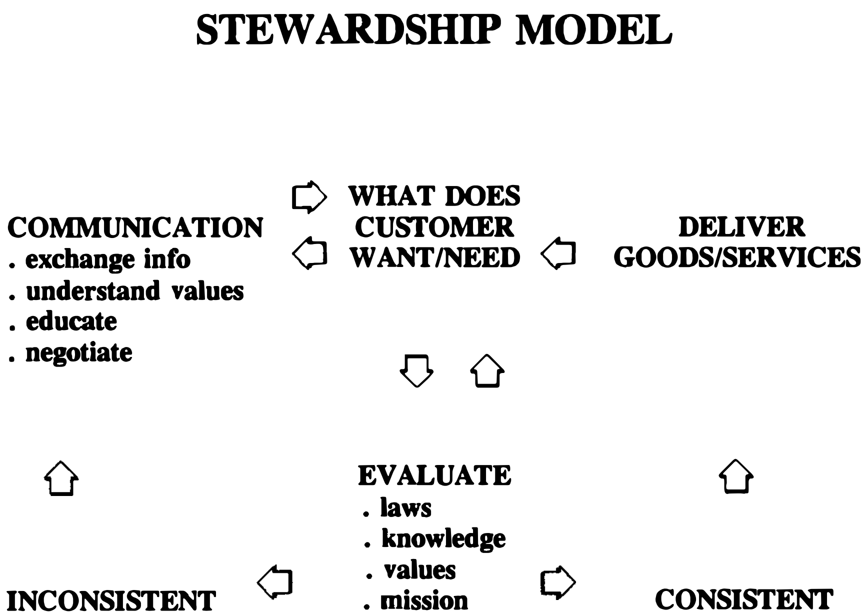

Figure 2. A customer-based business model that helps agencies meet public demands consistent with long-term fish and wildlife resource stewardship.

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"A Symbiotic Relationship," Team Building and the Heritage Program

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The Arizona Game and Fish Department (Department), like other natural resource agencies, faces constantly changing priorities, increased demands for services and continuous budgetary challenges. Our constituency base has broadened from traditional sportsmen and support organizations to the entire statewide population, including both consumptive and non-consumptive users, and diverse special interest groups. We recognized that our survival and overall effectiveness depended upon our ability to change with the times in order to prepare for our new role as a natural resource agency and understand that with change there will be resistance accompanied by growing pains.

Our vision was clear: maintain the quality and integrity of our mission, while aggressively pursuing alternative funding sources to meet our increasing responsibilities and the expectations of our expanding constituency base. It also was critical to recognize and respect the traditional sportsmen, who have given us loyalty throughout the years, and, at the same time, welcome our increasingly diverse, new and growing constituency.

In January 1990, our Department was approached by a group called The Arizona Heritage Coalition. This organization was trying to organize a grass roots movement to push for the protection of Arizona's diverse natural heritage. They determined that it would be in the interest of The Arizona Heritage Coalition to bring together the Arizona Game and Fish Department, Arizona State Parks, the Nature Conservancy and the various special interest groups that supported these organizations. It became apparent that this diverse coalition of individuals had the potential to be very effective at striving to achieve a common cause. The Heritage Coalition then challenged our Department and Arizona State Parks to provide a list of programs within our respective agencies that were in need of financial support, and that were appropriate as components of Arizona's Heritage concept.

Ironically, our Department has been implementing Planned Management Systems and with the approach of "Management by Objectives" we were able to provide a list of program areas that were growth limited due to serious budget constraints. These areas were Environmental Education, Habitat Protection and Acquisition, Urban Wildlife Management, Land Access and the Protection of Threatened Wildlife Species.

The Heritage Coalition pursued public support and legislative funding of their proposition through the initiative process. Mounting an aggressive petition campaign, they were able to gather enough signatures to place "The Heritage Initiative" on the November 1990 ballot. The initiative proposed a new funding source of 20 million dollars from the state lottery to be split equally between the Arizona Game and Fish Department and the Arizona State Parks Department for the conservation and protection of Arizona's cultural, historical and environmental resources. The Initiative was well-received and obtained more votes of support than any other initiative or candidate on the ballot, including the Governor.

Simultaneous to the Heritage Initiative campaign, we recognized that a dramatic cultural shift was about to take place within the Arizona Game and Fish Department. We also recognized that it would be necessary to employ a strategy that would prepare our employees and traditional constituents for the change. Our intent was to share our vision with them, to solicit their active participation in bringing about the new vision and making it a reality, while minimizing growing pains and unnecessary paranoia.

To begin, Department managers and supervisors attended extensive preparatory sessions to set the stage for ''change.'' January 1990 marked the beginning of our on-going effort to develop and maintain an active and participating team. Our team was appropriately named, ''Team Wildlife.'' Every employee within the organization attended a comprehensive program designed to improve our overall organizational effectiveness.

The program, spanning three intense days, zeroed in on the basics: (1) understanding the role and function of others within the organization in order to develop cohesiveness and empathy; (2) developing time management skills to get more done in an efficient and effective manner; (3) identifying who our ''new and potential customers'' really are and what they may want; and (4) combining a myriad of role playing activity sessions to reinforce learning. More importantly, the broad message was to reinforce the individual employee's role in achieving our mission, goals and objectives through teamwork. We knew that only through the active participation of our employees, could our vision for the future become a reality. It also gave us the opportunity to introduce all personnel to the concept of the upcoming Heritage Initiative and recognize its need, and ultimately garner their support for the concept.

Most employees embraced the message that adapting to change meant survival, that participation in change meant challenge, opportunity and reward. Each employee left the program with a clear understanding of our vision, a commitment to the Arizona Game and Fish Department mission, a commitment to teamwork, and their role clearly defined within the goals and objectives of the organization.

While participating in the program, management learned from the employees as well. It became apparent that they shared many of the same ideas, concerns and apprehensions as management—that continuing the team concept would be difficult and challenging, and not without setbacks.

During the sessions, ownership of decision making became a very topical issue. The issues discussed focused on building excellence in Department operations through improved communications, internal partnerships and a ''Code of Ethics.''

Through a team effort, the employees came up with the following commitment list of how they agreed to interact with each other to maintain the team. The first commitment was to *respect others*, followed by *act with integrity*, *resolve conflicts*, *be open and honest*, *strive for excellence*, and *practice and promote teamwork*. These guideposts are used as a continual point of reference when communication and teamwork breakdown.

I will not tell you that all has been rosy since the introduction of the team concept to the Arizona Game and Fish Department. We have learned as much from our failures as we have from our successes. (We have not eliminated our share of the ''whiners''—but they now are all whining in the same direction!)

Another challenge was maintaining the trust and support of the traditional Department constituents and, at the same time, supporting the Heritage Coalition and the broadening constituency base that was rallying around our Department. It was imperative that we solicited our traditional constituents input regarding future program direction and promoted beliefs that the recruitment of these new special interest groups into our ''Team'' would only increase our ability to achieve the Department's mission.

The passage of the Heritage Initiative gave us the opportunity to "walk our talk." The first action taken was to implement a special assignment of 20 employees from different work units throughout the Department and empower them with the responsibility to develop the framework of the new Heritage Program into operational plans. We made the decision to invite members of the coalition and various traditional groups to assist us in developing programs and establishing future direction. This gave our public ownership in the Heritage Program and status on our "Team."

We have reaped great benefits from these efforts. From the moment the initiative was passed, certain legislators have made numerous attempts at modifying the intent of the Heritage program through efforts to divert the funding to other program areas. Our Department's and Arizona State Parks' ability to avert this effort would be limited without public support. Support has been greatly provided by the Heritage Coalition who transformed into "The Heritage Alliance," an organization whose grass roots comprise over 100 various special interest groups and have generated enough financial support to hire a full-time executive director. The Heritage Alliance, with a membership diversity ranging from historical preservationists to trappers, has a primary objective to monitor and ensure continuity of the State Heritage Program. This has been beneficial on the legislative front, but viewed by some as troublesome in program administration. Our Department's approach has been to view the Heritage Alliance as a member of "Team Wildlife," a direction we will take with our entire constituency base.

We are about to embark on a renewal of our "Team Wildlife" commitment; bringing new employees into the "light," while enhancing the teams we already have developed and rebuilding those that have broken down.

Comprehensive and responsive management techniques currently are being integrated, along with the implementation of "Total Quality Management." We have embraced the concept that a commitment to quality is a commitment to continuous improvement; that there is no beginning and end to team building, but it is an evolutionary process. We are aware that there has been no "quick fix" to management and organizational problems and that 99 percent is not good enough.

We are striving to be on the cutting edge of the new and emerging vision of public agencies: lean, decentralized and innovative; flexible, adaptable and quick to change; and competition driven and customer oriented.

Critical to our success in embracing a new vision for the Department was the obvious need for additional funding to respond to these new challenges and our changing role as a natural resource agency. Even with the additional funding achieved through the Heritage Program we have realized that this will be perpetual challenge. We were fortunate to have public support for the Heritage Initiative and continued support for the developing programs. But we are even more fortunate that our "Team" was willing to accept and embrace change. Change always is occurring and always will be resisted. If we in the profession of resource management are to survive the future, we must adopt and overcome all obstacles and accept change, not as an obstacle, but as a challenge and opportunity.

In the words of Dr. W. E. Deming, "You do not have to do this; survival is not compulsory."

Paying Attention to Politics Pays Off in South Carolina

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During 1992, the South Carolina Wildlife and Marine Resources Department (Department) was selected as a participating state agency in the Management Effectiveness Project initiated through the Organization of Wildlife Planners, U.S. Fish and Wildlife Service Division of Federal Aid, and Virginia Polytechnic Institute and State University. One of the major parameters that identified the Department as an effective agency was the political arena. There was nearly unanimous agreement that the agency is a politically effective state agency and the study noted that having had success in this arena is a story worth sharing with other fish and wildlife professionals so that it may produce ideas or be of benefit to other fish and wildlife agencies throughout the country. The purpose of this discussion, therefore, is to identify and discuss the political arena in South Carolina and the manner in which the Department integrates within this arena to enhance its effectiveness. This discussion is not intended to produce a single variable that an agency would review to enhance its own effectiveness, but to identify a process that has worked effectively for the Department, in an attempt to help other agencies identify a process or those processees that may be beneficial to enhancing their effectiveness.

To understand the manner in which the Department integrates in the political environment in South Carolina, it is important for one to understand the nature of this environment and its structure. South Carolina has traditionally been predominantly a legislative state dominated and managed from a policy standpoint by the South Carolina General Assembly. The South Carolina General Assembly is composed of 124 members of the House of Representatives and 46 members of the South Carolina Senate, all serving under single-member districts. The General Assembly also has been organized throughout its history by County Legislative Delegations composed of elected representatives and senators that reside and/or whose districts are in a particular county. These County Delegations have made various legislative initiatives and policy decisions on a county basis for a number of years. The implication of this type of structure has been the passage of local legislation which is countywide in nature as it relates to resource management, law enforcement and related items.

In addition to the General Assembly, the Governor's Office is a very vital component in the political structure in South Carolina. Our present Governor is in the second term in office and the previous Governor also was a two-term Governor for eight years. Thus, both Governors have used the time to gain more credibility and improve working relationships with the General Assembly, which enabled them to focus their primary agendas. With the two-term Governors, the ability to garner political support for their focus areas has been enhanced and created an environment in which our agency has worked diligently to become a part of this process for the benefit of our programs and services. In addition, these Governors have appointed our South Carolina Wildlife and Marine Resources Commissioners which are our policy making governing board and the impact on these appointments certainly has tailored the direction and perspective of our agency.

As mentioned earlier, the main component in the political process in our state is the General Assembly, and it is through this body that our agency has to focus its efforts in the political process in order to accomplish importance to our Department because the General Assembly controls all aspects of our agency's operations. We work closely with the General Assembly because our agency has a statutory mandate to advise the General Assembly each year on fish and wildlife, marine, natural resources, boating, law enforcement and related issues, and our agency also has regulatory authority over fish and wildlife programs and can promulgate regulations which must be approved through the General Assembly. Thus, our interrelationship with the General Assembly is of utmost importance. In most cases, all of the Department's programs and services are governed through actions of the General Assembly and most of our direction is given statutorily and it is important to work through this statutory process to present a program which will be beneficial to the agency.

As a result, our agency each year develops a formal legislative proposal, approved by our Commission, which is presented to the General Assembly for consideration. This proposal is processed through the House Agriculture and Natural Resources Committee and the Senate Fish, Game and Forestry Committee. In addition to working diligently on this process, our agency also reacts to legislation that affects the Department as it relates to resource management, law enforcement and day-to-day administrative matters, such as the State's Procurement Code, Personnel, Administrative Procedures Act and other legislation which affects our Department. It is through these processes that the Department integrates through all subcommittees, committees and legislators in the General Assembly and we depend on various networks to assist in this process on proposed legislation.

Basically, the Department's ability to work in the political arena through the various entities of the political structure in South Carolina is governed by two major systems. One system is a formal system whereby the agency works closely through the Office of the Governor, standing Committees of the House and Senate, the leadership of the General Assembly and through the contacts that our agency has with any and all members of the General Assembly itself. The Department's legislative proposal presented to the standing committees in the House and Senate, as well as other legislative initiatives which develop over a period of time, help drive this formal process and provide a mechanism of contacts which evolve by the very structure of the political environment itself. This formal structure is important to the agency's operations and ensures that there is forum in which to deal with legislative issues which govern our agency. It also provides a mechanism whereby our agency can recommend change based on sound resource management data and other tools that are important to maintaining viable wildlife and fishery populations and habitat in South Carolina.

In addition to this formal system, there is an informal system of political contacts with the General Assembly and other groups in South Carolina that ranges from the top to the bottom in our agency. These contacts include our Commissioners, Executive Staff, Division Directors, top management staff, Chiefs of Fisheries, Law Enforcement and related positions, as well as contacts with legislators and others by field biologists, law enforcement officers and other personnel that we ask to make contact with legislators or other elected officials. Through the political culture in our state, legislators depend heavily on the voice of their constituents to help them decide how to vote or deal with various issues and we have learned through the process that direct contacts by a few constituents in a legislator's district can have a profound impact on his or her decisions on an issue.

As such, our personnel located throughout the state are people that are respected in the community and their contacts with local legislators and the networking that has developed has an effect on the way legislators vote on various issues. In addition to the process that we use with our staff, we also depend upon constituent groups and leaders in the community to provide this kind of networking in contacting legislators on resource issues. Another group on which we depend heavily is our Advisory Boards to our Commission which is appointed jointly by the Governor and our Commission. These Advisory Boards are established to provide public input to our Commission on resource management issues and they are composed of citizens located throughout the state who are active in the outdoor arena and are interrelated with hunting, fishing, and other aspects of the programs and services provided by our Department. These Advisory Boards are appointed along programmatic lines to include Law Enforcement and Boating, Marine Resources, Wildlife and Freshwater Fisheries, Conservation Education and Communications, and Marine Saltwater Recreational Fisheries. Over the years, the Department has learned that the effective use of these Advisory Board members in the political arena can be quite beneficial and have impacts on the manner in which legislators make decisions and vote on particular issues. In general, the informal system has been quite effective for our agency and subsystems are developed depending upon the timing, the nature of the issue and whom the Agency feels could be most beneficial in having an impact on legislators for a particular matter.

Another area the Management Effectiveness Study identified was the credibility of the Department with the public and the agency's leadership which has provided for an enhanced ability to be effective in the political arena in South Carolina. In general, the Department has credibility with the public as there is a very strong public involvement and public decision-making process which has enabled the Agency to gain tremendous public support. This public support obviously has been quite advantageous in the political arena as various leaders in the community, constituent groups and related supporters are utilized in the network of political support for various resource, budget and other issues.

The Department is run in a highly professional manner and the Management Effectiveness Study revealed that most resource management decisions are made on a scientific basis rather than through the political process. By maintaining a highly professional organization that governs the resource management process, we have generated greater public respect for the Department, thereby preventing decisions from being made strictly on a political basis.

Another area in which the Department has gained political clout is through its leadership. Dr. James A. Timmerman, Jr. has been able to develop continuity of leadership, serving as Executive Director since 1974, and has gained the respect of the Governor, legislators and other participants in the political arena. It is through Dr. Timmerman's approach and leadership that the Department has been successful in the General Assembly; he is highly respected by the legislators and other key politicians. This leadership, along with effective direction of the Commission—which has approached its policy role from the standpoint of resource management rather than politics—has further enhanced the Department's credibility, not only with the public, but with the legislature and others. The Executive Director and Commission also have worked diligently on constituent needs and keeping legislators informed on problems and issues in their respective districts. This type of networking is of utmost importance in a political climate such as South Carolina's, in order to be effective and gain results that are beneficial to the resources and their users.

In general, the use of the political structure in South Carolina has basically been a part of the Department's marketing strategy to promote the programs that the agency feels are important and to gain change or secure needed decisions for the benefit of resource management in the state of South Carolina. The Department deals with public goods and services, and the manner in which these goods and services are delivered to the public must be viewed from the standpoint of marketing any type of product. In the case of our agency, the marketing of this product includes the effective integration within the political environment. This type of marketing strategy is basic in nature, but very complex in delivery, thus, the effectiveness of the strategy is determined by the results which are achieved. Thus far, the results have been positive and the agency maintains a very high profile in the minds of the people of South Carolina, as well as the political leaders of the state. An example of the Department's effectiveness in this process is in the fact that approximately 45 percent of its budget is comprised of general revenue funds for all programs, which indicates political credibility gained through such funding for the Department.

In conclusion, the legislative and political environment in South Carolina is by nature the driving force in which decision making occurs and through which the Department must work to attain needed results. The agency has been able to adapt to this political environment and not only work within that environment to maintain adequate programs, but it has been able to use the environment to enhance its programs through strong political involvement by all components of the Department and through networking of public support throughout the state. While this may work effectively in one state, it does not necessitate that such would be the case in all states. Each state must access its own political environment and develop a system which works best for the respective fish and wildlife agency and ultimately the resource. The South Carolina Wildlife and Marine Resources Department is fortunate to be able to adapt to the political environment described and gain desired results. The ultimate goal of this political system is to be of benefit to the wildlife, fishery and marine resources in the state of South Carolina and the Department feels as though it has met this obligation to the public and to the resource.

Florida's Environmental Law Enforcement Program

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Background

General littering and the unlawful dumping of household garbage and other waste has been a problem in Florida for many years, as it has been in most other states. While such activity created unpleasant sights and was offensive to many people, particularly landowners, its magnitude was not sufficient to significantly impact wildlife or its habitat.

During the 1980s, Florida Game and Fresh Water Fish Commission (Commission) personnel noted increasing noncompliance with environmental laws. As Florida's population increased, so too did garbage and landfill disposal fees, resulting in significant increases in illegal dumping. Dump sites in woodland areas became commonplace, most often occurring on private lands without landowner consent. Ironically, landowners often were held responsible for illegal dumps on their property and were made to clean and restore the sites even though they were innocent victims. Such instances resulted in many lands previously available for public recreation being closed to public use, including thousands of acres of public hunting lands in the Commission's wildlife management area programs.

Also, new laws governing disposal of hazardous waste increased disposal costs and thus illegal disposition of these very damaging materials. Other laws protecting the environment and fish and wildlife habitat were enacted, both by the Legislature and by regulatory agencies, with similarly unacceptable levels of compliance.

There were several additional factors contributing to increased noncompliance. First, violations of environmental laws generally were not taken very seriously by the public, the courts, or prosecutors, and certainly were not looked upon as criminal acts. Rather, they were viewed in the same way as wildlife violations once were viewed. Second, the regulatory agencies responsible for enforcing Florida's permitting and other protective requirements have no criminal enforcement authority or expertise, and must rely on less timely and effective administrative processes and civil court procedures to obtain compliance from violators. Third, there was no agency with criminal enforcement authority and expertise making a concerted effort to enforce these laws through criminal prosecution.

As a result, Commission personnel encountered more and larger dump sites of garbage, construction debris and other waste; encountered heavy metals, pesticides and other toxicants in fish and wildlife; noted declining quality of aquatic habitats due to numerous sources of pollution; and observed degradation and destruction from illegal dredge and fill and other habitat-altering activities.

In assessing these impacts, the Commission's administration concluded that noncompliance with state and federal environmental laws was having a more devastating and irreversible effect on the fish and wildlife resource than noncompliance with traditional hunting and fishing laws. Because of the state's projected growth, the increasing costs to comply with environmental protection laws, and the lack of a concerted criminal enforcement effort on a statewide basis, it was anticipated that violations would increase with corresponding adverse impacts to fish and wildlife.

Commission Response

While performing traditional resource protection duties, Florida's wildlife officers have, for many years, made arrests for certain environmental violations as they were encountered. However, due to the increasing complexity of apprehending and prosecuting environmental violators, it was recognized that enforcement incidental to other duties was insufficient to assure an acceptable level of compliance.

The Commission administration concluded that to meet this challenge to the well-being of fish and wildlife, and to at least begin to reverse the degradation of their habitat, a concerted effort specifically directed at environmental law enforcement by a group of experienced, well-trained officers with broad legal powers would be required. Commission officers were determined to be best qualified to fill this role for several reasons. First, resource protection was the function of the agency and the job of its officers, and both had proven records demonstrating their commitment. Second, Commission officers already were involved in environmental enforcement to some degree and had acquired some knowledge and expertise in criminal prosecution of these violations. Third, the officers already were known to the courts and prosecutors as competent resource enforcement professionals and therefore would be more readily accepted in that capacity than general peace officers or a new, unproven group of officers. Fourth, Commission officers not only have full police powers, enabling them to enforce all laws of the state, but have additional statutory authority not granted other state officers, to wit, to "... enter upon any land or waters of the state for performance of their lawful duties ... and such entry shall not constitute a trespass." Lastly, habitat protection was identified as the Commission's first priority in managing and protecting fish and wildlife resources, and the impact of environmental law violations was having a greater negative impact than violations of traditional protective regulations.

Recognizing that obtaining additional personnel and funding for this initiative was highly unlikely, if not impossible, the Commission undertook the effort with existing resources. In October 1989, the Commission established its Environmental Enforcement Unit, utilizing 39 positions formerly classified as Wildlife Corporals and serving as first-line supervisors of wildlife officers. Although these corporals were serving an important function, environmental enforcement was deemed a higher priority. Adjustments in supervisory duties were made throughout the chain of command to compensate for the reassigned corporals.

Staffing the Unit with existing personnel provided several positive aspects: the Commission received credit for undertaking a major initiative without additional costs or employees; the removal of an entire level of supervision from the chain of command was well-received at all levels in the enforcement division, particularly by the wildlife officers; and experienced officers immediately were available to initiate a new enforcement program. This last factor is particularly important because of the specialized aspects of the program, the often lengthy and frequently sensitive nature of the investigations, and the necessity of minimizing mistakes in a new enforcement endeavor.

The Unit was assigned within the Bureau of Field Operations, and divided into five teams, corresponding to each of the Commission's five administrative regions. Each regional team has a supervising sergeant; each officer is classified as an Investigator I.

As teams are assigned on a regional basis, a close working relationship is maintained with other regional personnel, both enforcement and biological. This is especially important as these employees supply vital assistance to the teams by reporting violations, providing intelligence information, providing back-up for surveillance and arrests, and other support.

Officers assigned to the Unit were given additional training in specialized state and federal environmental laws, the elements of various violations, appropriate charges to file under given circumstances and other processes unique to environmental law enforcement. Extensive training was given in Superfund law, the Federal Insecticide, Fungicide and Rodenticide Act, the Resource Conservation and Recovery Act, and the environmental applicability of the Racketeer Influenced and Corrupt Organizations Act (RICO). To date, officers have attended 63 different training courses providing the Unit considerable environmental enforcement expertise ranging from air quality violations to groundwater contamination.

Authority

The Commission's primary and most compelling authority derives from the Florida Constitution, which states: "The Commission shall exercise the regulatory and executive powers of the State with respect to wild animal life and fresh water aquatic life. . . ." This provision has been interpreted by courts and the Attorney General to bestow broad authority upon the Commission to take all legal actions necessary to protect and manage the resources with which it is entrusted. Such authority encompasses enforcing the environmental laws of the state when violations have negative impacts on fish and wildlife and, as previously stated, wildlife officers are empowered by statute to enforce all laws of the state.

The Legislature enacts laws and various state agencies enact rules protecting the environment, most of which provide for criminal prosecution, as well as civil remedies. These are the provisions of law on which Commission officers focus. Examples are Department of Health and Rehabilitative Services, and Department of Environmental Regulation (DER) rules governing sewage disposal and hazardous waste; DER and water management district rules governing dredge and fill in wetlands; and statutes dealing with pollution of the state's waters.

The Florida Litter Law, §403.413, F.S., is perhaps the Unit's most effective and most utilized source of authority. This law defines litter very broadly to include, among other items, garbage, tires, appliances, building materials, vehicles and sludge. It is a broad mechanism for prosecuting not only ordinary roadside littering, but other common environmental violations as well. It provides for felony prosecution of illegal commercial (for profit) and large-scale dumping, and provides for forfeiture of vehicles and equipment used to dump larger quantities of litter. In addition to traditional criminal penalties, the law allows the court to order the violator to remove or render harmless the litter, repair or restore damaged property, pay damages, or perform public service.

As the Commission often is enforcing rules or laws made by or in some way involving other agencies, it is imperative that close interagency coordination be maintained, particularly at the field and enforcement level. Working cooperatively, agencies can utilize civil, administrative and criminal processes, as appropriate, to obtain compliance. Obviously, to work independently on the same case would not only be counterproductive and duplicative, but could result in persecution rather than prosecution of violators.

Results

Initially, there was concern that assignment of personnel to environmental law enforcement would result in diminished effectiveness in enforcement of more traditional resource protection and boating safety laws. However, monitoring of activities in these areas detected no decrease. In fact, during the first full year of the Unit's existence, total resource and boating arrests increased by 9 percent over the previous year.

The Unit's goal is to significantly increase compliance with environmental laws. Often, education and information efforts better serve this purpose than arresting someone. Depending on the nature and severity of the violation, the intent of the violator, previous dealings by the violator with regulatory agencies, and other factors, officers may choose from several options. They may simply inform the involved individual(s) of the law and request compliance, refer the matter to the appropriate regulatory agency for administrative or civil actions, issue a written warning, issue a citation and pursue criminal prosecution, or select some combination of these options.

Even though arrests are not the objective, they often are the most effective means of obtaining compliance and sending the message that violations will not be tolerated. Some violators obviously have decided that administrative actions and civil fines simply are a cost of doing business. However, an arrest record and criminal prosecution are another matter entirely, and just the possibility of being subjected to these actions has compelled compliance from some individuals.

The number of arrests made by the Unit during its first three full years substantiates that significant violation of environmental laws is occurring. The Unit issued 691 warnings and 966 arrest citations in 1990, 497 warnings and 996 citations in 1991, and 1,534 warnings and 1,266 citations in 1992. Arrests and warnings by the Unit continue to increase, even though members spend approximately half their time assisting in traditional resource and boating law enforcement.

Disposition of cases generally has been excellent, with courts and prosecutors increasingly recognizing the seriousness of these violations. For purposes of analysis, cases are considered successfully concluded if the defendant enters a plea of guilty or is found guilty by a judge or jury; if a pretrial agreement is reached that includes remedial action by the defendant; if adjudication of guilt is withheld but the defendant is placed on probation, pays court and/or investigative costs, or is ordered to take remedial action. Applying this criteria, the Unit's successful disposition rate is 90 percent.

Examples of Cases Made

The following are brief descriptions of just a few of the cases made since the formation of the Unit.

1. In north Florida, two individuals were charged with felony littering for dumping dead chickens in a wildlife management area. These poultry farmers were using the site to dispose of thousands of dead, dying and diseased chickens. This activity posed a direct and real threat to native turkey and quail populations.
2. In central Florida, the owner of a waste oil company was charged with felony commercial dumping after one of his 10,000-gallon tank trucks was observed driving down State Road 19 in the Ocala National Forest with the drain valve open and waste oil pouring onto the road shoulder. Not only is waste oil itself a contaminant, it contains heavy metals that can pollute surface and groundwater supplies.

3. In the Panhandle, two individuals were charged with felony dumping after illegally disposing of over 3,000 waste tires in a two-week period in an isolated area south of Tallahassee. Tires pose a very real fire danger, become breeding grounds for mosquitos and vermin, and release toxins as they degrade.
4. In south Florida, two individuals contracted with a nursery owner, at bargain prices, to dispose of unwanted chemicals. They abandoned a semi-trailer loaded with acids and out-of-date pesticides adjacent to a wildlife management area. As a result of a newspaper photo of the trailer and accompanying story, the nursery owner recognized the trailer and led officers to the guilty individuals.
5. An investigation in the environmentally sensitive Florida Keys revealed an illegal dump site containing batteries, tires, used motor oil and various chemicals. The corporation involved, and some of its employees, were charged with operating an illegal landfill and felony dumping. The water in this dump site was tidally influenced and the contaminants would have leached into the adjoining bay.
6. Numerous cases have been made statewide for the illegal disposal of raw sewage. The situations varied from individuals dumping tank truck loads of sewage onto unpermitted sites or in remote areas, to fish camps and recreational vehicle parks pumping raw effluent directly into rivers and streams. Raw sewage poses a definite health threat to people, as well as to fish and wildlife.
7. All too often, individuals and companies illegally and intentionally dispose of hazardous waste materials improperly. These materials pose a direct threat to fish and wildlife, as well as potentially affecting groundwater supplies. In one instance, the DER was monitoring a firm in Brevard County that generated hazardous waste. Investigation by Commission officers discovered that prior to DER inspections, employees routinely removed barrels of hazardous waste from the premises to unknown locations. Additionally, hundreds of gallons of phosphoric acid were being poured into an underground holding tank. Unknown to DER, the tank had a pipe in its side that drained into surrounding groundwater. This investigation resulted in a record DER penalty assessment of $425,000 for a hazardous waste violation.

Unit Acceptance

Since its inception, the Unit has enjoyed strong support from the environmental community, sportsmen, media and the public in general. However, some segments of agribusiness (primarily ranchers and farmers) and petroleum and development interests oppose the Commission's involvement in environmental enforcement. Their opposition seems to stem from several factors: a misconception of the Commission's enforcement policy for environmental laws, believing criminal prosecution will occur for any infarction, no matter how minor; a belief that Commission enforcement efforts should be confined to traditional resource laws; a belief that environmental laws, except for the most serious intentional violations, should not carry criminal sanctions; and a general disagreement with all environmental laws and opposition to all enforcement, criminal or otherwise. This opposition, though relatively small in numbers, is politically influential and was successful in placing legislation before the Florida House Natural Resources Committee in 1991 that would have prohibited enforcement of environmental laws by Commission officers. However, due to the actions and testimony of the program's supporters, and the demonstrated benefits of the Unit's work, this proposal was defeated by a 17 to 7 vote of the Committee.

During the 1993 Florida Legislative Session, the program was again faced with a legislative challenge when a House Appropriations subcommittee moved to delete all the positions assigned to the Unit, as well as its appropriation, from the Commission's budget, ostensibly as a cost-cutting measure. The legislator who initiated this action later stated that he opposed the Commission's efforts in the environmental enforcement area. Again, due to an even greater expression of support by the public, various organizations and particularly newspapers, this move was defeated in the full House Appropriations Committee by a 24 to 13 vote. It is hoped that this will be the last legislative challenge to the Commission's program and that the Commission's enforcement of environmental protection laws will be accepted as appropriate, necessary and a highly effective means to protect the state's fish and wildlife resources.

Conclusion

Violation of environmental laws poses a significant threat to the long-term welfare of fish and wildlife. Without the compliance achieved by rigorous enforcement, even strong laws offer scant protection. Florida's Environmental Enforcement Program, while still in its infancy, demonstrates the ability of a fish and wildlife agency to fill the enforcement void and markedly improve protection of the resources and its habitat.

Implementing Management Effectiveness Strategies

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Introduction

This session was designed as a unit. According to the time-tested speech outline, Larry told you what we were going to tell you; Steve and the other presenters told you; and I'll tell you what we've told you—and talk a little about where we go from here. I'd like to thank and compliment the authors and presenters for giving us some valuable food for thought, along with some suggestions for action. One caution, however, may be in order—don't go home and try to do these things yourselves, at least not without carefully analyzing your situation first. As exciting as Idaho's Wildlife Congress or Wisconsin's ''Managing for the Future'' sound, they might not be a good fit in your situation, or they might need modification. As we've learned from helping states develop management systems over the years, each situation is different. It's dangerous simply to copy what worked for somebody else.

This project began, as Larry explained, with a fairly simple notion: that there is a lot of good management being practiced by fish and wildlife agency administrators. As we set out to document that good management, we first had to define the boundaries of success—of agency effectiveness. Those boundaries included the 21 parameters discussed in McMullin et al. (1991). Those boundaries—parameters—are a useful context for considering how to address preparation for a changing future.

The Good News

The good news is that, as you already have heard here today, there are wonderful examples of effective management in fish and wildlife agencies. The frequent assertions that fish and wildlife agencies led by people with largely resource management backgrounds cannot be well managed simply is not true! It is more good news that the presentations by Steve and by the representatives of the nine case study states here today only scratched the surface. Information from the agencies not included as case studies is coming in response to a survey by the Organization of Wildlife Planners (OWP) and will provide, I'm certain, many additional exciting ideas.

What's Happening—Where Are We?

As trend watchers tell us, and as we all realize, we are living in a new and unpredictable world. In 10 years, at least one fourth of all current ''knowledge'' will be obsolete. The life span of new technologies is down to 18 months and still decreasing. Within 10 years, 20 times as many people in the U. S. will be working from their homes. Two-career families will multiply: currently half of all families have two paychecks; this will increase to three quarters. Workers under the age of 25 can expect to change careers every decade and jobs every four years. Women, who now own more than 3 million businesses, will own more than half of all businesses by the year 2000. Minorities are a growing influence. The public demands more participation and new services for less money.

In short, it's a new game and the rules are different. Fish and wildlife agencies are newcomers to this broad and diverse arena, and simply recycling, revamping or revising conventional wisdom will no longer assure success (Peters 1992).

Although the business community has invested vast amounts of time and energy preparing for and dealing with change (Peters 1987, Lynch and Kordis 1988), fish and wildlife agencies continue to focus primarily on the technical aspects of their areas of specialty. But the game has changed. The truly big decisions facing resource managers are settled more on the basis of economic, social, or political concerns, rather than biological, technical or "factual" concerns. The old rules no longer apply.

Retaining and increasing market share for the products and services of fish and wildlife agencies in a world filled with televisions, video games and computer-generated recreation is a formidable task.

The framework described by the 21 parameters of management effectiveness can be employed by fish and wildlife agencies to prepare for the greater challenges of the new game.

Where Are/Should We Be Heading?

As resource agencies embrace the concepts of "planning," they grow less enamored with "plans." In the future, even more than in the past, planning systems and processes will become more significant, while plans will become only small steps necessary for the documentation of rationale, decisions and policies (Crowe 1989). Public input and involvement will be important to virtually everything agencies do. Achievement of resource management goals will be dependent on the integration of human dimensions data into resource management policies, programs and plans.

If our leaders take advantage of the opportunities the environment provides, the business of fish and wildlife management will be a growth industry in the coming decades. At the same time, it will be important to recognize that the business of fish and wildlife management is just that—a business. And fish and wildlife agencies will have to explicitly decide, for the benefit of themselves and their constituents, what business they are in.

In the future, the answer to the question "What business are we in?" must be broader. More and more constituencies are forming effective advocacy groups, all with potential veto power over agency actions. Sometimes these groups work with the agencies themselves and sometimes through the political process. In any case, it is clear that in order to function effectively, agencies must function in such a way that the various, often competing interests do not neutralize management decisions.

Professionals in fish and wildlife management are well trained and educated in their several fields of technical specialty. But as individuals, we must not forget that these professionals have very different viewpoints and values than the general public. Though complex and sometimes difficult, it is imperative that public and professional values and viewpoints be balanced throughout the decision-making process.

The subject of "trends" and trends tracking continues to gain attention. John Naisbitt (1982) brought significant attention to trends analysis in his book *Megatrends*. In *Megatrends 2000*, Naisbitt and Aburdene (1990) outline 10 directions they claim will take us into the next century. Although works like *Megatrends* and others (e.g., Faith Popcorn's predictions in *The Popcorn Report* [1991]) offer new ideas and direction for fish and wildlife agencies, it is even more important that agencies track relevant trends themselves and carefully consider the consequences of trends for the fish and wildlife business. For instance, trends in demographics, social awareness and attitudes, and consumer values could influence fish and wildlife management policies and redefine the profile of an effective agency.

Challenges facing fish and wildlife agencies in the future will be both internal and external. There will be challenges stemming from the interests, needs and values of employees, and challenges from the interests, needs and values of customers. Fortunately, the tools exist to identify these evolving interests, needs and values and to incorporate them into programs and policies, even though the future may be very different in many instances. Fish and wildlife professionals will rely on social, economic, political and cultural information as much as biological knowledge, and the citizenry will have its say regarding resource use, conservation practices and management programs.

Institutions will undergo significant changes as well. Agencies responsible for the management of fish and wildlife will become parts of larger super-agencies under the leadership of politically appointed and sensitive directors (although these agencies will continue to be run as separate businesses). It will be harder for single-focus constituencies to "capture" and control agencies. A few traditional fish and wildlife agencies may cease to exist or may lose control because they are unwilling or unable to adapt to the changing environment (a business corollary to the ecological principle of natural selection). Undoubtedly these dinosaurs will be replaced by agencies better suited to the fast-paced, customer-oriented world.

Successful fish and wildlife agencies in the future will be those foremost at translating general knowledge and understanding to their specific situations. A profile of an effective agency in the future can be described in terms of the management effectiveness parameters.

Profile of an Effective Agency

The profile of an effective agency in the future begins with the agency attitude (sometimes referred to as the agency "culture"). The agency will have a positive attitude about its customers and about its employees. Above all else, the effective agency will be open, honest and fair with customers and employees. As Bleiker (1990) points out, employees are simply a special class of customers.

Public support will be *active* support, not passive. Because the public understands and cares about the importance of what fish and wildlife agencies are doing, support will flow naturally through demands for agency products and services. This support will be manifested through activist, political channels. Through a variety of outreach and partnership activities, agencies will aggressively provide information to all constituents and will seek to involve constituencies in planning and evaluating programs.

Effective agencies will explicitly engage in marketing, just as any successful business or corporation does. Specific marketing tools and activities will focus on listening to customers, providing information to customers and packaging agency programs to meet customer needs. Agencies in the future will face an increasingly educated and sophisticated public and must abandon the perceived needs to be "the experts" in fish and wildlife management and to dictate societal goals for fish and wildlife resources. Ecological information and education programs will take advantage of the public's strong ecological awareness, providing factual, honest, and entertaining perspectives on basic ecological issues of the day. Two-way communication technology involving digital telecommunications will facilitate sharing information with the public, as well as allow citizens to share their ideas in a user-friendly way.

Agency management and leadership will be the keys to agency survival and prosperity in the new business of fish and wildlife management. To be effective in this playing field, leaders must understand the changing values of customers and employees alike and apply new skills. Leaders failing to understand and practice the new approaches will drag their agencies out of the game.

Communications technology will be important for informing customers and employees alike. Rapid, routine polling on critical public issues will be possible through computer and video technology, as will wide-spread dissemination of information. The effective agency will practice the philosophy of service; decentralization of authority and responsibility to local levels will promote an attitude of stewardship at the community level.

The effective agency of the future will be effective politically. Because of open information sharing with customers, today's common practice of special interests using the political route to lobby for their ideas and desires will become obsolete. The issue will turn from whether groups can get their way to whether the agency is employing a fair, reasonable decision-making process. This means that although not everyone can have their way, everyone can have their say! And more importantly, they'll be heard.

Fish and wildlife agencies will have an increasing share of society's attention with increasing opportunities to influence other social sectors. The effective agency of the future will develop the role of providing staff support to the political process, assuring solid, objective resource information for the decision-making process. Because of the complexity of issues in the natural environment, cooperative programs involving representation from various specialties and diverse organizations will become the norm.

Agency trepidation with planning largely will disappear; it simply will be unreasonable for an agency not to identify goals, set priorities and be accountable in both program and fiscal arenas. The effective agency will have explicit *processes* and procedures for planning and evaluation. It will be judged as much on the integrity of its planning, management, and decision-making processes as on the results of individual decisions. Effectiveness will be directly related to how well the agency anticipates and responds to customer needs and wants.

Predicting the future is virtually impossible. However, the philosophy of the successful agency will be one of anticipating change, rather than expecting a static environment. The successful agency will actually stimulate change, constantly seeking out new opportunities. Employees will be sought and nurtured, from such non-traditional resource management backgrounds as sociology, anthropology, economics, journalism, education and marketing.

Adequate funding will continue to be a challenge. However, through a variety of innovative and cooperative approaches, new funding sources will be developed. Private companies, rather than being viewed as competitors, will be encouraged and assisted by public agencies to provide fish and wildlife oriented products and services. Many unique and innovative partnerships will result.

What we have called "conflict resolution" in this study will become a normal pattern of anticipation, reasoned discussion among all parties and collaborative decision making, thereby avoiding most conflicts as we now know them. Opinions of all stakeholders will be sought early and genuinely. Environmental scanning, practiced as part of the planning process, will provide insights into trends and issues before conflicts arise (Schenborn 1985). Such philosophies will reduce the potential for conflict; prevent premature curtailment of soundly planned, ongoing programs and activities, and identify the programs and activities that really do need to cease.

The effective agency of the future will seek common elements of agreements among factions and will emphasize achievement of shared goals. Agreement on basic values and goals among competing interests will bring implementable programs and solutions. Sharing responsibilities for planning and decision making with all stakeholders—including potential antagonists—will make ''partnerships'' the standard for effective program implementation. It is even likely that the fish and wildlife agency will share some of its authority with its partners.

Employees will be the stars of tomorrow's effective agency. The agency's attitude must be one of facilitating the success of its employees. This will include employee involvement programs, such as in-service training, provision of the most up-to-date technologies and equipment, pay plans and initiatives, and job enrichment, as the basic tools of personnel management. Continuing education will consume a substantial portion of each employee's time as a true cost and investment in the personnel component of the agency budget. Employees will have greater freedom in determining appropriate strategies for completing tasks and meeting responsibilities. Evaluations will emphasize team performance and contributions, rather than only individual achievements. Employees will be involved in defining individual and group goals, as well as establishing agency direction and policy. In some cases, the agency will decide to rent, rather than own, expertise. Routine tasks and rarely-needed special expertise, especially, will be candidates for contracting to private firms.

The agency mission will be clear, simple and articulated so easily that everyone, customers and employees alike, can envision their roles in that mission. The joint efforts of customers and employees, the implementation of creative solutions to solve old and new problems and the cooperative efforts of numerous agencies will result in improved fish and wildlife programs for everyone. A focus on management effectiveness will reinforce and strengthen existing programs and lead the way to more innovative and responsive fish and wildlife management strategies.

The strongest assurance of a bright future for the fish and wildlife management business is the public demand for the products and services provided. By explicitly defining its products and services and applying marketing techniques and other tools for communicating and sharing information, the agency will build successful partnerships with existing and new customers, and enhance management effectiveness.

To be successful in dealing with the future challenges, both internal and external, the effective agency will employ effective management *processes*, using more than just biological or wildlife strategies to anticipate and respond to other real needs.

Communication technology will play a major role in the future of resource management. Members of the public, and especially representatives of the growing number of constituent interest groups, will have easier access to more information than ever and can process that information just as readily as resource management professionals. The effective agency, therefore, must view each change and innovation in technology in light of how such developments can be used to communicate with customers and better integrate information and viewpoints into management processes and programs. Communication on the human side also will expand. Collaborative processes such as negotiation, consensus building and facilitation can improve and increase communication skills and effectiveness (Nierenberg 1986, Fisher and Ury 1981, and Doyle and Straus 1976).

How Can/Will We Get There?

First of all, we have to have the proper mind set, or philosophy. ''There'' as a single static objective doesn't exist. We are talking about continual pursuit of enhanced agency effectiveness—a direction, not a destination. The philosophy of constantly seeking ways to become more effective is a must for success in the future. It will not be possible to relax the commitment to being the best we can be.

Previous presenters here today outlined some of the actions and strategies they are employing in their constant pursuit of management effectiveness, and I just gave my vision of the model effective agency. Now I would like to go back and revisit some of the areas that I think will be most critical in the future.

Public Support and Awareness Category

The way agencies relate to their various publics will probably do more to help achieve management effectiveness than any other single thing. The whole package of identifying the full range of customers, *actively* seeking their ideas, and acting on those ideas in partnership fashion with groups of customers and stakeholders is an important demonstration of the philosophy of managing the agency in a totally open, honest manner. Agencies must seek public input not only because that is the ''right thing to do,'' but because that is the agency's role in the future. The public will not tolerate insincerity from agencies in the future.

The main point in achieving effectiveness in dealing with the public is to be aggressive communicators, including not only providing information, but just as importantly, listening and involving people in the agency's business. Constituencies are broader than just hunters and anglers. The new, non-traditional customers need developing and nurturing just as aggressively as these traditional customers. Hire and use employees with greater training in the social sciences—especially those concerned with two-way communication with constituents. However, in spite of hiring employees with special focus on communication skills, it is every employee's job to communicate (sharing information *and* listening) with the public. Work actively with schools—implement the long-term view that today's students will be tomorrow's customers. In setting agency goals, as well as in developing, selecting and evaluating agency management plans, share responsibility with constituents; invite them to serve on agency task forces to deal with important issues. The dramatic increase in the level of public interest in fish and wildlife management issues will benefit agencies only as long as agencies take the time to listen and involve their customers.

Agency Management Category

Dealing with the changes in management approaches required for agency effectiveness in the future may be a challenge for some agency leaders. This is because employees in fish and wildlife agencies learn their management skills and practices by watching those around them. Unfortunately, there haven't been enough good examples of leaders who concentrate on communication skills and interpersonal relationships; who are good listeners as well as good talkers; who are sensitive to and supportive of employees; who are open, participative and teamwork oriented; and who emphasize employee training as a basic part of doing business. These are the trends in effective agency leadership, and they offer large rewards to those strong enough to develop them into their personal styles.

Balance crisis management with focusing on the future. Provide and encourage training and continuing education opportunities for all employees, and balance concern for tasks with concern for employees. Welcome all news from employees, not just the good. Leaders who fail to develop and involve their employees will simply find their influence eroding as employees turn to others who will listen. Involve employees in planning and decision-making processes. Delegate decision authority and responsibility to the lowest possible levels, and provide open, honest information about decision making. Use formal and informal mechanisms and new technology to keep in touch with employees, and visit field stations frequently. Routinely address major issues by constructing teams representing the entire agency (and frequently the public). Provide the teams the necessary authority and support to function and act on their recommendations.

Planning and Funding Category

Funding is and will continue to be a topic of great interest. It is grouped here with planning because the way to deal effectively with funding is through planning (including all that planning represents and can be). Pursuing nontraditional funding is important to agency effectiveness. As is keeping constituents informed of the benefits of funding. Agencies seeking to secure new funding sources will do well to look for funds from groups without political power. Private funds can provide significant opportunities. And constituents can be of great help in searching for and in supporting new funding sources.

Actively tracking socioeconomic trends, focusing on the long term, encouraging risk taking by employees, and creating and taking advantage of opportunities all make the most of planning activities. Give employees considerable job freedom and flexibility to help anticipate and deal with changes. Train them in the planning and budgeting processes, and encourage their participation.

Politics Category

Probably the most important aspects of effectiveness in this category are the agency's reputation and credibility—with the public as well as with the legislative and executive branches. These are most successfully achieved by being open and honest, and by being able to muster grass-roots public support when needed. Continue to maintain a sense of being nonpolitical, while pursuing legislative agendas important to the agency's overall goals. Develop and maintain credibility by emphasizing resource protection over political considerations. Virtually all employees in politically effective agencies must be involved in maintaining local political ties—keeping legislators informed of actions in their districts. Responsiveness to legislators, without playing favorites, is important.

Conflict Resolution Category

Effectiveness in this category requires continually monitoring public opinions, issues and concerns, and aggressively sharing information. Maintain a dialogue with all stakeholders, including opponents. Listen to hear how the agency might need to change. Although various survey techniques are important, field staffs need to be the eyes and ears of the agency. Therefore, good two-way communication between the field and headquarters is vital.

In conflicts, take a long-term view of relationships with constituents, looking beyond the immediate skirmish. Target communication with groups having veto power. Basic themes should include doing what's right for the resource and being responsive to public desires. Emphasize sharing information and listen to all sides before making a decision. And take a proactive approach to issues management—shape issues; don't wait for them to erupt.

Personnel Category

Informed and involved employees are an agency's best asset and increase an agency's effectiveness. Work diligently to deal with pay inequities and be generous in acknowledging—and rewarding—employee contributions. Provide clear guidelines on expected results and considerable latitude in how work is accomplished. And make job descriptions and performance appraisal systems meaningful tools for communicating and providing focus.

Sharing the Good News

We're not absolutely sure of how to continue sharing the good news from this project. But we are committed to doing so. Phase three of the Management Effectiveness Project as originally designed was described as "getting the results in the hands of potential users." Given that we haven't yet finished gleaning information from the case studies, and given that we probably will pursue related studies, it is nonetheless an appropriate time to begin sharing the good news with people who can benefit. We're going to continue trying to provide useful information in as many ways as possible to help agencies identify and implement ideas that will make them more effective.

In late July 1992, leaders of the nine case study states met to share ideas on the project. Their deliberations ranged from first-hand sharing of their respective stories, to identifying needs for improved agency management practices to suggesting ways to share study results. These nine agency leaders identified the directors of all state fish and wildlife agencies as the primary audience for project information. They also recommended attention be given to state leaders and managers at other levels, and to employees of other agencies (e.g., U. S. Fish and Wildlife Service, etc.).

Certainly, this session itself is one way to highlight some of the study results. And we decided it would be more effective to have the stories told primarily by those who live them and know them best. We hope this approach worked well.

There also will be other reports and written papers. Steve's dissertation will be available to those who want a thorough reporting. And we anticipate reporting in other formats. Some have requested concise, one-page narratives, each discussing a single action or strategy—probably best prepared by, again, someone who lived the event, and containing a name and phone number of a contact person for follow-up.

The case study state leaders suggested regional workshops as one way to gain stimulating discussion of key ideas. In January, we were invited to hold such a workshop at the western directors' mid-winter retreat. We learned some things from that experience which we hope to apply when invited to other regions. Somebody suggested we make a videotape to help get the word out; that's why we have the cameras here today. From this footage, we plan to produce a video that will stimulate thinking about management effectiveness. Case study state directors also suggested learning not only from the success stories, but from observing those techniques that didn't work so well. We're not quite sure how to proceed on this one. We're also looking into putting together informational/

instructional packages covering suggestions for becoming more effective in specific areas; here we hope to draw on the OWP and on key staff from the case study states.

We know all the success stories haven't been identified; and we hope that the survey being performed by the OWP will identify many other exciting ideas.

So, You May be Thinking: "I'm Interested. What Should I Do?"

I said early you shouldn't simply copy what these folks have done. So what's been the point in listening to them? The purpose, as I see it, has been to stimulate your thinking about doing something that will work in your agency. If you are interested in improving management effectiveness, I suggest you start with an assessment to help you decide what areas to work on. Perhaps it would be appropriate to use something like the case study questionnaires; we (the Management Assistance Team and the OWP) could probably even give you a hand. After that, it's not really too complicated: look at what some of the case study states have been doing and create the ideas that will work for you. Again, perhaps we could help you develop the process for doing this.

Conclusions and What Next

My first conclusion is that this study was definitely worth doing! We identified some excellent examples of agency management. Hopefully in part, at least we debunked the notion that retread biologists can't manage agencies.

Second, we can conclude that agencies are willing to share this type of information with one another. Being a case study state resulted in some considerable disruption of these agencies' routine activities. However, all case study agencies participated willingly, and I believe all will confirm that they benefitted from participation.

Third, we demonstrated the changing nature of the fish and wildlife business, and we have outlined a context for helping agencies deal with the changes—indeed, for helping them thrive in the new environment!

And last, we must continue the dialogue about management effectiveness, extending it to those who haven't yet been involved.

Acknowledgments

I hope it is clear that this project is a team effort. Without the joint sponsorship of the U. S. Fish and Wildlife Service's Federal Aid Program, the Organization of Wildlife Planners and Virginia Tech it simply would have been impossible. Without the support and encouragement by Bill Conlin, of the U. S. Fish and Wildlife Service's Federal Aid Division, the project probably would never have gotten started. Dennis Schenborn was OWP president when initial project discussions were held; his enthusiasm for this type of project and his continued support, plus that of his successors: Dwight Guynn and Bob Hasenyager, have been crucial. The privilege of working and sharing overall project responsibilities directly with Larry Nielsen and Steve McMullin from Virginia Tech was very satisfying. Early critiques by Jack Berryman, Max Peterson and Mark Reeff of the International Association of Fish and Wildlife Agencies helped us avoid or overcome numerous pitfalls. My colleagues at the Management Assistance Team—Verlyn Ebert, Bob Hays and Jack Hicks—contributed ideas, support and encouragement throughout, and shared in much of the work. Our secretary Sheila Cage cheerfully made everyone's travel arrangements. I'd like to acknowledge the time and insights offered by the more than 60 members of the Management Research Study Team who collaborated on all aspects of study design and implementation. Thanks to May Hall for her creative editing of this manuscript and for her help with the presentation. And, finally, I'd like to thank the more than 40 individuals and their agencies who participated as members of the case study teams. It was working with all of you that has made this project simply the most exciting, rewarding thing I've ever been associated with.

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Special Session 5. *Watershed Land Use and Fish Populations*

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Effects of Coastal Pollution on Living Marine Resources

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Introduction

Tens of thousands of chemicals are used to meet society's technological and economic needs. Many of these chemicals find their way into marine environments, therefore, it is important that we understand whether complex mixtures of chemicals found in coastal waters are causing adverse biological effects in marine organisms. This need is urgent because our ability to measure and detect minute levels of chemicals is advancing rapidly, but our understanding of the possible biological effects of these contaminants on living marine resources is lagging far behind. This imbalance contributes to public frustration and puts pressure on management and regulatory agencies to act without sufficient scientific information. To provide credible and balanced guidance for protecting valuable resources and their habitats, we need to carefully and unequivocally determine which of the biological effects in urban waterways are due to contaminants and also which groups of pollutants are major contributory factors. Such information, combined with the knowledge of the levels at which contaminants bring about toxic effects in biota, is crucial in providing rational guidelines for setting sediment and water quality standards, and for setting criteria for natural resource damage assessment and subsequent restoration of degraded habitats.

There are two basic ways by which chemical contaminants can affect living marine resources by (1) directly affecting the exposed organism's own health and survival, and (2) contaminating those fisheries resources that other species, including humans, may consume. We have been studying this dual impact of contaminants using a variety of marine organisms ranging from bottom-dwelling invertebrates and fish to pelagic species such as salmon and marine mammals. In this paper, however, we will focus our discussion on serious biological effects in marine fish and invertebrates induced by exposure to complex mixtures of contaminants present in urban embayments, waterways and other coastal sites. Many of these sites receive contaminants through a variety of sources, including non-point and point sources and by accidental spills. Substantial evidence indicates that large amounts of the toxic contaminants in coastal areas are derived through non-point sources (Hoffman et al. 1984). Below are examples of several multi-year, interdisciplinary field and laboratory studies that demonstrate links between observed biological effects in marine biota and chemical pollutants. These biological effects include: (a) diseases such as liver lesions in bottomfish; (b) decreased reproductive success in bottom fish; (c) impaired immune competence in anadromous fish; and (d) growth impairment in invertebrates.

Significant Findings

Liver Lesions in Bottomfish

Previously, we documented that certain bottom-dwelling fish species, such as English sole (*Pleuronectes vetulus*), feeding from and living on contaminant-laden sediments in polluted areas of Puget Sound take up toxic chemicals and show a variety of liver lesions, including liver cancer (Myers et al. 1987, Landahl et al. 1990). Moreover, when healthy English sole sampled from relatively clean areas were exposed in the laboratory to toxic chemicals (e.g., polycyclic aromatic hydrocarbons [PAHs]) extracted from contaminated sediments from Puget Sound, they developed many of the same lesions found in the livers of fish sampled from polluted areas (Schiewe et al. 1991).

The results from the early phase of our research on bottom-dwelling fish in Puget Sound served as a model for the development in 1984 of the National Benthic Surveillance Project (NBSP), which is part of the National Oceanic and Atmospheric Administration's (NOAA) national monitoring program, the National Status and Trends Program. The NBSP documents concentrations of chemical contaminants in sediment and bottom fish, and prevalences of pathological conditions in the same species of bottomfish to assess the status of environmental quality in many of our nation's coastal and estuarine waters. Through yearly sampling and monitoring of various marine species at coastal and estuarine sites throughout the country, a comprehensive data bank is being established on the distribution of liver lesions and chemical contaminants in marine fish species in more than 70 sites. This type of investigation allows NOAA to determine the current status and to follow possible temporal trends of chemical pollution and associated biological effects in selected areas.

The results from the NBSP for the West Coast and Northeast Coast obtained over a several-year period were statistically treated and recently reported by Myers et al. (1993) and Johnson et al. (1992), respectively. The West Coast report included data on fish species captured annually from 27 sites ranging from the Chukchi Sea, Alaska, to San Diego Bay, California; 19 sites were located in urban embayments and 8 sites were in relatively pristine waters. Briefly, the results showed that the prevalence or frequency of liver lesions was significantly higher in three of the fish species, English sole, starry founder (*Platichthtys stellatus*) and white croaker (*Genyonemus lineatus*), captured in urban sites in Puget Sound, San Francisco Bay and the vicinity of Los Angeles compared to prevalences in these species from nonurban sites (Figure 1). Previous publications

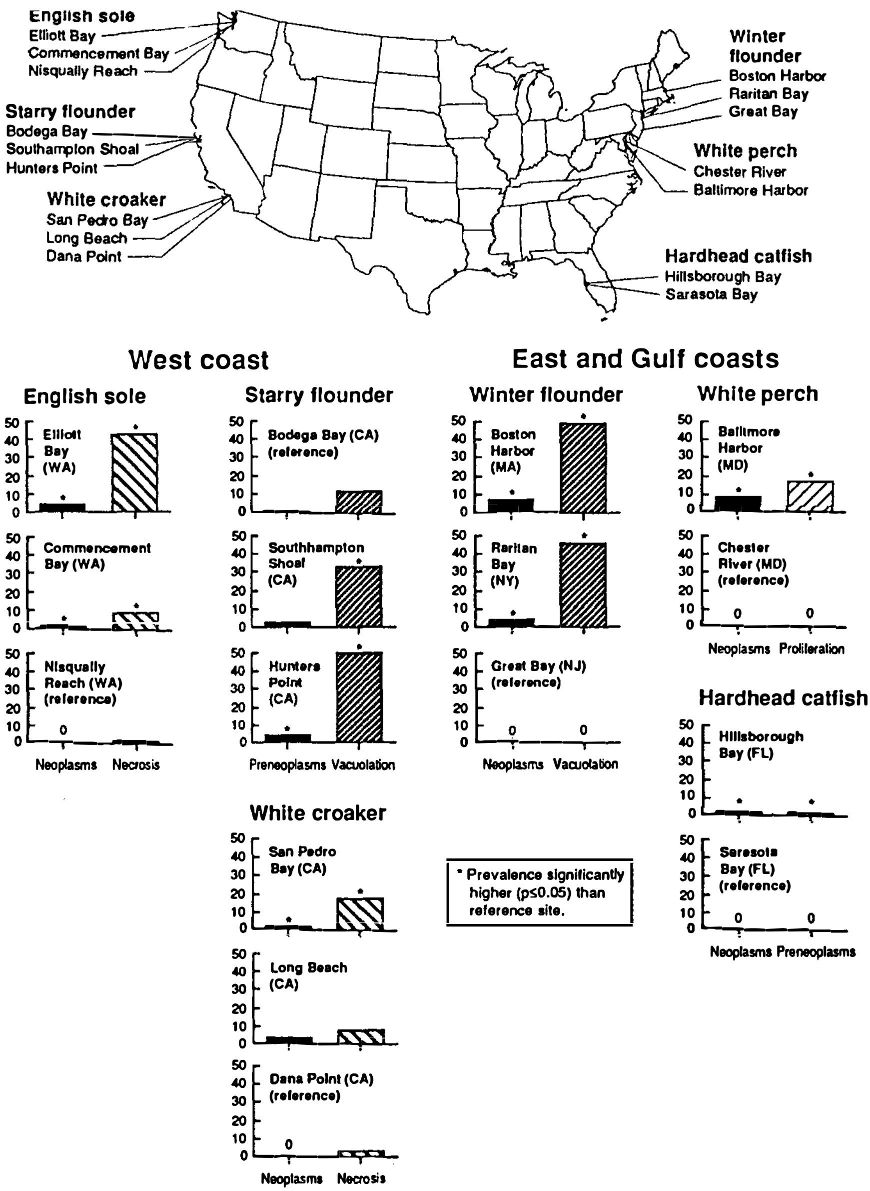

Figure 1. Prevalences of liver lesions in bottomfish species from selected coastal sites of the United States. Fish were collected between 1984 and 1991, and 30 to 170 fish from each site were examined histopathologically. Asterisk (*) indicates prevalence is significantly ($p \leq 0.05$) higher than the prevalence at the corresponding reference site. Adapted from Myers et al. (1993) and Johnson et al. (1992).

from the NBSP have reported high levels of contaminants in sediment and fish from these urban sites (Varanasi et al. 1989, McCain et al. 1992). The report on the Northeast Coast presented results from monitoring activities at 22 sites distributed from Great Bay, New Jersey, to Salem Harbor, Massachusetts (Johnson et al. 1992). Fifteen of these sites were located in urban areas and the remaining seven were in nonurban areas. This report also showed high prevalences of liver lesions in winter flounder (*Pleuronectes americanus*) from sites in urban embayments such as Boston Harbor, Raritan Bay and western Long Island Sound (Figure 1).

In both reports, elevated levels of chemical contaminants in sediment and fish tissues were positively correlated with higher prevalences of certain liver lesions. These correlations provide strong evidence that environmental pollutants, such as PAHs and certain chlorinated pesticides are significant risk factors in the development of certain liver lesions in several marine fish species. Interestingly, in the Northeast, polychlorinated biphenyls (PCBs), which are found in sediment and fish from many urban sites, were not consistently correlated with liver lesions. These reports also demonstrated clearly that biological effects such as liver lesions are appropriate indicators of marine environmental quality.

Effects on Reproductive Processes in Bottomfish

Monitoring reproductive activity in important marine species is a critical task because of the potential of toxic substances, among other factors, to cause adverse effects on the reproductive processes that might affect the abundance of these fish. Consequently, we have undertaken studies to assess the impact of complex mixtures of environmental contaminants on the reproductive processes in natural fish populations. Contaminant exposure could interfere with the reproductive cycle of fish in a number of ways (Thomas 1990). Aspects of the reproductive process that are being investigated in our laboratories include ovarian development, sex hormone production and metabolism, spawning success, and larval development.

In the initial phase of this project, English sole was chosen as the primary experimental species because previous research has shown that this species is sensitive to contaminants. In addition, these fish can be found in a wide range of areas in Puget Sound, including both relatively uncontaminated sites and sites with high levels of complex mixtures of contaminants in the sediment, and their life history and spawning behavior are fairly well known.

Ovarian development and spawning success. To examine the effects of exposure to toxic chemicals on ovarian development in English sole, we sampled prespawning females from four sites in Puget Sound, Washington, during two successive winter spawning seasons (Johnson et al. 1988). Two sampling sites, Eagle Harbor and the Duwamish Waterway, had high concentrations of contaminants in the sediment, while the other sites (Port Susan and Sinclair Inlet) were less contaminated. The results of this study showed that female English sole from the two contaminated sites had lower blood levels of the female sex hormone, estradiol, and showed signs of inhibited ovarian development compared to fish from the relatively uncontaminated sites (Figure 2). We also measured concentrations of classes of environmental contaminants, such as PAHs and PCBs, in bile and tissues, respectively, of female sole. In addition to documenting these between-site differences in reproductive success, we used multivariate statistical techniques to determine which factors most strongly affected ovarian development and estradiol levels.

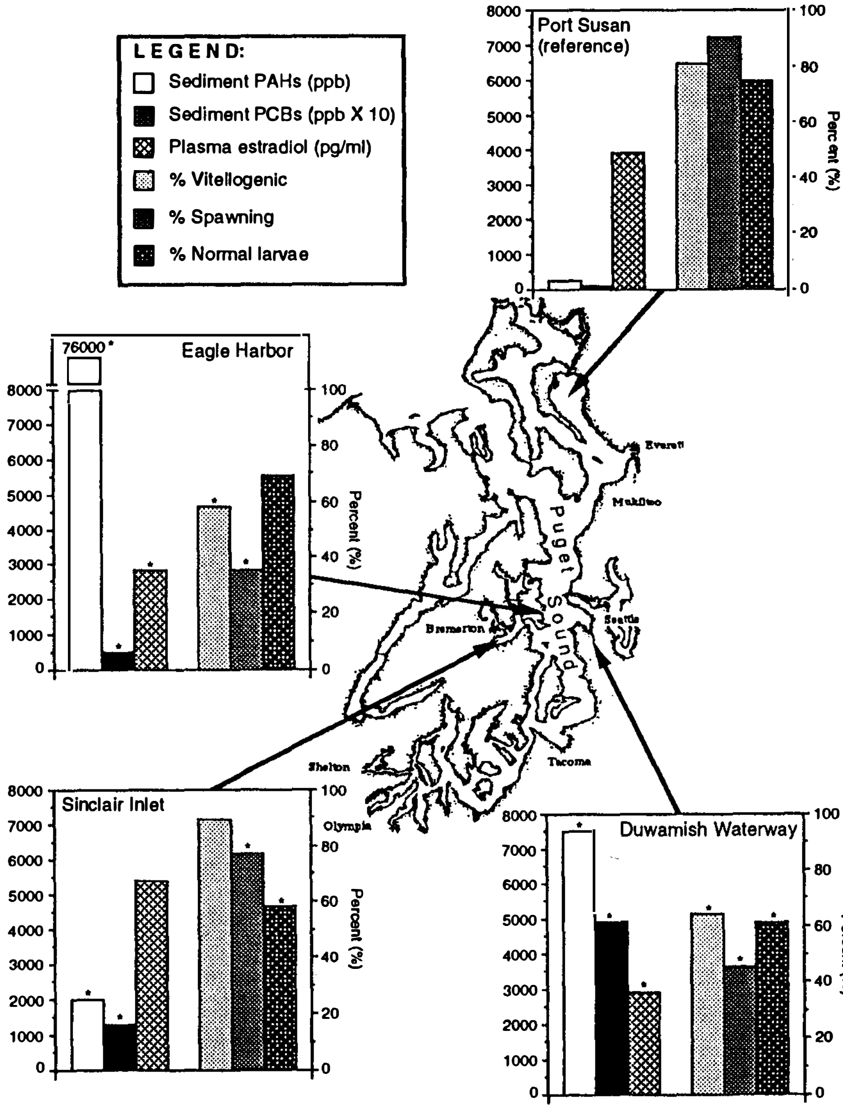

Figure 2. Mean concentrations of sediment polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), plasma estradiol, and percentages of several indicators of reproductive success in female English sole from four sites in Puget Sound, Washington, with various degrees of chemical contamination. The (*) indicates that the value is significantly different from the corresponding value found in English sole from the reference site. Adapted from Johnson et al. (1988) and Casillas et al. (1991).

A special advantage of the multivariate method was that, in addition to assessing the effects of contaminant exposure, it allowed consideration of other factors that could influence reproduction, such as fish size or age, time of sampling, and the condition of the fish, so the biological effects could be separated from effects of contaminants. These analyses indicated that exposure to PAHs, measured as fluorescent aromatic compounds in the bile, was most closely associated with inhibited ovarian development and depressed levels of estradiol. This association between exposure to PAHs and depressed estradiol levels was corroborated by the finding of lower estradiol levels in the blood of female English sole exposed to contaminants extracted from urban sediments (Stein et al. 1991). Moreover, the statistical analyses showed that hepatic levels of PCBs were not correlated with these effects. This result was supported by the finding that, although PCB concentrations were high in the livers of English sole sampled from the Duwamish Waterway, the prevalence of inhibited ovarian development at this site was no greater than the prevalence of inhibited ovarian development at Eagle Harbor, a site with high levels of PAHs, but no appreciable PCB contamination. These findings emphasize the success of our approach to identify classes of contaminants that may be contributors to certain biological effects as well as those that may not be as significant even though fish may be exposed to and accumulate a wide range of contaminants.

Because hepatic lesions in English sole are highly correlated with contaminant exposure (Myers et al. 1987, Landahl et al. 1990), and because English sole from the contaminated sites are less likely to undergo ovarian development than those from relatively uncontaminated sites, it was important to evaluate if liver lesions were associated with inhibited ovarian maturation. We found that the presence of hepatic lesions was not significantly correlated with increased risk of inhibited ovarian development (Johnson et al. 1988).

In order to explore whether impaired ovarian maturation had consequences for later stages of the reproductive process, another study was conducted in which sexually mature fish from many of the same contaminated and reference sites sampled in the above study were induced to spawn in the laboratory (Casillas et al. 1991). The results indicated that female English sole from contaminated sites were less likely to spawn than females from reference sites. Moreover, females from contaminated sites that did spawn produced a higher proportion of abnormal larvae than fish from less contaminated areas (Figure 2).

Fertilization success. The above findings indicated that some female English sole from contaminated sites would not complete ovarian development, resulting in some cases in prevention of normal spawning. Females affected in this manner would not be part of the spawning population of English sole. This hypothesis was tested in an extensive field study of the relationships between contaminant exposure and reproductive success in actively spawning female English sole in Puget Sound (Collier et al. 1992). In this study, reproductive success was evaluated by measuring the viability of eggs and larvae produced by female sole which already had migrated to their spawning grounds. These animals were spawned aboard a research vessel immediately after capture. Statistical analyses of the data showed that maternal contaminant exposure was only a minor factor in determining egg and larval viability. However, the range of contaminant exposure in these actively spawning fish did not include the high levels previously observed in prespawning animals by Johnson et al. (1988) and Casillas et al. (1991). Accordingly, the results of the three studies (Johnson et al. 1988, Casillas et al. 1991, Collier et al. 1992) suggest that female sole exposed to high levels of environmental contaminants in urban estuaries might be excluded from the spawning population, at least to some degree, and that the naturally spawning animals sampled on the spawning grounds represented a comparatively less-exposed group.

To date, the results of this multi-year project on reproductive success in English sole show that in contaminated areas, mature females had a 40 to 50 percent chance of not reaching sexual maturity. In addition, more than half the female fish that did mature in a heavily contaminated area failed to spawn, and those that did spawn had larvae with higher frequencies of abnormalities. We found that PAHs were statistically correlated to impairment of ovarian maturation. Larval defects and the failure to spawn also were associated with exposure to PAHs.

Thus, it is evident that certain bottom fish species residing in polluted estuaries may experience both liver disease and reproductive impairment. These effects on individuals can in turn have an impact at the population level. The data on body burden of contaminants and biological effects now are being incorporated into statistical models to examine the effects of contaminant exposure on populations of English sole in Puget Sound (Landahl et al. in press). The preliminary analysis suggests that contaminant-induced effects (particularly reproductive impairment) may cause significant declines in English sole populations in urban estuaries such as the Duwamish Waterway, if all other factors remain unchanged. The best test for this hypothesis would be provided by detailed stock assessment of English sole in this region; however, such an investigation would be a major undertaking.

Exposure and Effects in Juvenile Salmon

Several west coast populations of Pacific salmon are dwindling, and in some cases, declining so seriously that they have been listed under the Endangered Species Act. A number of factors, such as dramatic habitat loss and overfishing, are believed to be the major contributors to the problem. However, other environmental factors also may play a role. One of these is the chemical contamination of urban estuaries through which some juveniles pass on their migration to the open ocean. To address this pollution issue, we are conducting a multidisciplinary project to determine the levels of contaminant exposure and extent of adverse biological effects in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from polluted urban estuaries of Puget Sound, Washington.

Young, outmigrant Chinook salmon were chosen as the test organism because, as juveniles, they are one of the Pacific salmon species most dependent on estuaries as a feeding ground and they stay in the estuaries the longest. They feed on a variety of epibenthic prey organisms, such as amphipods and copepods. In addition, like the young of many animal species, juvenile Chinook salmon undergo rapid physiological change and growth and could be especially vulnerable to the effects of chemical pollution, particularly as they undertake the crucial transition of going from freshwater to saltwater.

In Puget Sound, at least two urban estuarine systems, through which juvenile salmon migrate, receive both point-and non-point-source pollutants from a variety of municipal and industrial activities. These estuarine systems include the Duwamish Waterway in Seattle and the Puyallup Waterway (Commencement Bay) in Tacoma.

Contaminant exposure. First we assessed whether young salmon were accumulating toxic chemicals in their stomach contents, livers and gall bladders during their brief residence in the urban estuaries (Varanasi et al. 1993). The results showed that juvenile salmon collected from the Duwamish Waterway did have levels of PAHs in their stomach contents that were several hundred times greater than those in juvenile salmon collected from the relatively unpolluted Nisqually River estuary, a reference site (Figure 3). Moreover, the levels of PCBs in the stomach contents of fish collected from the Duwamish Waterway were approximately four times higher than in the reference fish. These same fish were tested for the presence of fluorescent aromatic compounds in their bile (a measure of uptake of PAHs) and levels of PCBs in liver. The results showed that the Duwamish Waterway fish had levels of fluorescent compounds in bile and PCBs in liver that were several fold higher than levels in the reference fish from the Nisqually River (Figure 3). The stomach contents analyses also showed that sediment-associated amphipods were among the prey organisms upon which the juvenile salmon were feeding. These observations, combined with the fact that amphipods accumulate high concentrations of toxic chemicals from sediment, suggest that diet may be an important route of contaminant exposure in the juvenile salmon. In addition, the elevated levels in bile of the Duwamish Waterway salmon demonstrated that the fish were taking up PAHs, biotransforming them, and then excreting the resulting fluorescent metabolic products from the liver into the gall bladder.

Physiological changes. One of the first physiological responses in fish and mammals, upon exposure to certain PAHs and PCBs, is the induction of an enzyme system, specifically cytochrome P450, which is important in the biotransformation of many toxic chemicals and thus serves as a marker of early biological responses to toxic compounds. The activities of this enzyme system were measured in the liver of juvenile Chinook salmon from the three estuaries and hatcheries, and the results show that juveniles from the Duwamish Waterway had cytochrome P450 activities that were nearly two times higher than salmon from the Nisqually River (Figure 3). The Duwamish juveniles also had significantly elevated cyctochrome P450 activities as compared to Chinook collected directly from the three hatchery sites.

A biomarker of DNA damage also was included as part of this study. Investigations in many animal species have shown that certain environmental contaminants (xenobiotics) may covalently bind to an organism's genetic material, DNA, following biotransformation by cytochrome P450 to chemically reactive intermediates. Of the myriad chemicals present in a polluted estuary, some are taken up by organisms, converted to reactive intermediates, and a small fraction is bound to DNA (Stein et al. 1992). It is believed that the physical attachment of a carcinogen or its metabolite to cellular DNA is one of the necessary steps in chemically induced carcinogenesis and teratogenesis. The determination of the levels of toxic chemicals bound to DNA (xenobiotic-DNA adducts) provides a measure of exposure to chemical compounds that can adversely affect the integrity and function of the genetic material. The investigations showed that juvenile salmon from the heavily polluted Duwamish Waterway had the highest levels of DNA-adducts among fish collected from the three estuaries (Figure 3). Moreover, the Duwamish fish had adduct concentrations about twice as high as juveniles just leaving the Green River hatchery.

These chemical and biochemical studies confirm that contaminant exposure can be measured in water-column inhabitants that reside only briefly in contaminated areas, and that such an exposure elicits significant responses, such as changes in enzyme levels and DNA damage.

Alterations in immune function. As juvenile salmon make the transition from freshwater

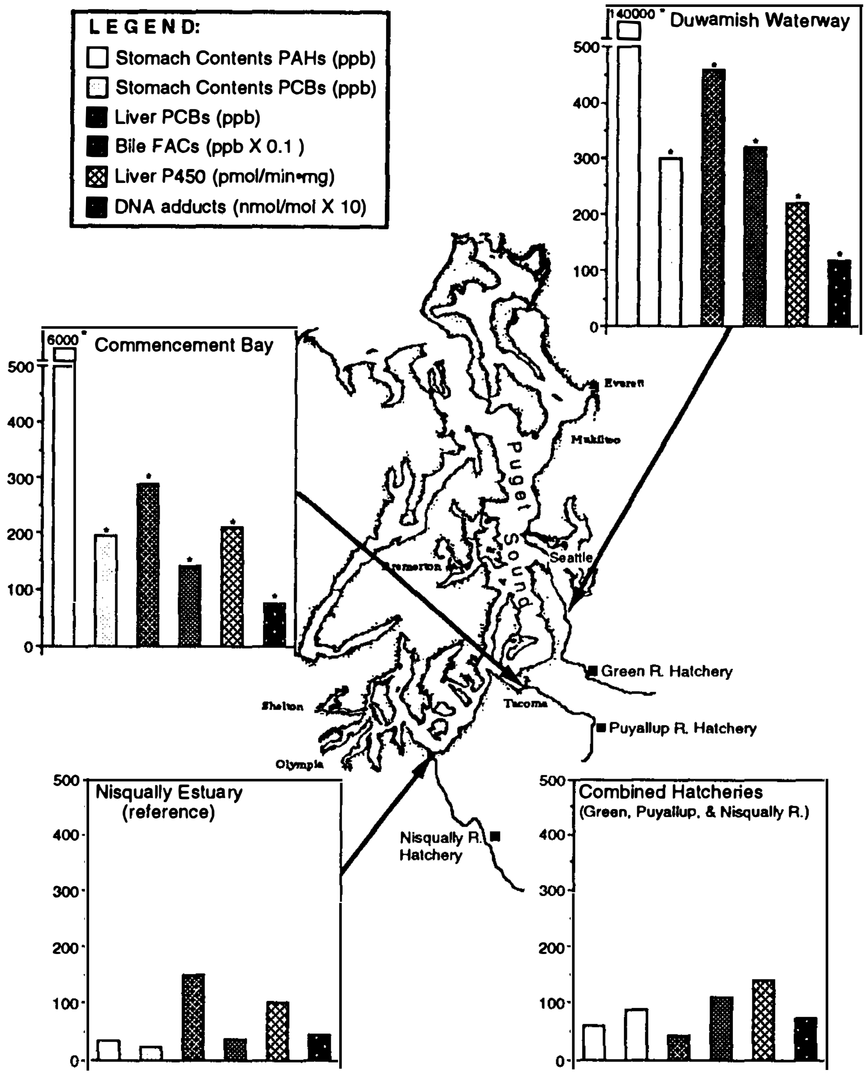

Figure 3. Mean concentrations of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in stomach contents and liver, fluorescent aromatic compounds (FACs) in bile, and DNA adducts and cytochrome P450 activities in liver of juvenile Chinook salmon from sites in Puget Sound, Washington. The Duwamish Waterway and Commencement Bay are within urban centers while the Nisqually River estuary is a reference area. Also shown are values for salmon sampled just before being released from the major hatchery on each river system. The (*) indicates that the value is significantly different from the corresponding value found in fish from the reference site. Adapted from Varanasi et al. (1993).

to saltwater, they are subjected to many stresses, including exposure to a broad spectrum of pathogens and parasites not previously encountered by the young fish. Accordingly, alterations of the fish's immune system could have serious implications for their early ocean survival. Previous scientific studies have shown that a variety of chemical contaminants can suppress immune function in both mammals and fish (Arkoosh and Kaattari 1987).

Accordingly, juvenile Chinook salmon were collected from the Duwamish Waterway, Nisqually River estuary, and corresponding hatcheries and their immunocompetence was tested (Arkoosh et al. 1991). For these immunological studies, it first was necessary to develop salmon cell culture techniques. Our findings suggest that the cells involved in generating immunological memory to specific foreign substances (antigens) are compromised in Chinook salmon from a polluted urban estuary (Figure 4). These findings for juvenile Chinook salmon from the polluted estuary were similar to those reported previously for trout exposed to a potent liver carcinogen, aflatoxin B_1 in the laboratory

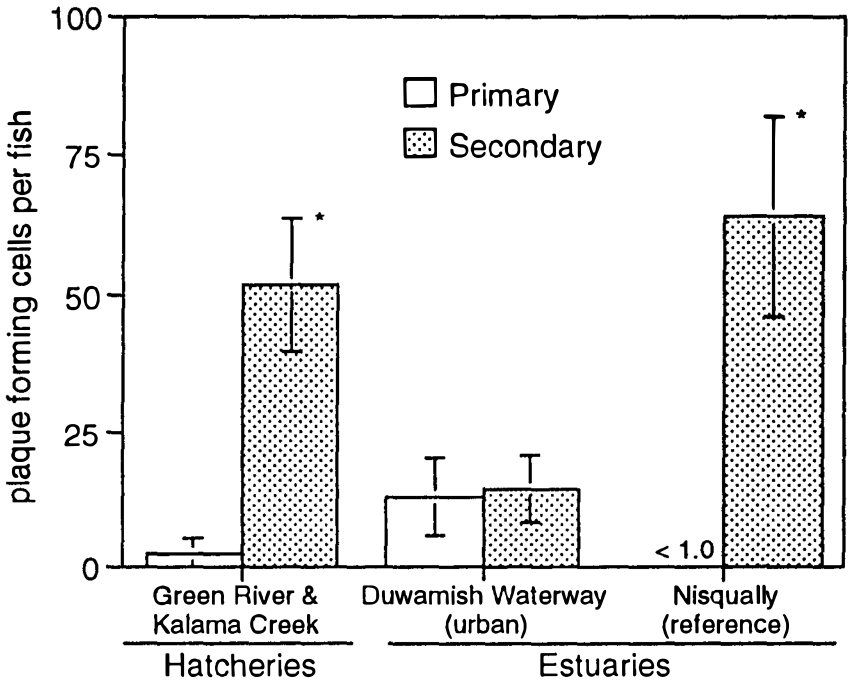

Figure 4. Primary and secondary humoral immune response (measured as plaque-forming cells per fish) in anterior kidney of juvenile Chinook salmon from the urban Duwamish Waterway and the reference Nisqually River estuary and the major hatchery on each river system. The (*) indicates that the secondary response is significantly higher than the corresponding primary response in fish from the uncontaminated Nisqually River estuary and the hatcheries. Note that there is no significant increase in the secondary response in salmon from the contaminated Duwamish Waterway, showing that these fish were impaired in their ability to generate immunological memory to a foreign substance (the standard antigen, trinitrophenyl-keyhole limpet haemocyanin). Adapted from Arkoosh et al. (1991).

(Arkoosh and Kaattari 1987). They also raise questions as to whether weakened or compromised immune systems in young salmon may lower their resistance to disease.

The finding of altered immunocompetence observed in juvenile Chinook salmon from the Duwamish Waterway was followed by additional laboratory studies to substantiate that toxic chemicals could alter the immune system of salmon. These studies, are examining the immune response in salmon from the Green River hatchery that were exposed to contaminants extracted from sediment from the Duwamish Waterway. These studies will help to establish whether there is a clear cause-and-effect relationship between contaminant exposure and changes in immune function in juvenile Chinook salmon. At present, the potential importance of a threat such immune system alterations may pose to the health of fish is not well known. It has been reported in the literature that when a commercial mixture of PCBs was injected into channel catfish, their disease resistance to the bacteria *Aeromonas hydrophila* was reduced (Jones et al. 1979). This type of disease challenge experiment with Chinook salmon will be planned only if the cause-and-effect research establishes a clear linkage between contaminant exposure and altered immune function.

In addition, preliminary results in these studies with juvenile salmon indicate that the growth of fish (as measured by length) collected from the Duwamish Waterway was significantly inhibited compared to the growth of fish collected from the Green River hatchery or the reference estuary. These initial growth studies were conducted on fish held in seawater for up to three months. Longer-term studies are underway to confirm this finding and to determine if the inhibitory impacts on growth persist.

Growth Impairment in Invertebrates

To date, the management and disposal of contaminated sediments has relied principally on chemical analyses of sediments and sediment bioassays using mortality as the endpoint. Reliance on mortality as the primary measure of toxicity potentially could underestimate the toxic effects of contaminated sediments. Hence, inclusion of sublethal responses, such as growth impairment, should be particularly important in evaluating sediment toxicity because these effects frequently are more sensitive indicators of the toxic effects of contaminants.

In recent years, we have conducted research on the effects of contaminated sediments on the growth of selected invertebrate species. Based on these results, we designed sediment bioassays using the most promising species and have compared the results of these sublethal bioassays with the results of mortality bioassays employing the commonly used amphipod, *Rhepoxynius abronius*. The results of two of these sublethal bioassays will be described here.

One sediment bioassay (Plesha et al. submitted) uses a sediment burrowing polychaete, *Armandia brevis*, and the other uses the sand dollar, *Dendraster excentricus* (Casillas et al. 1992), both are indigenous and widely distributed in the Pacific Northwest and are available during most of the year. Both organisms have relatively short life cycles and grow rapidly during their early life stages, making them particularly suitable for assessing sediment toxicity.

In evaluating the sensitivity of these sublethal bioassays, juveniles of both species were exposed to sediments with various levels of chemical contaminants for several weeks. Tests were conducted on sediment samples from several contaminated and reference sites in Puget Sound (Figure 5), and on sediment samples from 17 sites on the West Coast sampled as part of the NBSP. Sediments from these 17 sites represented a range of contaminant concentrations, from highly polluted to relatively clean, with many in the moderately contaminated category. The toxicity of some of the sediments also was tested using the amphipod mortality bioassay.

The results of the study showed inhibited growth in *A. brevis* and sand dollars exposed to sediments from moderately to highly contaminated sites in Puget Sound, but inhibited growth was not observed in test organisms in sediments from nonurban sites (Figure 5). Moreover, impaired growth of juvenile *A. brevis* and sand dollars was a more sensitive index of sediment toxicity than mortality in these test animals or in the widely used amphipod, *R. abronius*. Most of the moderately contaminated sediments that were toxic in our sublethal bioassays did not cause mortalities, and, therefore, would have been classified as non-toxic if tested only with a bioassay employing mortality as the endpoint. Similar results were found using sediments from sites along the West Coast, indicating that the use of sublethal responses in assessing sediment toxicity has broad application.

The relationship between inhibited growth in these test organisms and chemical contaminants also was explored. These analyses demonstrated that the animals had taken up chemicals throughout their exposure to the sediments. In addition, the observed levels

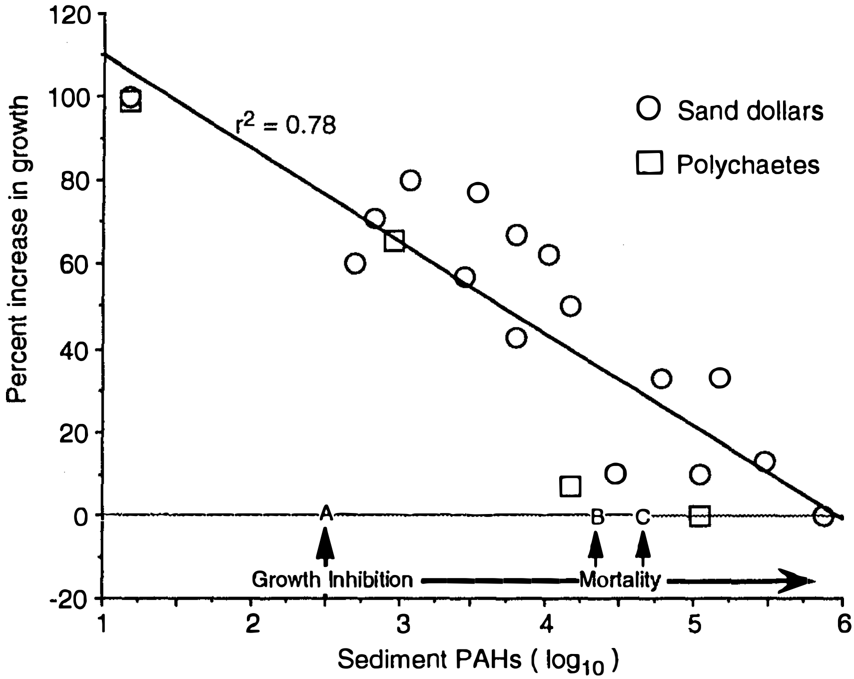

Figure 5. Relationship between sediment PAHs and growth in juvenile sand dollars (*D. excentricus*) and polychaetes (*A. brevis*) exposed to sediments from Puget Sound, Washington. Values reflect the growth of sand dollars or polychaetes on test sediment relative to growth when held on their native sediment. The arrows indicate where significant inhibition of growth (A) and mortality (B) of both juvenile sand dollars and polychaetes are first observed, and where a significant increase in mortality (C) of the marine amphipod, *R. abronius*, occurs. Adapted from Casillas et al. (1992) and Plesha et al. (submitted).

of growth inhibition were statistically correlated with concentrations of groups of contaminants in the sediments, including PAHs (Figure 5) and PCBs. Experiments currently are in progress in which juvenile invertebrates are exposed to sediments amended with specific classes of contaminants to determine their ability to cause growth inhibition in these test species. Using this approach, we hope to obtain more information on the effects caused by these contaminants and on their "no-effect" levels. These results and those of other laboratory and field studies should yield data on realistic "no-effect" levels for various sediment-bound contaminants that can be used for sound environmental management decisions.

Conclusions

Using some of our ongoing studies as examples, we have described an approach to better understand relationships between complex mixtures of environmental contaminants and adverse effects in marine biota. In each of these examples, we have endeavored to evaluate cause-and-effect connections between pollutants and biological effects. We feel that it is essential to identify the chemicals or classes of chemicals, as the case may be, causing these adverse effects. To this end, we have employed appropriate statistical procedures to treat our large data base, relating levels of contaminants in sediment and tissues to diverse biological effects. This approach is followed, where possible, with controlled laboratory studies in which animals are exposed to groups of chemicals isolated form urban sediments or to mixtures of chemicals added to uncontaminated sediments. In these studies, multiple dose levels often are used to help elucidate the nature of the effects and determine the threshold and "no-effect" levels of these chemicals.

Some of the biological effects we have mentioned here, including liver lesions, reproductive dysfunction, immunological impairment and growth inhibition, are examples of promising and sensitive sublethal effects that can be used to determine degrees of environmental degradation. However, keeping in mind the multitude of diverse species and the myriad chemicals present in many coastal environments, our methodologies are, at best, still very limited. An expansion of these efforts will be needed, especially in developing more sensitive sublethal end-points (or biomarkers) that may serve as early signals of serious effects. Such biomarkers with predictive capabilities are needed by environmental managers for taking timely actions to prevent deterioration of marine ecosystems.

For enhancing other tools needed to assess environmental conditions, especially in response to environmental emergencies, such as oil spills, we have developed state-of-the-art chemical and biochemical techniques that can rapidly screen sediments and tissues of fish, invertebrates and marine mammals for exposure to complex mixtures of contaminants. For example, we developed a set of screening techniques for marine sediments and biota that measure mixtures of aromatic hydrocarbons and their metabolites—present in petroleum and combustion products—in a much shorter time and at a far lower cost than attainable with standard analytical protocols. Recent application of these techniques to oil spills in Alaska and the Persian Gulf, as well as environmental monitoring in urban estuaries has enabled us to provide "real time" analyses to resource and regulatory agencies (Krahn et al. 1993).

An important concern to environmental scientists and managers alike is the ability to determine temporal trends in the concentrations of, and biological effects caused by, chemical contaminants of concern. Over the last several years, as part of our efforts in monitoring coastal environments, we have found modest, but notable, temporal decreases in the levels of certain chemicals (e.g., PCBs, DDTs) in marine sediment and certain fish species (Landahl et al. in press, McCain et al. 1992). This is not surprising, because the production and use of these chemicals have been discontinued or strictly curtailed and hence, their input into marine waters has been decreased. However, in some areas, especially near large cities, the input of other chemicals, primarily non-point source pollutants (e.g., PAHs), has either not changed or has increased due to increases in human populations in coastal regions, which leads to increased use of fossil fuel and resulting discharges of fossil fuel combustion products into coastal waters. Many non-point source pollutants enter the waters of our urbanized coastal areas via major outlets, such as combined sewer overflows or storm drains (Hoffman et al. 1984). At present, efforts are underway to regulate some of these larger non-point source dischargers by requiring permits, and, in a few areas (e.g., Elliott Bay in Seattle, Washington), restoration/remediation actions have been initiated, or are being planned, to "clean up" sediments contaminated with pollutants from major non-point sources. The use of sublethal effects (biomarkers), such as those discussed above, can significantly enhance our ability to test the success of these remedial actions. It is critical that a battery of sublethal effects be measured and that these sublethal effects be sensitive enough to predict possible ecosystem impacts.

Based on the research results presented in this paper, it is evident that the organismal and ecosystem health, rather than the levels of individual contaminants, may serve as a more accurate and integrated indicator of the environmental quality. Hence, we need to enhance our quest to better understand the processes that underlie normal functioning of key components of the aquatic ecosystem and to apply a systematic and holistic approach using chemical, biochemical and biological indices to evaluate the biological impacts of chemical pollution. Such research will provide critical knowledge of the many possible detrimental effects of complex mixtures of pollutants on organisms and enhance our ability to identify resulting impacts at the population or ecosystem level.

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Freshwater Flow Diversion and its Implications for Coastal Zone Ecosystems

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Introduction

The current attitude toward utilization of river runoff is based on the erroneous assumption that supply would never be a limiting factor on agricultural and urban growth or have any serious impact on riverine/marine environment. However, this approach has had devastating effects on semi-arid and arid ecosystems in the south of Ukraine and Moldova, Central Asia, eastern Mediterranean and western Africa, and some western states of the United States. The cause is that the natural renewability of runoff is limited by geophysical and meteorological properties of each watershed. Not recognizing this natural phenomenon has led to overestimation of water surplus. This, in turn, has triggered overpopulation and despoliation of the water ecosystems whose limit of tolerance is prescribed by nature's universal laws.

Societal Effects of Watershed Development

The experience gained from studying the extensive watershed development in the former Soviet Union is instructive for western society (Rozengurt 1991).

Unarguably, a similar development has been looming over the horizon in the U.S., where enormous water projects undertaken in the 1930s to 1960s had been focused on purely political or economic local, state or federal goals toward multi-utilization of water and land resources (California and Texas semi-arid zones). Subsequently, the preservation and balanced optimization of watershed environments were not given equal weight in water management planning processes; the ecological appraisal of natural runoff limitations were not discussed. Therefore, environmental goals and societal goals and objectives related to them were all but neglected and known ecological tolerances of riverine/estuarine systems to water diversions were ignored. Three decades later this failure hampered the Columbia, Sacramento, San Joaquin, and Colorado and Gulf of Mexico river ecosystems, as it did the Nile River's normal functioning (Duke and Sullivan 1990, Halim 1991, Leet et al. 1992, Rozengurt and Haydock 1991, Sherwood et al. 1990).

Habitat loss due to human manipulation of the natural hydrological cycles of rivers has evolved new, unprecedented ecological crises and precipitous declines of commercial and recreational fisheries and shellfish. The general sequence of deleterious events in coastal zones of Central and South Atlantic and Western Pacific are the same as those in the Black, Azov, Caspian, Aral and eastern Mediterranean seas and other parts of the world oceans. Among many causative factors which triggered these processes, the four *"Ds"—dams, diversion, dewatering* and *desertification* of arable land—have played significant roles in the economic downfall and deterioration of semi-arid zones' infrastructures.

Ecosystem Effects of Perceived Watershed Development

The direct origin of the four "Ds" is related to the following typical erroneous doctrines: (1) the effect of rivers impoundment on deltaic/estuarine/coastal environment can be of limited significance, and some negative development, say, in fishery losses can be mitigated through rearing of fish in hatcheries or providing special paths for migration to spawning grounds; (2) surface (river) and groundwater runoffs are inexhaustible; (3) deltas should be effectively transformed into a plumbing network to serve local and long-distance water conveyance facilities; and (4) river runoffs into coastal ecosystems are wasteful. The following are brief descriptions of some major ecological and economic consequences of implementation of these fallacious doctrines in water management practice.

1. As known, the first doctrine contradicts completely the essence of river ecosystems' functioning, for a river parted by dams is no longer one ecosystem. Strategic essence of the first doctrine has put aside the major societal and environmental objectives, namely, protection, preservation and conservation. Several decades later this neglect has entailed some grim repercussions. The modified runoff seasonal and annual values (volumes and timing of discharges, velocity, temperature, oxygen, nutrient, and sediment load) do not retain significant pre-project essentials to support migration, breeding and maturity of fish or maintain tolerant habitat (Leet et al. 1992; Rozengurt et al. 1987a, 1987b).
2. The assumption of inexhaustible runoff was, is and will be profoundly wrong, for it denies the fundamental stochastic principles of runoff formation, cyclicity and limitation of its renewability within strictly defined watersheds. As a result, human-induced subnormal wetness or even droughts, particularly in spring, for the last three to four decades persistently have prevailed regardless of precipitation over watersheds. Notably, remnants of spring regulated runoff often is less than 30—35 percent of normals and the frequencies and absolute values of the deviations are up to -40 to -85 percent (instead $\pm$ 25 to 30 percent for unimpaired runoff (Figure 1). Subsequently, since the 1960s, the frequency of occurrence of years of dry, critical dry or drought-like conditions (particularly in spring) have increased three to five times in comparison with unimpaired runoff over 55—100 years. These perennial water deficits have plagued river flushing and coastal rejuvenation and become chronic events of nearly global proportion; the Nile, San Francisco Bay; Gulf of Mexico river networks, except the Mississippi; Colorado River and Southern California Bight; the Black, Azov, Caspian and Aral seas; etc.

The residual runoffs usually are in disconcert, either singly or simultaneously, with water demands for fish migration and spawning versus power production and irrigation in the most vital period of the year—spring (Rozengurt et al. 1985, Rozengurt and Hedgpeth 1989). Undoubtedly, this new, acutely negative phenomenon has eliminated alternate historical probabilities and duration of years of different wetness. With time, these non-equilibrium conditions have imposed deleterious changes on the coastal zones due to immense losses of waters' organic and inorganic matter, sediment load, oxygen, etc. Their cumulative totals much exceed anything known for the last millennium.

Suffice to say, for example, that in the last two decades spring inland water use had deprived the Black/Azov Sea basin nearly 1,700 cubic kilometers freshwater (three times the volume of the Sea of Azov) and the Caspian Sea of 1,000—1,200 cubic kilometers (equal to the North Caspian volume). At the same time, the runoff of two major rivers of Central Asia—Amu Darya and Syr Darya—to the infamous, landlocked Aral Sea ceased to exist (freshwater deficit has reached 1,300—1,400 cubic kilometers). This has triggered catastrophic reduction of surface area, volume (down to 40 percent of that in 1964) and a four-fold increase in salinity. And the sea, a formerly rich basin, teeming with valuable fish (44,000 tons average annual harvest in the 1940s through the 1960s) has turned into a deadly, receding, hypersaline lake (Figure 2).

Modification of watershed has impaired ecological properties of some major rivers in Northern (Nile) and Southern Africa (Zambezi, Myobenselini, Kwa-Zulu), and Near East (Tigris and Euphrates), China (Yellow and Yangtze), and India (Indus); similarly impaired in the U.S. are the Columbia, Sacramento, San Joaquin, Colorado, Appalachicola and numerous other rivers of the Gulf of Mexico; the California Bight, some 26 coastal plain rivers have been dammed and water was diverted from their natural course. As a result, about 95 percent of formerly rich wetlands have completely disappeared, and kelp sustainability in proximity of the mouths of these rivers is very limited and fragile. The "domino effect" of consequences of these modifications are appalling and, unfortunately, irrevocable if ecological integrity and health of the ecosystems are in question.

3. The third doctrine reflects a typical, single-minded authoritative attitude toward managing deltas as plumbing systems. Such an approach demonstrates the lack of knowledge of the dynamic deltaic complex for sustenance of coastal waters as a whole.

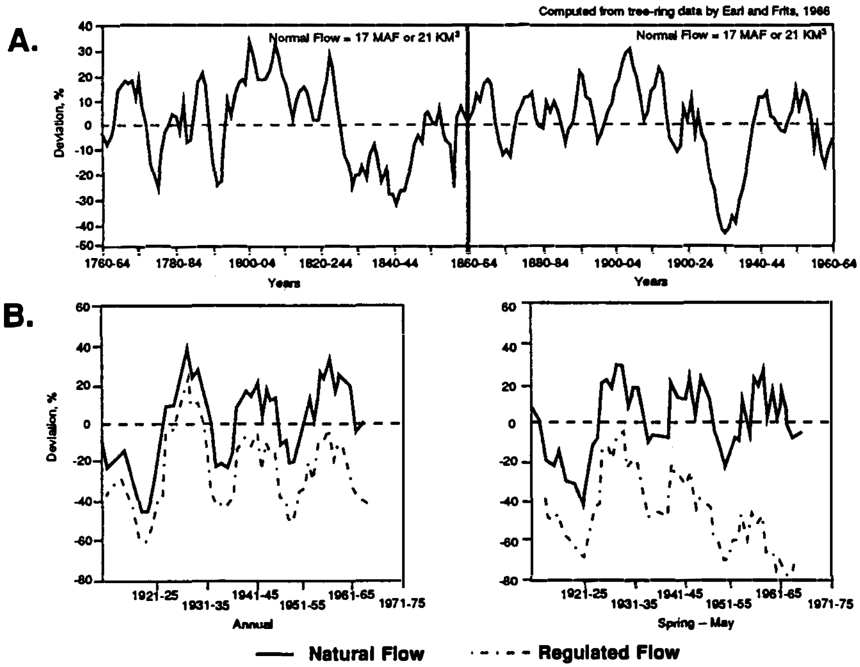

Figure 1. (A) Deviation of the five-year running mean combined four river runoff of normal for 200 years, (B) Deviation of the five-year running mean runoff to normal to the San Francisco Bay.

Historically, the delta is the heart of estuarine/coastal ecosystems and the most suitable home, nursery and breeding ground for many commercially important species. In processes of their evolution, deltas have received organic and inorganic load from upstream and produce, circulate and reprocess nutrient increment (about 70 percent) within their freshwater body, and maintain the unique richness of deltaic bodies. Furthermore, the delta outflow acts as a buffer zone to repel saltwater intrusion, and flushes the natural and human introduced pollutants. Over millennia, this natural process maintains optimal tolerant salinity equilibrium and enforces entrainment, mixing and enrichment of estuarine and coastal waters by introducing million tons of oxygen and other matter vital for survival and reproduction of fish and shellfish.

However, when human-induced subnormal wetness prevails, myriads of negative features are developed nearly simultaneously. Among them, the salinization of estuarine waters is the most insidious, the inverse of the runoff process (Figure 3). Another development is trapping sediments behind the dams. This aggravates subsidence of levees and increases the danger of catastrophic flooding of deltaic croplands and erosion of deltaic tributaries. For example, the High Aswan Dam built on the Nile River in 1964—1965 has deprived its delta and its coastal perimeter of about 140 by 10^6 tons per year of fine sand, silt and clay. As a result, the geomorphologic equilibrium between the delta and coastal zone has all but vanished and the Nile deltaic perimeter (200 kilometers in length) has retreated toward the south with the speed of 125—175 meters per year (Halim 1991). In the Sacramento/San Joaquin Delta sediment losses alone ranged between 70—90 million tons (since 1945). This, coupled with scouring and erosion, has provoked the subsidence of levees and deltaic arable land to the point where maintenance of some of them is considered economically useless.

The diking, channelization, straightening and deepening of deltaic tributaries to accommodate much of spring delta outflow or conversion of marshes, wetlands and deltaic

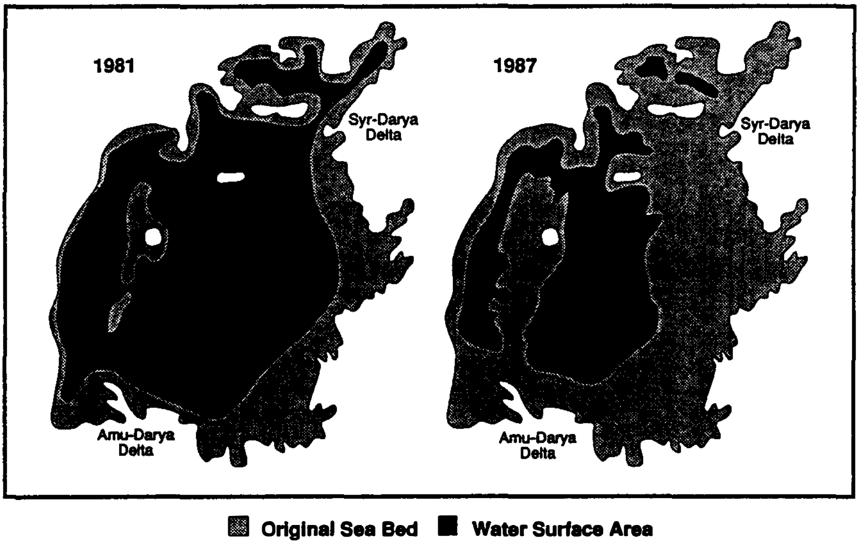

Figure 2. Aral Sea desertification.

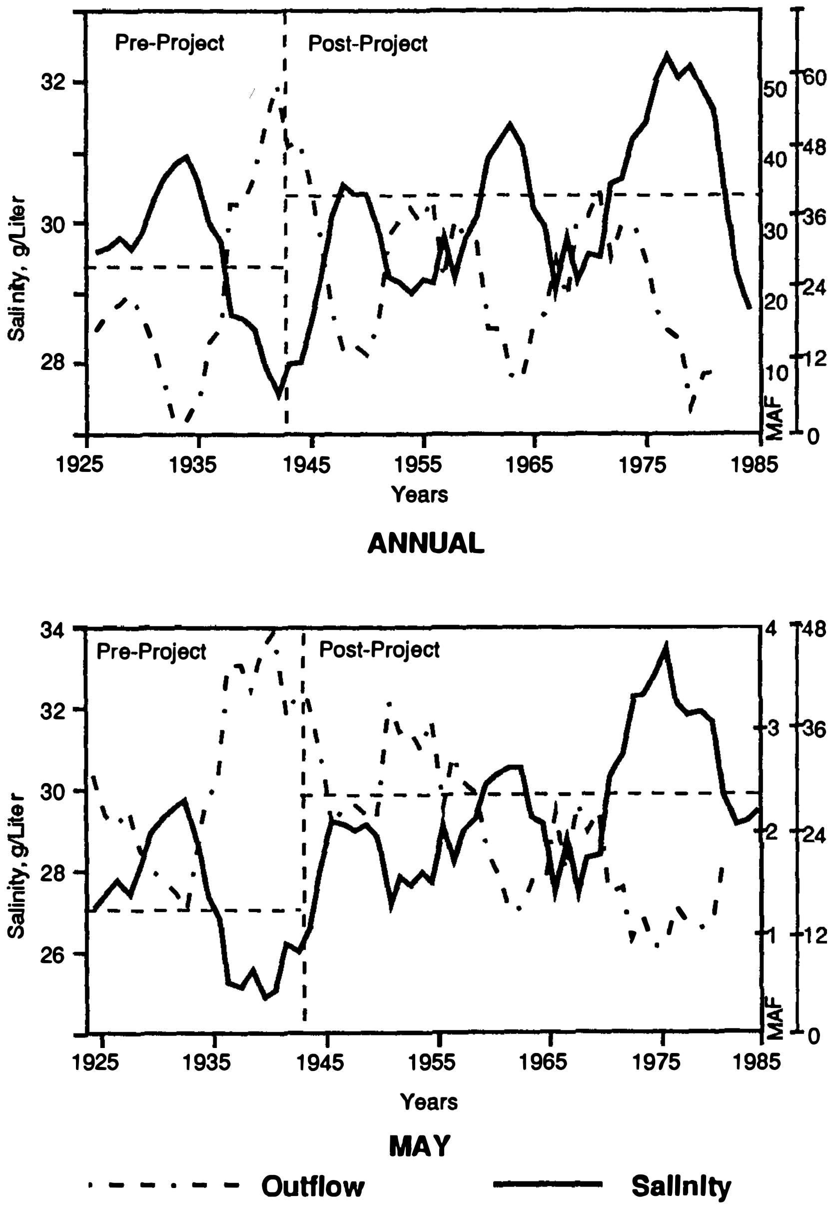

Figure 3. Chronological fluctuations of the five-year running mean delta outflow and salinity of surface water at the Golden Gate, San Francisco Bay.

islands to cropland has led to the denudation, dewatering and desertification of the deltaic islands and banks that further aggravate their environment by increased warming, evaporation, eutrophication and erosion. The dewatering, in concert with salt intrusion, fortifies abnormal density stratification that provokes oxygen deficiency (hypoxia) and mass mortality of vegetation and living creatures. Note that, after 15—25 years of such extremes, many of the discussed deltas have acquired a "ghost" composure in comparison with their lustrous past.

The Sacramento/San Joaquin Delta encapsulates many of the negative developments found in other systems. But, to our dismay, one particular process, namely, the relentless carnage of millions of fry at pumping station screens, makes this delta notoriously unique. Over the last 36 years, cumulative water losses for the Delta alone of up to 100 million acre feet (78 times the delta volume) were accompanied by striped bass and salmon fry kills at pumps' screens (Figure 4) three times higher than that of reported fish kills due to all causes for all 22 coastal states between 1980—1989 (Lowe et al. 1991). Arguably, but according to California Department of Fish and Game, toxicity is not the issue it was in the 1950s—1960s; runoff depletion in the delta has made these and other fishes nearly endangered species.

Notably, the same conclusion had been presented by the senior author to the California Department of Fish and Game and the National Oceanic and Atmospheric Administration (NOAA) in a series of letters, publications and reports in 1980—1987. Unfortunately, these programs were ignored. Therefore, the time to stop the despoliation of valuable fishes was lost.

4. The fourth doctrine unscrupulously assaults the causative origin and formation of estuarine and coastal environments for thousands of years. Specifically, the "freshwater runoff is a waste" approach to estuaries denies their definition as a cradle of the highest biological productivity of adjacent coastal areas. Their plumes (coastal hydrofront) through mixing and entraining action enhance manyfold over the rejuvenation of coastal waters. This annual renewal is necessary to sustain a thriving biota, for their life cycle (migration, breeding, feeding) is much adjusted to seasonal runoff fluctuations. Even strictly marine species indirectly, through the food web, profit from the richness of estuarine flow and biota. That is why a five-mile-wide band along the shoreline of the coastal shelf is the major fish provider.

Conclusion

Failure to recognize the above mentioned historical facts and not incorporate them into risk assessment analysis of water project alternatives encourages unrestrained water development. Unchanged, this policy leads to the detriment of both society and the environment. The west coast examples of the annihilation of salmon in the Columbia River and Sacramento/San Joaquin River networks (as well as striped bass and shad in the latter) in our daily news are vivid reminders of incompatibility between the sustainable environment and human's excessively perceived water needs. Even worse conditions typified the southern estuarine/coastal ecosystems of the former U.S.S.R. There, the biological impoverishment has reached the scale of ecological cataclysm unseen or undocumented, as least since Ivan the Terrible. In general, the coastal ecosystems of southern seas have become impaired and formerly rich habitats fragmented.

It must be emphasized that the first signs of pending peril appeared in three seas—Black, Azov and Caspian—nearly simultaneously in the mid-1960s. By that time about

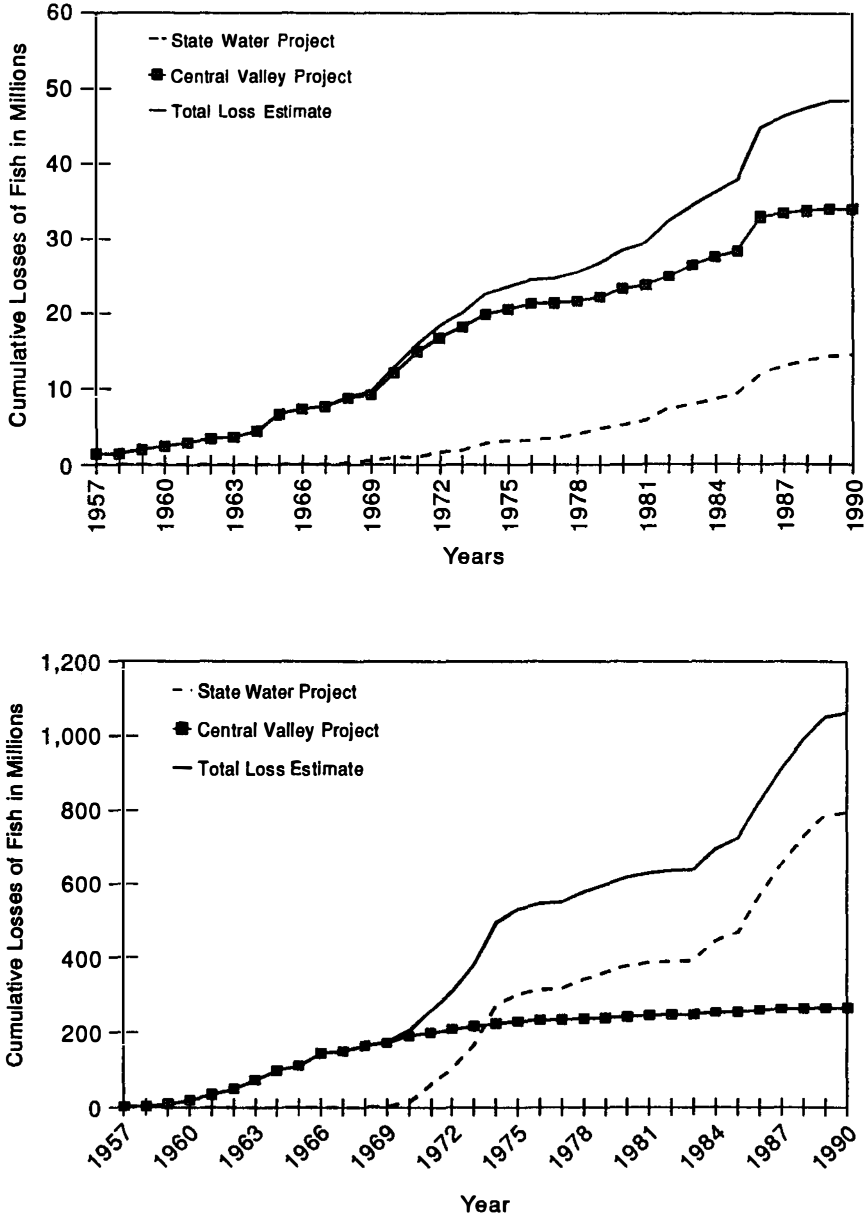

Figure 4. (A) Cumulative losses of the chinook salmon (21–150 mm) at the Sacramento—San Joaquin Deltaic Pumps (1957–1990), (B) Cumulative losses of stripped bass (21–150 mm) at the Sacramento—San Joaquin Deltaic Pumps (1957–1990).

20 large dams became operational. For example, in the Sea of Azov, the pearl of biological productivity among all other southern seas, the catch for most prized anadromous and semi-anadromous fish was nearly nullified by the 1970s. The cumulative economic losses alone mounted to billions of dollars, and hardship shadowed the lives of millions.

The significant cumulative losses of freshwater behind numerous dams of the Danube (28—40 percent of spring normal runoff is diverted annually), Dniester (45—75 percent) and Dnieper (45—85 percent) draining to the Black Sea reduce the intensity of vertical and horizontal mixing (entrainment) and seasonal turnover many times. Subsequently, relatively deep and bottom waters of western Black Sea (maximum depth around 60 meters) have been left for years isolated from sources of oxygen. As a result, more than 10,000—15,000 square kilometers of area have become stagnant and anoxic. This triggered the disintegration of 10 million tons raw weight of the algae *Phyllophora* (sort of a floating kelp) and diversity of benthic organisms and flatfish. Nearly the same has happened in the Sea of Azov, where summer recurrence of anoxia occupies over 10,000—20,000 square kilometers (one-sixth to one-third of sea area) of subsurface and bottom layers; similar events were observed in the Gulf of Mexico (Duke and Sullivan 1990). It appears that increased recurrence of human-induced years of droughts substantially exceeds the tolerance limit of coastal embayments for recuperation, and remnants of runoff have effectively lost the ability to restore biological equilibrium to the coastal zones. The interrelation between eastern Mediterranean fishery and the Nile river regulated runoff before and after the Aswan Dam became operational provides strong support to this statement (Halim 1991) (Figure 5).

Overall the evidence is clear that only 25—30 percent of historical runoff is available for other uses, without radically affecting ecological balance in natural watersheds the world over. From the coastal shelf humankind can reap only what is sowed by the productive waters of the land.

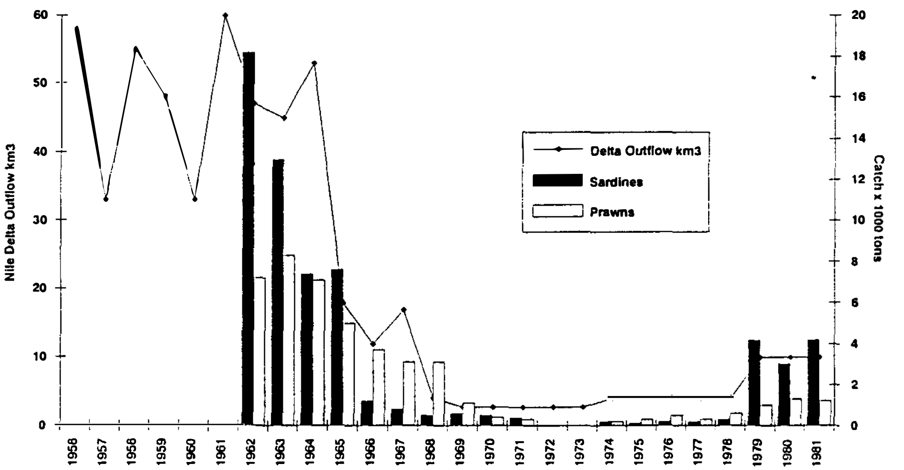

Figure 5. Relationship between Nile Delta annual regulated outflow and Mediterranean Sea coastal catch of Egypt.

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Managing Watersheds for Fisheries and Wildlife: An Integrated Approach to Natural Resource Management

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Introduction

We realize that this special session is intended to discuss watershed land use and fish populations. However, we would like to broaden discussion of this topic by exploring the context within which watersheds and fish populations are managed. We intend to make a case for a holistic approach for managing landscapes which we call Integrated Resource Management. Specifically, we'll explore how, in an Integrated Resource Management approach, we (1) view and manage the resource, (2) view and work with our customers and the public, and (3) organize our institutions and our work.

Some Background

During the late 1950s and early 1960s it became obvious that maintaining the quality of the nation's river, stream, lake and reservoir fisheries would require a river basin approach. However, most work tended to focus on segments of rivers or specific lakes. Within these segments, management interest usually was focused on one or two commodity species. Scientific research also often reflected this single-species approach. At the same time, state and federal environmental efforts were largely aimed at dealing with point source pollution impacts.

During this period, our customers tended to be anglers and hunters, and our interactions with them centered around casual contact and discussions at local sportmen's clubs. As fishing and hunting got more specialized, we began to deal with our customers through organizations such as Trout Unlimited and Ducks Unlimited. Although these organizations espoused broad environmental concerns, they generally represented a special interest related to fishing or hunting. Thus, in effect, they were extensions of our traditional clientele.

The organization of the Wisconsin Department of Natural Resources and many other agencies around the country at this time was hierarchical. Administrators in the central office directed programs and field activities through line supervision and authority. The species approach to managing the resource required strong, separate programs. Within programs, this specialization discouraged, or at least did not encourage, collaboration or integration. It was watershed management that stimulated interdisciplinary work, and was the beginning stage of a growth toward more comprehensive management of natural resources.

Today, increased knowledge of community ecology has led us to understand that a complicated set of interconnected environmental, biological, social and economic factors determine the kind and quality of fish and wildlife communities. We have learned that the scale of the landscape examined by managers and the range of disciplines considered during problem definition are key to the success of fishery and wildlife management programs. This new approach to resource management is called landscape-scale management. Further, we try to manage biotic communities in a broad social context rather than managing a narrow range of game species for selected publics.

In terms of our customers, we now realize that the physical management of the landscape, be it an ecosystem or watershed, is only part of the broad range of social, economic, recreational and political factors that affect the character of the resource and its use. Thus, a fishery is a product of the complex interaction of relationships among factors that affect people's view and use of the land and water associated with the landscape where they live. In this view, our customers include traditional users such as anglers and hunters, as well as nontraditional users such as canoeists, bird watchers, hikers and nature enthusiasts. Likewise, our concept of who is affected by a proposed project also has expanded. It now includes users (traditional and nontraditional), area residents, private land-holding groups such as The Nature Conservancy, and the general public.

Although we still are organized programmatically and hierarchically, we have made great strides in integrating our work. Interdisciplinary work is necessary to manage across landscapes. Collaboration and consultation among colleagues in different programs as well as in different agencies is sought voluntarily to deal with the complexity of work that today's professionals face. Most of these changes have come about because managers have come to view their work differently. Thus, what may be an outdated organizational structure is being adapted to meet present-day operational needs.

Definition and Benefits of Integrated Resource Management

Integrated Resource Management is what we call this new way of doing business. We define it as an approach that blends human needs and values with ecosystem capability and sustainability. In effect, we are attempting to look at land and water use, recreational, agricultural, urban, suburban and other uses all at one time, while weighing the impact of these uses on the landscape an ecosystems contained within them.

We believe that using this approach creates an opportunity to consider and plan the enhancement of more than one resource at a time. Resource managers who look at the broadest segment of landscape that they manage or cooperatively manage with other jurisdictions can produce benefits across a wide range of resources. Thus, forestry practices can be designed to protect water resources and fisheries. Land management practices may not only protect riparian stream bank areas but also can provide grasslands for upland nesting waterfowl and grassland birds. If broadly conceived, a project will provide a wider range of recreational benefits that support a larger customer base. This should enhance political, financial and other kinds of support.

A key to using Integrated Resource Management is to establish the scope of the project and appoint people, professional and lay alike, who will participate in it from the outset. Early objectives must cover the range of alternative uses of the landscape and account for social, economic and recreational needs that may be wider than the watershed. This kind of thinking brings with it the ability to attach a much greater variety and number of supporters to the project. It also allows resource managers to develop a more inclusive land management ethic among their customers.

We believe that an Integrated Resource Management approach has many benefits. Increased efficiency results from the synergy produced from working at a landscape level rather than working on individual habitat plots. The world is organized on a landscape scale and once we understand the structure and function of the ecological systems operating at that level we can save energy by imitating some of the natural tendencies of the system. The opportunity to enhance many different kinds of fish and wildlife populations at once with landscape level projects provides more return per dollar expended.

Efficiency also is achieved by avoiding the pitfall of failing to identify rare or threatened resources after program goals have been set or during implementation. Since landscape projects operate at a real-world ecological scale, integrated planning results in lower costs for making environmental impact determinations and allows managers to plan protection enhancement of these resources as part of their project plan. Therefore their plans are less likely to be set back by surprise discoveries of unwanted impact to other programs or biological resources.

The use of landscape-scale management better allows us to identify and balance recreational objectives in consort with the real world and the real way people think about their recreation. For example, hunters hunt grassland birds like prairie chickens or forest wildlife like grouse and deer. Anglers quickly sort their fishing experience into cold, warm or saltwater fishing. Most identify themselves further as stream or lake anglers. Thus, landscape scale projects emulate the broad interests of our diverse public and, in so doing, increase our credibility with those who pay for management.

Integrated Resource Management allows us to include many formerly ignored people in project design. Proper definition can set up scenarios where seemingly disparate groups like bird watchers, bird hunters and hikers can benefit from the same expenditure of funds. Lake property owners, boaters, anglers and duck hunters have benefited from integrated projects. New and different lines of communication and understanding result from such projects. The interaction of these groups during the design and construction of a project lessens unforeseen conflict from arising later and provides a base of trust for resolving conflict in the future.

Integrated Resource Management is not a perfect approach. It is an evolving approach that brings together current thought on the resource, public involvement and organizational function. It must continue to evolve as these ideas change. One of the strengths of this approach is its incorporation of critical thinking and continuous improvement.

In this paper, we describe how the Wisconsin Department of Natural Resources (Department) is applying Integrated Resource Management in the areas of landscape-scale management, public involvement and institutional function. We also provide case studies of projects that have attempted to follow the principles of Integrated Resource Management.

Landscape-scale Management

When we speak of landscape, we refer to a land area, including the watershed that culturally and physically affects the make-up of biotic communities. Landscape-scale is defined as the appropriate spatial and temporal scale for planning, analysis and carrying out management activities in order to sustain ecosystem capability. The following examples demonstrate ways in which the Department is applying this type of thinking.

Forest Habitat Classification System

The Habitat Type System is a natural classification system for forest communities and the site on which they develop. It utilizes systematic interpretation of natural vegetation with emphasis on understory species. Its primary use is the assessment of biological potential of forest sites necessary for management of various natural resources. It enables managers to recognize ecological units useful for making management decisions. The habitat type system serves the following basic functions:

1. *Communication.* It provides managers and research specialists with a common language for describing forest communities and sites.
2. *Research.* It provides a framework for systematic gathering and interpretation of research data and empirical knowledge.
3. *Management interpretation.* It allows resource managers to make prescriptions for manipulating vegetation based on knowledge of the ecological potential of the land.

Ecoregion System Development

Ecosystems are self-sustaining units where biological processes continue, even with some perturbations, and implicitly include the physical and biotic ingredients used in the processes. Ecological systems, then, are a function of physical and biotic features as well as anthropogenic forces. Where these factors come together, as they do everywhere, an ecosystem results. Ecosystems can be pristine as well as the most disturbed of landscapes. Areas with relatively homogenous ecological systems are termed ecoregions. Ecoregions are usually based on patterns of land use, topography, present and potential natural vegetation, and soils. Ecoregions are used by resource mangers to develop logical, regional strategies for land acquisition and management.

The Department is presently reviewing existing ecoregion designations for the state and nation in preparation for developing a system for agency-wide use. A system recently developed by the Wisconsin Geological and National History Survey divides that state into six natural divisions. An earlier effort (1988) by the U. S. Environmental Protection Agency divided the Midwest into 18 ecoregions, 9 of which occur in Wisconsin.

Land Classification System

The Department is developing Land Management and Use Classification Administrative Rules to guide land management and public use of state-owned land. The rules will describe a process under which resource managers develop conceptual management models that consider site capacity, local and regional resource needs, and recreation needs. In addition to seeking public input in the rule making process, the Department will require managers to solicit public participation as the rule is administered on all state properties.

HRA Habitat Models

The Department is overlaying habitat models for several species of game birds with those of 13 species of nongame birds to identify critical areas for habitat protection and restoration. Through the use of a Geographical Information System (GIS), biologists can locate specific sites where habitat restoration and/or protection will benefit the maximum number of species. This not only greatly increases efficiency for field managers, but also ensures that habitat objectives for all species can be met with the minimum of funds and effort. For example, the habitat requirements of both mallards (*Anas platyrhynchos*) and ring-necked pheasants (*Phasianus colchicus*) are well understood. For both, in Wisconsin, secure nest cover is the limiting factor. While pheasants readily use nest cover within two miles of winter range, mallards prefer nest cover within one mile of brood water. The Department can readily identify areas of overlap, i.e., sites that are both within two miles of pheasant winter cover and within one mile of brood water. Overlaying the habitat needs of grassland bird species further defines these areas of overlap. The resulting common areas become priority sites for restoration and/or protection.

Addressing Biodiversity Concerns

The Department established a technology team in 1989 to begin discussion about how the Department might be affected by the increased public dialogue about conserving biodiversity. The charge to the team was to define the issues related to biodiversity and to develop recommendations to help the agency more effectively integrate biodiversity concerns into programs.

The resulting draft report proposes that we expand our ecological point of view so that biodiversity concerns will be assessed for all our management and regulatory actions. Management should be carried out using an ecosystem approach that includes a long-term perspective, landscape-scale management and an emphasis on preserving ecological structure and function. The report also identifies the need to train employees in the latest knowledge about community and ecosystem ecology. Training in critical thinking skills and values clarification also was recommended. These skills will be essential in leading the public dialogue on biodiversity and in helping to resolve the many conflicts that will surface.

Public Involvement Process

Our public involvement process has evolved from one that was statutorily directed and narrow in focus to one that is agency directed and widely focused. Not only is citizen support needed to gain approval of projects, citizen support coupled with participation is often critical to accomplishing projects.

Statutorily Directed

The Department traditionally has involved the public in a number of legally mandated ways, including public hearings, contested case hearings, the Wisconsin Conservation Congress and the Natural Resources Board. We also participate in and testify at standing committees and study committees of the legislature.

Public hearings are somewhat useful in informing people and giving them a chance to formally respond to the agency, although they do not resolve problems or encourage two-way communication. Contested case hearings are a formal way to decide an issue when in conflict. They are effective, but are expensive and do not encourage win-win solutions.

The Natural Resources Board directs Department policy and is made up of seven citizens appointed to staggered three-year terms by the Governor. They will accept public appearances on any issue and can direct the staff to do more public involvement. They also serve as a conduit to public opinion through their work in the private sector and through local contacts.

The Conservation Congress is a statutorily-defined advisory body to the Natural Resources Board. Its members are elected at annual meetings held in each county in conjunction with Department hearings on fish and wildlife rule changes. Members of the public can attend these meetings and vote on rule proposals. We get the voting results from a large number of people at the same time but they may not represent the entire license-buying public. The hearings also do not allow for constructive discussions or developing options in a form other than that of a rule change. Resolutions presented at the county hearings are considered by congress study committees, the executive council and district meetings before appearing as advisory questions at next year's spring hearing. Department liaisons often work through a Congress study committee on Department rule proposals.

Agency Directed Work with the Public

All of the above mandates, if only used in formal ways and by themselves, have limited usefulness in achieving good public involvement. Thus, the Department has developed additional ways of involving and working with the public. Many agency personnel have been trained in public involvement techniques. Trained consultants within the Department advise and help others in planning and conducting citizen involvement.

Six basic steps are used in designing a citizen participation program:

(1) Identify the decision-making process.

(2) Identify the citizen participation objectives for each stage in the decision-making process.

(3) Identify the information exchange needed to complete each stage in the decision-making process.

(4) Identify the publics with whom information must be exchanged.

(5) Identify any special circumstances surrounding the issue and publics that could affect selection of citizen participation techniques.

(6) Identify the appropriate techniques—and their sequence—to accomplish the required information exchange.

This process helps Department managers to custom design a citizen participation program to meet the needs of projects. Special committees, task forces or teams sometimes are formed on specific issues. These often include citizens and representatives of citizen's organizations.

The Department also has specified liaisons with various organizations such as Trout Unlimited an Ducks Unlimited. This keeps a segment of the public informed on issues and provides a contact person. We have strong programmatic relationships with customers, some provincial and others eclectic (Ruffed Grouse Society, Trout Unlimited, Wisconsin Woodland Owners Association, Sierra Club, land trusts, etc.).

The Division of Resource Management embraces many aspects of Total Quality Management (TQM) to improve integration of its programs. TQM is based on three main principles: customer focus, team work and the scientific approach. Focusing on the customer improves our definition of quality services and is vital to decision making. Marketing specialists and a survey specialist help us focus on our customers. Teamwork is necessary on many projects because of their interdisciplinary nature. Teams function well when participation is valued, decisions are made by acceptance and conflicts are resolved rather than avoided. Team roles, emphasizing leader and facilitator, are important ingredients of effective teams. A management support team with frequent communication with the project team is important to ensure acceptance and implementation of recommendations. The scientific approach uses data to enhance creative problem solving, seeks quality data, looks for root causes of problems, views the organization as a system, and uses the plan-do-check-act cycle to constantly improve processes.

The beaver management team, pulp siting team and trails team are examples of successful teams in the Division of Resource Management.

Institutional Function

Land acquisition, planning, budgeting and issue management are dealt with through an integrated approach within the Wisconsin DNR. We believe that bringing stakeholders together to identify problems and opportunities as well as identifying, choosing, implementing and monitoring solutions is the preferable way to solve resource management problems.

Land Acquisition

In 1991, the Division of Resource Management completed a Land Acquisition Policy Report to guide the Department's aggressive and long-standing land-acquisition program. The report recommends priorities for acquisition, articulates a series of policies to guide the land-acquisition program and proposes implementation strategies.

The report, developed with the input of nine Department programs, identifies Department land-acquisition needs by region of the state. An important and recurring theme throughout the report is the need to buy land in an integrated fashion. Doing so meets the heretofore provincial needs of specific Department programs. The idea is that the Department should buy in such a way that we can maximize the resource management objectives of as many subprograms as possible with each purchase. A diverse group of professionals scrutinizes each candidate parcel, weighing the benefits and costs with those of other parcels. Chief among the criteria considered during evaluation is the number of programs that can achieve specific programmatic objectives with each purchase.

Planning and Budgeting

Within the state's biennial budget process, the Department identifies budget initiatives through a participative process with all levels of the agency, as well as all 28 subprograms nominating major issues that should be addressed through the budget. Once selected on the agency level, administrative divisions emulate the participative process in nominating and choosing projects consistent with the Department's initiatives. The Division of Resource Management, for example, selects interdisciplinary teams to write budget guidance for specific issues. The teams then scrutinize the projects, forwarding projects to the Department budget that address a broad range of resource management issues. Often, the projects are written collectively by resource managers representing more than one discipline. An example of a project likely to be reviewed favorably is one that restores wetlands in an urban area. Consider the genesis and outputs from such a project. A fish manager might see the need for a spawning marsh for northern pike; the wildlife manager identifies a shortage of brood water for waterfowl; the endangered resource manger notes the loss of semi-permanent wetlands and detects a decline in the local population of over-water nesting colonial waterbirds; the parks and recreation specialists in this urban area urge the development of outdoor recreation opportunities; and, finally, the Department education specialist calls for an outdoor teaching laboratory.

The Department urges resource managers to identify local needs within their area of expertise and work toward meeting those needs in a way that compliments the programs of others. The specialists and managers in our example might well co-author a project to restore a wetland in an urban area. The project, once fully developed, could meet the provincial needs of all of the managers and specialists we've talked about.

Team-based Issue Management

The Wisconsin Department of Natural Resources conceived the idea of Technology Teams in 1987. Teams consist of a small group of Department staff, organized across section, bureau and division lines and are recognized as a set of experts on a particular type of issue, technology or industry. Teams have the following characteristics:

- small, perhaps two to six people;
- led by a chairperson selected for technical knowledge;
- advisory in nature;
- serve as: (a) source of expertise, (b) forum for issues discussion, (c) mechanism for cross program and cross media issue identification, (d) place for entree and liaison with related industry groups, (e) DNR representation at industry/technology professional meetings, and (f) an opportunity to survey our client industries and other resource users about potential ways of improving our coordination and services to them; and
- constitute a partial assignment for staff, potentially requiring position description changes and affording the potential for professional growth.

The concept of Technology Teams was particularly supportive of the Department's Strategic Plan. That plan described five major strategic themes: sharing responsibility, preventing problems, interdisciplinary management, progressive work climate, and thinking long range.

Technology Teams provide an opportunity for sharing responsibility by providing a forum where technical experts from within the Department can work with technical experts or others from outside the Department to address technical or policy issues. In some cases, the Teams have been comprised entirely of Department staff, while in others, the Teams have included members from outside the Department. In nearly all cases, the Teams have met with outside groups and prepared reports and exchanged information with others. To date, there have been seven Technology Teams addressing a broad range of topics including incineration, pulp and paper, asphalt paving, federal agricultural policy, salvage yards, bioremediation, and energy.

Case Studies in Integrated Resource Management

Four examples will serve to illustrate how Integrated Resource Management has been applied by the Wisconsin DNR. While these initial attempts are far from perfect, we believe they demonstrate that impressive results can be obtained by integration, landscape-scale management and public involvement.

Habitat Restoration Area Program

Grassland and wetland dependent bird species throughout agricultural regions of the Midwest have declined as agricultural practices intensified. Specifically, dabbling duck, grassland songbird and ring-necked pheasant populations have decreased concurrent with the loss of grasslands, declines in both native prairies and domestic hay varieties, and the drainage and alteration of wetlands. The Department proposed a Habitat Restoration Area (HRA) project designed to reverse the decline of grassland and wetland dependent bird species and increase opportunities for wildlife-based recreation. The project aims to reestablish the compatibility of wildlife conservation and agricultural production that has largely disappeared with the emergence of intensive land use. The HRA, in contrast to traditional approaches to managing grassland-dependent wildlife, is designed to protect and enhance biodiversity in an agricultural landscape on a broad scale rather than on discrete limited acreages.

The HRA program was designed based on input from a diverse collection of organizations and land management agencies. The wildlife habitat objectives and implementation strategies reflect the multitude of interests, funding sources and programs that the contributors brought to the development process. For example, the first HRA has aggressive habitat objectives for both game and nongame species. Aside from the Department funding, several agencies and organizations have committed both funds and labor to the project. Among them are Ducks Unlimited and The Nature Conservancy representing the private sector, and U. S. Department of Agriculture—Agricultural Stabilization and Conservation Service and U. S. Department of Interior—Fish and Wildlife Service representing public agencies. Finally, implementation of the Ducks Unlimited MARSH Program, the federal Conservation Reserve Program and the state nonpoint program has been targeted to the HRA.

The project plans to restore 10 percent of available uplands (38,600 ac [15,621 ha]) to native and introduced grasses and 10 percent of the historic wetland base (11,001 ac [4,452 ha]) in a 530,000-acre (214,491 ha) area in east-central Wisconsin. Vestiges of native plant communities will be targeted for protection and enhancement. Habitat will be restored in relatively small tracts (<80 ac [32 ha]) interspersed with contemporary agricultural operations and existing blocks of public land. Land control and management rights will be gained through easements, fee title purchase, and cooperative agreements using public and private funds. State, county and federal agencies, as well as private conservation organizations will participate. The HRA is designed to be a focused landscape-level approach to improving wildlife habitat and associated benefits. We suggest that geographically focused landscape level initiatives such as the HRA are needed to reverse the losses in biodiversity and wildlife abundance due to agricultural impacts. The HRA approach appears to be a viable way of coordinating fiscal, political and biological considerations into a program of restoring grassland/wetland habitats in agricultural regions of North America.

The Delavan Lake Watershed Rehabilitation Project

Delavan Lake, a 9,200-acre lake in southeastern Wisconsin, was suffering from many of the same problems occurring on numerous lakes in agricultural and urbanizing watersheds: namely, declining water quality and clarity, out-of-balance fisheries dominated by an exotic (e.g., the common carp, (*Cyprinus carpio*) nuisance algae blooms), and increasing public dissatisfaction. The prescription for this situation became much more than the typical fish rehabilitation project. What was necessary to get at root causes and long-term solutions was a comprehensive, integrated project. It had to be comprehensive to look at the whole watershed and integrated to involve all players and cover all interactions.

Prior to 1950, Delavan Lake fish populations were diverse and relatively healthy, consisting of centrarchids, percids, ictalurids and cyprinids. The fish community showed increasing signs of becoming unbalanced in the ensuing decades. Carp and bigmouth buffalo (*Ictiobus cyprinellus*) became more abundant and comprised 95 percent of the fish biomass by 1984. Their feeding activities destroyed habitat and reduced food sources for other fishes. Intensive stocking efforts failed to establish healthy game fish populations.

At the same time water quality declined and the lake experienced severe blue-green algae blooms. Water clarity was measured at less than 1 foot in 1983. Restrictions on swimming and lake usage became necessary.

The rehabilitation of Delavan Lake is a demonstration of integration of the local lake community and federal, state and local government agencies. The following description by activity highlights some of those interactions.

- The lake community organized the Delavan Lake Sanitary District which build a sewer system and diverted upstream treatment plant discharges in the early 1980s. Water quality did not immediately respond and a study was initiated under DNR guidance with the U. S. Geological Survey (USGS) to identify water-quality problems and their sources. That evolved into a long-term lake monitoring program with USGS.
- The Town of Delavan formed a special Lake Committee in 1984 to advise them on lake issues. They played a lead role in promoting the project and published a newsletter to keep local residents informed.
- The University of Wisconsin (UW) Engineering Department completed a lake flow study and the UW Institute for Environmental Studies did a comprehensive lake improvement plan in 1986. These and other plans recommended several in-lake construction projects to control inflow and outflow, dam modification to allow bypassing high flows, a drawdown and fish eradication and restocking project, alum treatment, and wetland and sedimentation basin development.
- The Town of Delavan completed preliminary engineering planning reports in 1987, and legislation was passed allowing barrier peninsula construction.
- The Department completed an Environmental Impact Statement (EIS), and necessary engineering in 1988. The project began in 1989. Several public meetings were held in conjunction with the EIS and other planning work.

The Delavan Lake Watershed Rehabilitation Project was one of the largest fishery eradication projects ever done in the United States. The Town of Delavan and the U. S. Fish and Wildlife Service also helped fund the project. During a five-day period in the autumn of 1989, 50 Department personnel used 10 barges, 4 spray boats, 1 airboat, 1 helicopter, 5 drip stations, and backpacks to apply 52,200 gallons of rotenone to 31 miles of stream and marshes, 13 private ponds and 29,554 acre feet of lake water. Approximately 1 million pounds of fish (99 percent carp and buffalo) were dead within a few days. A diverse fish fauna was restocked in the lake in 1990–93 and excellent survival and growth rates have occurred thus far. Conservative fishing regulations are aimed at providing and protecting a quality sport fishery.

Dredging, dam reconstruction and the barrier peninsula were constructed in 1990. Following refilling, lake sediments were treated with alum, watershed nonpoint source controls were completed and wetlands purchased and restored. Water clarity of 26 feet occurred in 1991.

Total project costs were $7.14 million: with $4.3 million for construction and treatment, and $2.84 million for studies, plans, equipment, engineering and administration. By all measures so far, the project is an outstanding success. It also has raised awareness in the community that should ensure future watershed protection and good lake management.

The Winnebago System Integrated Management Project

The Winnebago system is composed of 138,000-acre Lake Winnebago (the largest inland lake in Wisconsin), three large upriver lakes (Butte des Morts, Poygan and Winneconne), two large rivers (Upper Fox and Wolf rivers) upstream from the main lake, and the Lower Fox River that drains Lake Winnebago into Green Bay.

Past management efforts on the Winnebago system have been hampered by the sheer size of the watershed, the complexity of the lake ecosystem, and conflicting interests among various users. The system is managed primarily by the Department (resource management) and the U. S. Army Corps of Engineers (water level control), though many other local, state and federal agencies have specific regulatory or management responsibilities for land use, recreation and navigation on the lakes. For the most part, each group has focused on a single issue or resource. Though valuable, these efforts were too small and narrow in perspective to result in effective, holistic management of the system's resources. Given the amount of use of the Winnebago system and the long-standing nature of its management problems, integrated management was needed to maintain, and more importantly, improve the quality of the resource.

For these reasons, a comprehensive management planning process was initiated by the Department in 1986, and the Winnebago Comprehensive Management Plan (WCMP) was completed in December 1989. The WCMP integrates Department management efforts with those of the other agencies and groups interested in the system's well being. The goal of the plan is ''to restore, improve, and maintain the ecological diversity and quality, and beneficial uses of the fish, wildlife and water resources of the Winnebago System.''

The WCMP project coordinator began the planning process with an extensive appraisal of the interests and concerns of individuals, agencies and organizations with a stake in the management or use of the Winnebago system's resources. This appraisal resulted in the formation of three technical planning committees as well as an ongoing citizens participation program. The three technical planing committees were formed to address fish and wildlife, water quality,and user conflict problems. The committees were composed of 12–28 members of diverse public groups, private groups and government agencies. They were charged with identifying problems that impair the ecological diversity and quality, or the use and management of the Winnebago system's resources; drafting goals and objectives for the desired state of the system; and proposing and evaluating alternative management strategies that would achieve the intentions of the project goal.

The WCMP project coordinator, with the help of members from the User Committee, also conducted a citizens participation process in parallel with the technical planning committee process. Extensive efforts were made to ensure citizens had opportunities to become involved in the Winnebago planning and decision-making process.

The WCMP is a conceptual plan that identifies resource use and management needs for the system, sets clear objectives to address those needs and lists options for management activities. Some of the activities outlined in the WCMP already are part of either the Department's or other agencies' programs. Other activities require various legal permits, legislation or further study to fully implement. Most of the activities taken from the plan require involvement by citizens, local governments and interested groups in the scheduling, funding or construction of specific projects.

Joint and single agency efforts and public volunteers, with funding coming from a variety of traditional and non-traditional sources, are implementing the WCMP. In addition, the Department is committed to ensuring that public involvement and program integration remain as active and visible parts of resource management of the Winnebago system.

A key proposal in the WCMP calls for habitat restoration through the construction of rock breakwalls in select areas of each of the three upriver lakes. This 15-year project will restore up to 5 square miles of wetland habitat on the 27,000-acre upriver lakes at a cost of approximately $9 million. Construction of the first phase of the project is scheduled to begin in early 1993, and to date there has been close cooperation and support among a number of local, state and federal agencies, as well as private individuals and organizations.

1990 Farm Bill

The Department is increasing its efforts to shape an influence federal legislation, programs and policies to protect, restore and manage natural resources. The Department recognized the profound impact of the federal government, both the legislative and executive branches, on the abundance, distribution and quality of natural resources. The Department now routinely develops position papers, works with special interest groups and the Wisconsin Congressional delegation, all in an effort to increase the role of the state in federal policy development. Among the issues the Department has worked on are the 1990 Farm Bill, the Clean Water Act and the Endangered Species Act.

Federal agricultural policies have far-reaching impacts on the quality and quantity of many natural resources in Wisconsin and most states. Wetlands, surface water, groundwater, soil, forests, wildlife and fisheries all are profoundly affected by land use. No other contemporary phenomenon affects land use in the United States more profoundly than federal agriculture policy. With that in mind, the Department appointed an Agriculture Technology and Policy Team (Team) to focus on shaping laws and programs to influence agriculture policies through the Farm Bill.

The Department had rarely worked directly with the Congressional delegation on the "front end" of legislation of this magnitude. Rather, the Department has most often relied on associations of resource protection agency administrators, such as the International Association of Fish and Wildlife Agencies (IAFWA) as well as the National Governors' Association (NGA), as a forum to make recommendations on federal legislation. In this case, however, the Team decided to emulate the modern political paradigm by working directly with the Congressional delegation. The Wisconsin Congressional delegation holds key committee assignments on the House Agriculture Committee, House Appropriations Committee and Senate Appropriations Committee. All three committees are important in passing five-year farm bills, due, in large part, to the remarkably high cost of agricultural programs.

The Team was charged with shaping conservation provisions of the 1990 Farm Bill by working with the Congressional delegation. In addition to working directly with the delegation, Team members maintained, and, in fact, stepped up activities with the resource protection organizations with whom we've worked in the past. For example, Wisconsin had important input in the IAFWA position paper on the Farm Bill and the Department worked with the Governor's office on the NGA position paper.

Department Secretary C. D. Besadny polled our Congressional delegation in late autumn 1989, to assess members' interest in working with the Department on the upcoming Farm Bill. The response was very encouraging and the Team began working on a position paper. Program integration was evident as Team members brought several disciplines to the process and shared writing responsibilities based on expertise and produced *Natural Resources Management and Federal Agricultural Policy: State of Wisconsin Recommendations Related to the Environment for the 1990 Farm Bill.*

Meanwhile, Team members met with Wisconsin's Congressional staffers in Washington to encourage them to work with the state. This meeting served three important purposes. Team members met face-to-face with key staffers opening lines of communication. Second, it confirmed the Department's commitment to environmental protection through working on the Farm Bill. Third, Team members fostered national support for our positions by meeting with others with similar interests.

The Team decided that a position paper would be far more influential if it were co-authored by the state Department of Agriculture, Trade and Consumer Protection (DATCP) and endorsed by Governor Thompson. Therefore, DATCP Secretary Howard Richards and his staff were asked to assist in drafting the position paper. With joint DATCP and Department participation, the agricultural and economic perspective had to be blended with that of environmental protection. Lengthy but productive discussions proceeded. The position paper, by virtue of being prepared by two agencies with markedly different missions, was widely perceived as a ''middle-of-the-road'' approach to agriculture policy, balancing environmental protection and a viable agricultural economy. The paper went on to the Governor's office accompanied by a transmittal letter for his signature. While Governor Thompson elected not sign the letter, the position paper was sent to the delegation, private organizations and Congressional committees bearing the signatures of both Secretary Besadny and Secretary Richards.

Senator Robert Kasten's Office was exceedingly interested in working closely with the Team to formulate conservation provisions of the 1990 Farm Bill. Senator Kasten's staff and Team members conferred two or three times each week over the many months of Congressional deliberations. For example:

- The Team recommended statutory additions and deletions to Congressional offices consistent with the Team's assignment from Department administration.
- The Team regularly responded to proposed Farm Bill legislation forwarded by Senators and House members. Typically, the Department was asked ''What is Wisconsin's position on this proposal?''
- The Team was asked to contribute to speeches given on the Senate floor.

What Did We Learn From the 1990 Farm Bill Experience?

We were not alone in forwarding recommendations to Congress on the 1990 Farm Bill. Special interest groups from the National Audubon Society to the Pork Producers, from the Sierra Club to the Corn Growers made their presence known. We were, then, a voice in a very large choir that was singing a multitude of different tunes simultaneously. Taken singly, our recommendations generally were not original; most of these recommendations also were advocated by others with narrower and more provincial interests. However, the full body of recommendations which appeared in the Team's position paper was balanced, concise and comprehensive in an attractive and readable format. Our *state* position that blended the needs of the environment with those of stable agricultural production seemed to find a ready audience.

There were several items that we suggested that became part of the law. For example, graduated penalties for Swampbuster, reauthorization of CRP, a Wetland Reserve Program and groundwater protection measures are now components of federal farm policy. We are particularly proud of the federal Wetland Reserve Program which reflects Wisconsin's state wetlands initiatives. Components of our HRA program, such as conservation easements, are emulated in the Wetland Reserve Program and we are pleased that a strong role for state conservation agencies has been established in the program. On the other hand, some of our recommendations were not adopted, but raised some issues for subsequent legislative consideration. For example, we pushed hard for conservation compliance standards based on water-quality parameters rather than soil erosion rates, which was supported by Senator Kasten. We are confident that this proposal received a thorough hearing and will have more support in the 1995 Farm Bill.

Summary

The Wisconsin DNR is making deterministic steps toward managing natural resources on a landscape scale through a process called Integrated Resource Management. We have recognized that our customer base has grown exponentially; concomitantly, the resource management issues that we need to address have grown as well. Our traditional customers, with their relatively narrow range of interests, were likely well-served by natural resource agencies that addressed their specific needs and often dealt with problems of only local concern. However, as science advanced and societal demands diversified, our management systems needed to change in response.

The evolution to a fully Integrated Resource Management system will continue. The scale at which we work will increase, the number of people representing emerging interests will grow and our ability to manage resources in this dynamic setting will be challenged. Integrated Resource Management will better serve us and our customers by blending human needs and values with ecosystem capability and sustainability. It will bring societal wishes into the decision-making process resulting in better decisions that will have widespread support.

We feel that we made a credible attempt at integration in the three broad areas of Landscape-Scale Management, Public Involvement and Institutional Function. Our desire to work at a landscape scale has resulted in some significant advances that affect most of our land acquisition and management programs. Developing the forest Habitat Classification System has enabled us to better discern physical possibilities for management. The emergence of an ecoregion approach, anchored in our study of biodiversity in the state, has become exceedingly important in land-acquisition decisions by giving a solid assessment of the state's biota. Developing habitat models for a specific assemblage of wildlife species (e.g. grassland birds) has helped further illuminate options in land acquisition and management within ecoregions.

We continually are attempting to stay one step ahead of being directed, either by other branches of government or special interest publics, into a public involvement process that is flawed. Our concern is that such a directive might well produce a public involvement process that is unbalanced and/or skewed thereby favoring the interests of one particular facet of society. While it is difficult to "open up" the decision-making process, indeed, to invite others into a process that has oft time been left to resource management professionals, we feel that the technical expertise provided by resource managers, while extremely important, is only part of the decision-making process. Cognizant of this, we are trying to solicit public input and involvement in most of our programs.

We have made some fundamental changes in the way people within the organization work. We have established teams at nearly every level of the agency. The teams have shared, for many activities, decision-making responsibilities that heretofore were held by administrative levels. The teams generally work to achieve unanimity on key decisions. The use of teams to develop land-acquisition criteria and make decisions has enhanced our program. Budget decisions, too, are made in a participatory process. Teams define the criteria for funding projects and effectively recommend the projects that should be

included in the state budget request. We also have attempted to increase dialogue among professionals with markedly different backgrounds and responsibilities by establishing Technology Teams. The Department has begun emulating the Agriculture Technology and Policy Team's effort on the 1990 Farm Bill with the reauthorization of both the Endangered Species Act and Clean Water Act.

The case studies we have described show, to varying degrees, our ability to incorporate the tenants of Integrated Resource Management in our work. They show, we believe, our determination to involve various interests in natural resource management by broadening the scope of our physical work to entire landscapes, of our public work to new interests and of our institutional work to that of teams working in untraditional settings. We are confident that the course we are on is the one needed to meet both the contemporary and future problems in managing natural resources.

Authors' Note: This paper was a team effort, thus, the authors have equal standing.

National Marine Fisheries Service Budget Outlook for FY 1994

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Role of the Fisheries and Wildlife Assessment

The Fisheries and Wildlife Assessment is the National Fish and Wildlife Foundation's policy analysis arm. The primary focus of the program is agency funding for federal natural resource programs. Since 1987, the Foundation has produced detailed line-item analyses for the major natural resource agencies. The inspiration for the Fisheries and Wildlife Assessment came from members of Congress, particularly Appropriation Committee members, who were seeking non-biased, comprehensive information that would assist their analysis of the effectiveness of federal natural resource programs.

The studies are designed to provide indices of the success of existing programs, and an analysis of budgetary shortfalls and the adequacy of current policy direction. The documents are extensively used by key Congressional staff on both the authorizing and appropriations committees. The Assessment documents are successful because they are the only analysis to cover the entire agency budget, and the range of issues an agency must deal with. In addition, the Assessment documents detail program accomplishments so that Congressional staff can have a clear idea of how the money is spent. Finally, the Assessment documents do not hesitate to criticize an agency's performance, but do so in a constructive form that searches for the root cause of a failure and recommends an alternative solution.

In 1990, the Foundation published its first comprehensive analysis of the programs of the National Marine Fisheries Service (NMFS). The study featured a survey of the status of our major marine fisheries and outlined critical funding and policy needs for the agency. This study was endorsed by NMFS itself and has become a template for a number of agency reforms, including the development of a strategic plan, instigation of a national status of stocks survey and changes in the organization of the agency. Subsequent updates of the Assessment report generated considerable public interest, including articles in the *New York Times*, *Wall Street Journal*, *Chicago Tribune* and others. The Foundation remains committed to helping NMFS revitalize America's aquatic resources. The Foundation's goals are to work to integrate existing federal programs, help set goals and priorities and, in the end, help develop effective comprehensive programs.

National Marine Fisheries Service Overview

Our nation's fishery resources are an important part of our economic, cultural and environmental heritage, but these resources are in trouble. Many important fisheries have declined substantially in recent years, and this has had severe biological, social and economic consequences. Harvest for some species is 10 percent of the long-term average and only 1 percent of historical yields. Habitat destruction, flow diversion, pollution and other effects of development are destroying essential coastal, estuarine and riverine ecosystems which sustain 75 percent of the U. S. commercial fisheries and an even higher percentage of recreational fisheries. Bycatch, waste and improper management are leading to overharvest and depleted stocks that will require innovative management strategies to restore. Examples of overharvested and depleted stocks include such diverse marine species as American shad, some shark species, striped bass, groundfish populations of cod and flounder, highly migratory species like bluefin tuna, and Atlantic and numerous Pacific salmon stocks. Some stocks of salmon, once a symbol of America's rich natural heritage, have been drastically reduced; 106 stocks are extinct, 2 are listed as endangered and 5 are proposed for listing.

Just as important as overfishing to the nation's living marine resources is the adverse effect on commercial and recreational fishing caused by the loss and degradation of coastal habitats. NMFS estimates that more than 75 percent of the Nation's commercial and recreational fisheries in the lower 48 states are dependent upon estuarine habitat during some stage of their life cycle. Conservative estimates of the total annual benefits of a comprehensive national habitat program (including project review) are likely to exceed $1 billion, at a cost of $50 million to conduct an effective national program. Increased habitat and water quality improvements can be expected to result in increased populations of inshore-dependent species. Currently, habitat destruction continues to result in reductions of commercial and sport fish catches. The ability of habitats to support high production levels of fish and shellfish is diminishing, while pressures for their conversion to other uses are continuing.

The decline in fishery resources has an obvious and direct human dimension. As a result of these declines, many primary and secondary employment opportunities have been lost. Moreover, many recreational fishing opportunities and associated industry jobs have been foregone and will continue to be lost without significant action. As an economic asset, commercial marine fisheries are worth more than $3 billion annually in dockside value alone, while recreational marine fisheries and related industries are supported by annual direct expenditures from sport fishing of over $7 billion. Similar expenditures by sport fisherman on inland waters generate over $19 billion annually. The sport fishing industry alone provides more than 1 million jobs, according to industry sources. The multiplier effects of both these industries provides many more billions of dollars in economic activity to the U. S. economy.

A hallmark of current fisheries management for the commercial sector is open access to fisheries resources. Management strategies have principally focused on perpetuating access to the resource, and have, as a consequence, relied on quotas and gear and time restrictions on fishing. More often than not, resources have not been conserved using these management strategies. The social and economic consequences have been equally disastrous. Open access has led to massive fishing fleets that, when overfishing inevitably results, are economically devastated. Attempts to alleviate the distress of fishing communities often leads to fishing quotas higher than scientific evidence warrants, and this perpetuates dangerous levels of overfishing.

The situation need not persist. If fisheries resources are managed effectively as a renewable resource and their habitats are protected, society can promote sound fishery conservation and still maintain thriving commercial and recreational fishing industries. For example, on the commercial side alone, NMFS estimates that restoring the nation's fisheries resources could result in an increase in net revenues to commercial fisherman worth more than the total of current landings. This represents only a small fraction of the benefits to society. The annual increase in net revenues associated with recreational fishing is about $7 billion, significantly larger than that from commercial fishing. In addition to the direct economic benefits, maintaining a sound policy of conservation, habitat protection and economic growth would provide a number of benefits including:

- new opportunities for more Americans to enjoy the pleasure of recreational fishing;
- a steady supply of high-quality fresh domestic seafood;
- an increased quality of life as coastal and riverine ecosystems are improved and protected from unwise development and pollution;
- an improved economic climate, with fewer market gluts, that encourages economic growth for both commercial and recreational fishing; and
- recovery of such protected species as dolphins and sea turtles, as fishing practices become more conducive to conservation.

The Foundation believes that the problems associated with current fishing practices can and should be fixed as soon as possible to prevent additional losses to the nation's fisheries resources. With the development of its strategic plan, NMFS has taken the first step toward a balanced policy, that, if funded, will address the following key elements of rebuilding U. S. fisheries.

- NMFS must be able to make sound management recommendations that are based on good science. Of the 232 species assessed annually by NMFS, the status of utilization for 34 percent are unknown. Even for species where the status or tend is known, the information often is imprecise, and potential benefits worth billions are lost simply because of poor or absent information on both biological and socioeconomic benefits.
- NMFS must implement a comprehensive marine fisheries habitat protection program with aggressive national leadership. Coastal ecosystems are some of the most productive ecosystems in the world. They provide essential nursery and spawning areas for a variety of fish and provide migratory routes for salmon and other anadromous fish as they adjust from marine to fresh water. Although they are the most productive, coastal ecosystems are the most threatened, particularly considering that approximately 52 percent of the current population of the U. S. lives within 50 miles of the coast. Problems affecting coastal fishery resources include diversions of freshwater flows, the cumulative effects of development, non-point pollution and physical habitat loss.
- NMFS must provide sufficient manpower to assess the effects of all significant proposed projects (about 2,500 per year) and an effective research program to define critical habitats and the consequences of human alteration of these ecosystems as a sound basis for decision making by all involved federal, state and local authorities.
- NMFS must promote stronger scientific input into fisheries management. This includes foresight, planning, design and, above all, evaluation of federal fisheries' conservation strategies. New England groundfish, Gulf of Mexico red snapper, Atlantic salmon, bluefin tuna and Pacific salmon fisheries are in need of immediate attention.
- NMFS must be able to address the serious problem of overfishing through the development and implementation of innovative socioeconomic strategies to restore overfished stocks, particularly limited access schemes like Individual Transferable Quotas (ITQs). To date, NMFS has brought about four ITQ fisheries.
- NMFS must work to ensure that reduction of waste and bycatch are adequately considered by the Councils. The Foundation supports efforts to develop innovative solutions to reduce losses, as well as the development of better estimates of the

magnitude of waste and bycatch in U. S. fisheries including an analysis of the associated economic and biological implications on target and non-target species.

- NMFS must develop and implement innovative strategies for expanding its reach, including the idea of a cooperative venture to place NMFS observers on Coast Guard vessels, and the implementation of a uniformed service for dockside enforcement. Moreover, innovative enforcement activities are likely to be required in the future to adequately enforce the new provisions of limited-entry programs.

The National Marine Fisheries Service is the most grossly underfunded agency the Foundation assesses. Although its budget has grown, it largely has been in the form of add-ons rather than significant base funding. In many cases, the add-ons have led to further erosion of its base. The Foundation regards this as a serious mistake in light of the impacts NMFS has on both the marine fisheries resource and the economy. Aside from budgetary issues, NMFS faces the problem of being largely unrecognized within the Department of Commerce.

Over the last three months, the Foundation's Fisheries and Wildlife Assessment staff have visited four NMFS Regions and their associated Science Centers to determine NMFS needs and priorities for FY 1994. Several of the Foundation's priority recommendations are for additional funding and staffing to enable NMFS to improve its data collection and analysis; NMFS simply cannot afford huge uncertainties in its estimations of population sizes, harvest levels, or the causes of population declines. The Foundation will place a high priority on getting NMFS habitat program up and running. The Foundation also is recommending a new budget structure for FY 1994; one that is consistent with the goals of the NMFS Strategic Plan and provides more flexibility to the agency.

The Foundation believes that NMFS has taken the first step in what will be a long process of restoring the nation's living marine resources. The strategic plan and our recommendation for a new budget structure are based on three key components (1) rebuild U. S. Fisheries; (2) protect coastal fishery habitat; and (3) recover protected species. These goals can be accomplished, but only if the agency has sufficient funding and personnel and effective leadership. The following section details some of the main concerns and needs going into the FY 1994 process.

Initial Thoughts for the FY 1994 NMFS budget

Habitat Program

From a long-term perspective, there is little point in doing fisheries conservation and stock assessment work without also addressing their habitat requirements. Without sufficient habitat, the already depleted fishery stocks will not continue as sustainable resources. Over 75 percent of all fishery resources in the lower 48 states depend on coastal and estuarine habitat at some point in their life cycle, therefore NMFS' emphasis will be on coastal, estuarine and tributary riverine areas supporting migratory living marine resources. There also is a need for a pooling of effort between NMFS and the U. S. Fish and Wildlife Service (USFWS) on these areas of shared concern. This program sustained a heavy cut of $8.2 million below President's Budget for a total budget of $5.8 million.

Problems

- NMFS established a Habitat Office in FY 1993 with no funding in order to address the general habitat requirements for the fisheries under their jurisdiction.

- There is little understanding of marine and estuarine habitat requirements, or the functioning of the various coastal ecosystems.
- NMFS project review component consists of about 50 ecologists nationwide, or about 1.5 per coastal state. This clearly is insufficient to provide adequate analysis of the effects of the 10,000 development projects proposed annually.

Solutions

- Fully fund the Habitat Office in FY 1994 and require that NMFS start down the road toward a ''gravel to gravel'' (research and restoration) management program for anadromous and estuarine dependent living marine resources.
- Encourage NMFS, USFWS and the Corps of Engineers to coordinate in estuarine areas and share research efforts as well as facilities.
- NMFS should start a comprehensive status and monitoring program that will incorporate marine and estuarine species' habitat requirements.

Enforcement and Surveillance

A law is only as strong as its enforcement. The Magnuson Act contains provisions that should serve to protect the fisheries resource. However, the Enforcement and Surveillance Office within NMFS is underfunded and understaffed. The lack of sufficient presence and penalties has allowed the commercial fishing industry to view fines as simply a ''cost of doing business.'' Unfortunately, enforcement's situation seems to be worsening from a budgetary standpoint. In FY 1993, they received a reduction of $1.5 million below the President's budget for a total budget of $11 million.

Problems

- The enforcement presence is so small that it is accomplishing little in the way of deterring cheaters.
- There is a ''law-enforcement mentality'' that tends to put the emphasis on busting a few bad guys rather that preventing people from cheating.

Solutions

- Develop stiffer penalties to serve as greater deterrents. It is profitable for some fisherman to simply pay fines and continue their violations.
- Develop a uniform service to be a dock-side presence. This should help serve as a deterrent.
- Provide additional staffing and funding to meet NMFS legislative and management directives.

Fisheries Management

In its Strategic Plan, NMFS tried to promote the scientific management of fisheries. This would include rebuilding overfished stocks, maintaining currently productive fisheries, advancing fishery forecasts and ecosystem models and protecting living marine resource habitat. Unfortunately, NMFS' congressional budget has run contrary to the agency's goals by fostering a situation run piecemeal by add-ons. Many of the add-ons impede management flexibility. Indeed, the operational budget now consists of 49 percent add-ons, up from 39 percent as recently as 1990. More than $30 million in Congressional add-ons are in fact part of NMFS's base budget. It is imperative that the Administration, at a minimum, fully fund NMFS's base programs.

Problems

- Only 30 percent of the stocks under NMFS's jurisdiction have stock assessments being done. New England's groundfish surveys are the envy of NMFS and, yet, even they have been inadequate to make unchallengeable recommendations.

- Again, there is little understanding of marine ecosystem interactions, as well as habitat requirements.
- Add-ons force a piecemeal approach to fisheries management. The funding should be put into the base budget so NMFS can attack fisheries management issues comprehensively.
- There are many problems associated with incidental take or bycatch from certain gear types in certain areas.

Solutions

- Fund research to perform more long-term research on marine ecosystem interactions.
- Institute a comprehensive status and monitoring system. This will not be just an assessment of how many fish and where they are, but also must focus on habitat requirements. This effort, obviously, should be coordinated with the Habitat program.
- Fund stock assessments in the NMFS base budget rather than species-by-species in add-ons.
- Look at areas and times where bycatch can be avoided and gear types are less apt to make the problem worse. NMFS should take actions to reward those who use "safer" gear types by, for example, reducing their observer requirements.
- Individual Transferable Quotas/Individual Fishery Quotas and other limited-access schemes must be studied in the incidence of overfished and declining stocks.

Protected Species

NMFS is relatively new to endangered species and it shows. Its budget is woefully inadequate at $17 million and their program does not provide incentives to do the kind of "prelisting" work that could preclude listings. NMFS has won much praise for its efforts in the Northwest with salmonids, however, they are being buried under the consultation burden largely coming from the USDA Forest Service, who are consulting on each individual timber sale that might impact anadronmous fish.

Problems

- Possible salmon listings in the Northwest carry with them a large consultation burden.
- The protected species budget does not provide for a way to get out in front of listings.
- The Marine Mammal Protection Act may be colliding with protected species. The agency is not sure what effects growing marine mammal populations will have on declining fisheries stocks.

Solutions

- Working with communities and federal and state agencies on "prelisting" activities that may be able to preclude listing.
- Include a category and funding for prelisting activities in the NMFS budget.
- Provide funding and staffing to develop and implement recovery plans for listed species.

National Policy to Protect Coastal Fish Habitats

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Introduction

In the sea nothing lives to itself . . . each living thing is linked with all that surrounds it.
Rachel Carson

Fish, like every other living thing on this planet, are inseparable from their environment. That environment is not only wet, it is biological, physical, chemical and thermal—a complex inter-relationship between each animal and the world it inhabits during every stage of life. When we upset this delicate balance—by overfishing, altering, degrading or destroying the coastal environment—we diminish its capacity to support fish, other marine wildlife and, ultimately, human life.

Fish have the enviable luxury of not having to think about the nature of their relationship with their environment—they simply relate. We, of all animals, have the peculiar problem of having to find our place, of deciding how to act and how to react to the consequences of our actions. But in doing this, our world view is essentially anthropocentric. We tend to think of our own species as separate and apart from nature; controlling the world, not conforming to it.

Perhaps it is because we, in thought and action, defy our own symbiotic relationship with our environment that we choose to regard other animals similarly. Maybe that explains why we dissociate fish from their habitat in our fishery management policies, and place greater emphasis on managing fishermen than on protecting the environmental foundation of our fisheries.

Which is not to say we deny the inter-connection between fish and habitat or our substantial impact on both. Ecologists have made tremendous progress in enhancing our understanding of man/fish/habitat interactions. We know for certain that the quality and quantity of fish directly depends on the quality and quantity of habitats available to them, though precisely how and to what degree remains a topic for further scientific research. We know many of our activities in the coastal zone affect both fish and habitat adversely, even if we are not always clear as to cause and effect. That there is an immutable fish/habitat connection, however, goes without question. That we know enough to avoid much, if not most, of the damage we do is indisputable.

Nonetheless, a dichotomy exists in United States policy for managing marine fisheries. In our role as caretaker, or fishery manager, we've sworn to "conserve and manage the fishery resources found off the coasts of the United States" (Magnuson Fishery Conservation and Management Act, Public Law 94–265). But in practice, conserving and managing marine fisheries consists primarily of regulating the number of fish we remove from their environment. Protecting the coastal environment so that it might sustain greater numbers of fish is, for all intents and purposes, treated as a separate, and by implication, lesser issue.

The Fish Habitat Dichotomy

United States law governing marine fishing activities extends from the shoreline seaward 200 miles. The lofty goal of fisheries management is to regulate fishing throughout the migratory range of ocean fish, and we pursue that goal by coordinating federal initiatives with those of state agencies and by participating in international treaties. There is, as we know, substantial progress yet to be made in this area.

The range of coastal fish habitat is, if anything, even more extensive. Fish habitat has been broadly defined as wherever fish are found (Peters 1992). For marine species, including anadromous and catadromous fishes, habitat extends from upland streams to the continental shelf and beyond. Coastal rivers, bays, salt marshes, mangrove swamps, seagrass meadows and offshore reefs provide migratory paths and breeding and feeding grounds for virtually all the fish we eat or catch for sport.

But as the papers in this session make evident, those factors that impact the habitat of marine fish populations extend far beyond these geographical parameters. Upland land-use policies, water diversions, agricultural runoff and contaminant discharges; the entire terrestrial watershed that feeds the coastal zone must be considered as part of the ecosystem that marine fish inhabit.

Efforts to manage and conserve fish, therefore, must encompass measures to manage and conserve their entire coastal environment. And yet, our laws and institutions, for the most part, are set up to manage fish in isolation from the ecosystems they inhabit. Federal fishery management plans (FMPs) written under the Magnuson Fishery Conservation and Management Act pay lip service to habitat concerns, but little more. FMPs feature the obligatory habitat provisions, describing the significance of habitat to the species under management and assessing how changes in habitat might effect the fishery, but they contain no measures to control those changes. Even if they did, the National Marine Fisheries Service (NMFS), which implements all fishery management plans, has virtually no authority to enforce them.

The numerous federal environmental statutes promoting coastal habitat protection (Fish and Wildlife Coordination Act, Clean Water Act, National Environmental Policy Act, Federal Power Act, etc.) recognize the value of fish and wildlife, but they only authorize fishery managers to comment on potentially damaging activities and to recommend changes. Whether those changes are made is entirely at the discretion of other federal agencies, whose priorities may not and usually do not include fish conservation (Rosen 1992).

Separating habitat management from fishery management does harm to both objectives, with the result that the U.S. is not doing a very good job in either case. Populations of nearly all marine species of fish on the Atlantic, Gulf of Mexico and Pacific coasts are the lowest they've ever been (Chambers 1992). Although overfishing remains the most immediate cause of declines in fish populations, the chronic loss of habitat—to pollution, unwise development and other human activities—is without question the single greatest long-term threat to marine fisheries, especially for those fish dependent on coastal estuaries for their survival. Nationwide, 75 percent of sport and commercially harvested fish are estuarine-dependent (Chambers 1992). In Florida, where the percentage is as high as 85–95 percent, destruction of coastal wetlands would virtually obliterate the state's fishing industries (Cato 1990).

It doesn't make sense to give federal fishery managers stewardship responsibility for the nation's marine fish resources and then limit them to regulating fishing activities, with practically no authority over the numerous other human activities that can and do diminish fisheries production by damaging fish habitat.

Fishery management is destined to fail if not complemented by adequate protection of fish habitat. Likewise, efforts at habitat conservation and environmental protection require the aggressive advocacy of fishery managers and the fishing industry to better establish the link between fish on the one hand and productive habitat and clean water on the other, and to inspire public and political support. The only way this can be accomplished is by establishing an explicit national policy making coastal fish habitat conservation a national priority, integrating habitat needs with fishery management objectives, outlining specific goals for habitat protection and providing fishery managers with the authority and the means to achieve them.

National Agenda for Conserving Coastal Fish Habitat

It is often said, and rightly so, that habitat conservation is the common ground on which the commercial fishing industry, recreational fishermen and environmentalists can stand, and fight, for a common cause. In March 1991, the National Coalition for Marine Conservation (NCMC) brought these diverse groups together, along with fishery managers, policy makers and scientists, at a Symposium on Conservation of Coastal Fish Habitat, co-sponsored by the National Marine Fisheries Service (NMFS), U. S. Fish and Wildlife Service, Chesapeake Bay Foundation and the Sport Fishing Institute.

The proceedings of this symposium were published as *Stemming the Tide of Coastal Fish Habitat Loss*, and within that volume is a set of recommendations for turning back the rising tide of habitat loss in this country. This National Agenda for Conserving Coastal Fish Habitat represents a consensus of those who participated in the symposium and was subsequently endorsed by seven of the eight Regional Fishery Management Councils, the American Fisheries Society and others.

The following recommendations are based on that agenda:

- adopt and implement a comprehensive and aggressive national habitat conservation policy, incorporated into all fisheries programs and the programs of all marine-related federal agencies;
- give fishery managers the authority and adequate means to protect the habitat of fisheries under their jurisdiction;
- provide increased funding for the National Marine Fisheries Service's habitat conservation and research programs;
- broaden and strengthen existing environmental statutes to address the whole range of human activities that threaten wetlands and other key fish habitats;
- amend the Magnuson Act to feature tougher habitat conservation provisions;
- improve coordination among federal and state government agencies; and
- increase public awareness of the growing threats to fish habitat and the need for conservation.

Elevate Habitat Conservation to a National Priority

The Bush Administration adopted a promising "no net loss of wetlands" policy in 1988, but never followed through. The Clinton administration, along with the 103rd Congress, must replace lip service with leadership and make protecting our remaining wetlands and other critical fish habitats, while working to restore lost habitats, a national priority. That means elevating habitat conservation to the highest levels within each department and agency, including the Environmental Protection Agency, the Army Corps of Engineers, the U. S. Fish and Wildlife Service and, above all, NMFS. That means establishing a consistency of mission for habitat throughout the federal government. Responsibility and accountability for fish habitat protection within the government also must be clearly established. And Congress must stand behind those agencies charged with implementing the environmental laws it enacts and provide them with the budgetary support they need to do their jobs effectively.

Increased Regulatory Authority for NMFS

NMFS (and to a less extent the Fishery Management Councils) are the federal government's advocates for conserving the habitat of marine fish, but without the authority to command attention to their concerns, their voice is no more forceful than that of any other advocacy group whose demands on government policy compete directly with the needs of marine fisheries. NMFS should be given the authority to directly regulate projects that may cause significant damage to fish-supporting habitat. The agency should be authorized to modify, restrict or prohibit projects or activities which will alter, degrade or destroy essential fish habitats. Canada's Department of Oceans and Fisheries has this authority; so does the U. S. Environmental Protection Agency.

Funding Priority for Federal Habitat Programs

In October 1992, the National Oceanic and Atmospheric Administration (NOAA) created an executive-level Office of Habitat Protection in the National Marine Fisheries Service. This was in response to a recommendation of the 1991 NCMC symposium and the National Fish and Wildlife Foundation (Eno 1992). The new office oversees and coordinates habitat research and management throughout the agency's field structure. Unfortunately, NMFS was awarded no new funds with which to enhance its habitat program. The agency's habitat budget, in fact, has declined by 16 percent since 1982 (Eno 1992), leaving it under-funded, under-staffed and unable to fulfill its essential habitat conservation responsibilities.

Among these responsibilities are reviewing and commenting on roughly 10,000 proposed development projects each year, potentially effecting well over 400,000 acres of valuable coastal habitat. This is an impossible workload for the approximately 65 NMFS biologists and support staff who must review these proposals (Collins 1991). Research in the critical areas of wetland functions and contaminant effects also is poorly funded. National inventories of the quantity and quality of fish habitat are needed, including recent losses and gains. Congress should give immediate consideration to appropriating the level of funds for habitat conservation recommended by the National Fish and Wildlife Foundation in its "FY 1993 Fisheries and Wildlife Assessment for the National Marine Fisheries Service" (an additional $20 million above current levels).

Stronger Environmental Statues

Congress should enact a stronger Clean Water Act this session, emphasizing pollution prevention and ecosystem protection. No net loss of wetlands should be an expressed short-term objective of the Act, with net gain the long-term goal. Without recouping what we have lost in the past, we can never restore our fisheries to their biological potential. Loopholes in the wetlands permitting system must be closed. Currently, only about 20 percent of the activities affecting wetlands are covered by the Section 404 dredge and fill permit provision of the Act (Jahn 1992). The 404 program should be extended to cover all activities that degrade wetlands, including farming and forestry.

Federal water project management and water allocation policy must be revised in a way that protects and improves freshwater supplies to fish-supporting habitats. Freshwater inflows should be secured at or restored to levels approximating their normal (natural) flows. Federal subsidies for water diversions which adversely affect fisheries productivity should be eliminated.

Tougher Habitat Provisions in the Magnuson Act

Federal and federally approved projects should be required to be consistent with the objectives of the Magnuson Act. The Act should be amended to include habitat conservation as one of the National Standards for guiding management of marine fisheries. The Secretary of Commerce should be encouraged to consider knowledge and experience in habitat issues when appointing individuals to serve on the Fishery Management Councils. A 1990 amendment to the Act enhancing Council involvement in decisions that effect the habitat of anadromous species should be extended to all species.

Improved Inter-governmental Coordination

Thirty-seven federal agencies have some authority over activities affecting marine fisheries and their habitat (Gordon 1992). Under the present system, habitat and environmental concerns are merely one component within many separate agencies, where they often are subordinated to other, often competing, interests. Serious consideration should be given to consolidating federal environmental protection responsibilities, including marine fisheries, in order to reduce duplicative and conflicting actions. Failing that, the Administration should develop a process to foster closer coordination among federal agencies and between the federal government and the states.

Public Education

Overfishing is a serious and immediate threat to most of the nation's fisheries, including our most valuable commercial and recreational fisheries. With 67 species considered overfished (Department of Commerce 1992), regulation of fishing deserves every bit of the attention it receives from fishery managers, and more. Notwithstanding, it also is true that NMFS devotes the lion's share of its time and resources to fishing regulations and allocations because of the hue and cry from commercial fishing interests and others impacted by fish declines and subsequent restrictions on fishing. The fish habitat constituency also must make itself heard.

A well-informed public will back political efforts to strengthen habitat protection. That is evident from the consensus reached at the NCMC's 1991 conference, as well as the participation last year of commercial fishermen, seafood processors, sport fishing industries, professional societies, conservation organizations and others in the call for increased funding for coastal habitat programs.

Information on the vital contribution of fisheries and related habitats to the nation's economic health and quality of life must be a key element of all conservation programs and should be made available to the public. Similarly, members of Congress need to be better educated to the fact that coastal habitat and environmental protection are crucial to the health of our marine fisheries. While we're expanding the definition of fisheries to include fish habitat, we need to make sure the public understands that when we talk about protecting fisheries, we're also talking protecting the fishermen, their livelihoods, their recreation, the industries and jobs they support and the fish they put on the table.

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Special Session 6. *Wetland Management for Shorebirds and Other Species*

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Integrated Wetland Management: Concepts and Opportunities

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Puxico

Introduction

The current emphasis and interest in biodiversity and landscape ecology are indicators that managers have new challenges (U. S. Fish and Wildlife Service [USFWS] 1990, 1991a). The focus of wetland management has changed from a single species or taxonomic group approach in the 1930s to a more complex and comprehensive approach in recent years. Our most skilled managers have made great strides in providing the required resources for a constantly increasing group of target wildlife. A widely recognized and accepted terminology for such efforts has not been established, but descriptors such as holistic, comprehensive and integrated have been used to identify this general strategy. For the purpose of this paper, we choose the term integrated wetland management and define it as management to maximize benefits for a community of species associated with a wetland complex. The scale can be variable and might range from continental to local. The most difficult component of integrated management is the complex thought necessary to integrate an enormous amount of diverse information into a single, comprehensive plan. To be effective, managers must be cognizant of species biology and chronology of life history events, wetland ecology, engineering, and many regulations, as well as the biopolitics of each situation. Our goal is to provide an overview of why we need integrated management, and to offer some suggestions to stimulate the development of specific management strategies for accommodating a greater diversity of species within each wetland complex.

Historic and Current Perspectives on Wetland Status

Part of the process of developing management strategies requires an understanding of why management often is needed. Thus, understanding the status of wetlands at the continental, flyway, regional and local scale is essential. Although a comprehensive inventory of wetlands on the North American continent was never conducted, it is likely that wetlands originally composed over 741 million acres (300 million ha), of which about 215 million acres (87 million ha) occurred in the lower 48 States (Dahl 1990, Tiner 1984). Originally, many areas such as the Prairie Potholes, Gulf Coast, Central Valley of California and the lower Mississippi Alluvial Valley, contained a high density of wetlands that differed in many aspects, including functions, values, short- and long-term hydrologies, and plant communities. Such wetlands functioned naturally and supported a rich, abundant fauna because human populations largely were confined to the East Coast and the technology necessary to modify the landscape was not developed. These vast wetland areas were composed of complexes that were valuale to a diversity of wildlife for successful completion of life history events. The periodic drying of some wetlands within these complexes did not severely impact many vertebrate populations because wetlands were numerous, covered extensive areas and exhibited diverse hydroperiods ranging from ephemeral to permanently flooded. Further, species with limited mobility, such as herptiles, were well protected because wetlands were interconnected or distributed in a manner that supported survival.

Many early reports and estimates of wildlife abundance are based on cursory observations made by explorers and may have been exaggerated, but apparently wetland complexes supported a rich fauna that included not only waterbirds, but amphibians, reptiles and mammals as well. The productivity of these wetlands and aquatic systems was substantiated by the tremendous flow of fish, fur and fowl to urban markets before agriculture was well developed. Further, these extensive wetland complexes likely were valuable in most years, even during drought, because the myriad wetland types consistently provided at least some habitat for many wetland-dependent species.

As human populations increased and expanded west, the potential for wetland complexes to support high populations and many species was lost. The passage of legislation (e.g., Swamp Act of 1850), development of mechanical drainage equipment (e.g., dipper dredge) and agriculatural mechanization resulted in large-scale destruction of wetland complexes because they were considered worthless. Ephemeral wetlands were most vulnerable to modification because of the ease associated with converting such areas to agriculture. As technology evolved, the demand for food and fiber increased and government subsidies for drainage became available, conversion of wetlands with more permanent flooding regimes became feasible and economical, and wetlands originally deemed too difficult or costly to drain became prime targets for conversion. Although agricultural conversion has been responsible for 87 percent of wetland loss, other contributing factors include the lumber industry, transportation, urban encroachment, natural subsidence and increasing sea levels (Office of Technological Assessment 1984). As a result, not only have individual wetland basins been destroyed or modified, but complexes composed of different wetland types have been disrupted.

Nearly all wetlands in parts of Mexico, the 48 conterminous States and southern Canada have been severely impacted by human activities (Dahl 1990). Unmodified regional and local wetland complexes largely are restricted to small isolated tracts, except in Alaska and northern Canada. This disruption and loss altered the functions and values of remnant wetlands and resulted in a concomitant decline in the density and richness of wildlife that require wetlands to meet their life history requirements. This is evidenced by the number of species that depend on wetlands at least some time during the annual cycle that currently are listed as threatened or endangered and declining populations of many common wetland wildlife species. The severity of wetland loss and degradation has left no alternative but to manage remaining, disrupted wetlands intensively in an attempt to provide resources on a more consistent and reliable basis.

Current Programs and the Need to Consider Integrated Wetland Management

Decreases in wetland area, changes in wetland distribution, changes in the proportion of different wetland types and an increased awareness of the number of wildlife species dependent on wetlands have complicated wetland management. Resource personnel responsible for wetlands now must attempt to solve an intricate problem: manage fewer wetland areas for a greater diversity of wildlife, while simultaneously maintaining natural wetland functions and values. Because no single wetland type can provide the resources needed by all vertebrate species during a given period, nor can a single wetland provide the resources needed by a single species throughout the annual cycle, successful resolution of this problem requires increased knowledge concerning wetland dynamics and life history requirements of species that rely on wetlands. The management challenge is to provide these requirements in a timely fashion and in a manner that provides benefits to a maximum number of species. To meet these requirements, existing wetland basins must be protected, historic wetland basins must be restored, and/or new wetlands must be created in a manner that simulates hydrologic characteristics of historic wetland complexes.

To stop the current decline in wetland areas and promote increases in the number of wetland areas, numerous federal and state programs such as the North American Waterfowl Management Plan, Wetland Reserve Program and other private lands programs have been initiated. Such programs have been successful in reducing average net annual losses from 484,000 acres (195,872 ha) to 290,000 acres (117,361 ha), but losses of specific habitats often continue unchecked. For example, between the mid-1970s and mid-1980s, estuarine habitats continued to be lost at an alarming rate (Dahl et al. 1991). Further, the pattern of wetland distribution has been altered and the type of wetlands being restored/created are dissimilar from those being lost. This latter factor is a problem that many resource agency personnel and programs do not address. Nearly all information focuses on number of sites or total area, but information on juxtaposition, wetland type and hydrology is lacking (USFWS 1991b). Thus, measures of how these initiatives have influenced wetland values and functions are lacking.

Regardless of the program or size of area considered, maximum success will require that factors such as wetland type and distribution be incorporated within the framework of programs designed to benefit wildlife. Although such programs vary in scale, the general strategy is similar: maximize benefits using a diversity of wetland types in close juxtaposition. Thus, the foundation of integrated wetland management is based on knowledge of individual life history requirements of species and the associated chronology and type of biological events that are completed on the area being protected or managed. The scope of the area could be as large as a continent or flyway, or as small as a watershed or a single vernal pool. The goal is to provide a means of consistently providing resources to a diversity of target wildlife while minimizing the extent to which reproduction/survival of nontarget organisms is compromised.

The development of integrated wetland management requires a multifaceted approach, and includes incorporating information on the principles of wetland dynamics with available information on the life history strategies of wildlife using the area. Factors that must be considered include hydrology, soils, seedbanks, distribution and composition of invertebrate communities, species using wetlands, the chronology of use and mobility of each species, annual cycle events that are initiated or completed on the area being considered, and the habitat components necessary for successful completion of each event. Once compiled, this information reflects the complexity of integrated wetland management. In many cases, conflicts become apparent because the life history events and habitats necessary to provide needed resources differ greatly among species. Resolution of conflicts largely depends on the configuration, interconnections, diversity and size of wetlands composing the complex. In many cases, complete resolution is not possible because the wetland types necessary to support all species may not be present. If this is the case, the integrated wetland approach is useful for identifying the location and type of wetlands that must be developed. Such information also could be used to determine whether a particular wetland could be destroyed without deleterious effects, and if so, whether in-kind or out-of-kind mitigation is warranted. In the interim, information concerning the current condition of wetlands must be used to guide decisions concerning the best management strategy. When an existing problem is addressed to benefit a target species, other species often benefit. Thus, such an approach may not be beneficial for all species during a given season or year, but some benefits are provided and the long-term integrity and productivity of the wetland complex is maintained.

Implementation of Integrated Wetland Management

Flexibility in selecting management options is a salient characteristics of an integrated approach. Scale, geographic location and seasons must be considered, but hydrology; wetland size, number and type; environmental conditions; and the type of species present will modify strategies. For example, a management strategy considered appropriate for a wetland complex in the lower Mississippi Alluvial Valley may not represent an optimum strategy in the Central Valley of California, or even a wetland complex in an adjacent region such as the upper Mississippi Alluvial Valley. Thus, it would be impossible to develop a manual with stringent guidelines pertaining to the types of wetlands that should be created and the best approach to manage individual basins. Although clear direction concerning objectives are necessary, success is dependent on a stoichastic approach that bestows management responsibilities on individuals with the most experience in the geographical and ecological area of interest. Naturally, this will require employing competent individuals as managers and relying on their expertise to ensure appropriate management of specific wetland complexes. Because of the complex thought processes involved, acquiring such expertise takes years and represents a combination of continuing education to complement field experience. Much of the information required is available but must be methodically recorded. Pertinent data can be collected without formulating an extensive research design, and computer technology often is essential to help integrate such information into a useable format. Once this process is refined, managers will be able to provide resources to a greater diversity of wildlife. However, this will require competent wetland managers in the field with adequate budgets.

The Need for Integrated Wetland Management—An Example

To illustrate the necessity of an integrated approach to wetland management, we will apply the concept to Stoddard County, Missouri. The area originally was laced with low ridges, streams and shallow lakes (Korte and Fredrickson 1977). The dominant wetland habitat was lowland hardwood forest composed of different associations, ranging from bald cypress (*Taxodium distichum*)-water tupelo (*Nyssa aquatica*) at the lowest sites, to pin oak (*Quercus palustris*)-hickory (*Carya* spp.) at highest elevations. As the forested area was decimated and converted to agriculture, large blocks of wetland habitat were lost. Based on Soil Conservation Service (SCS) estimates of wetlands (defined as 50 percent probability of seven days continuous flooding during the growing season), only 34,737 acres (14,058 ha) of wetlands remained in Stoddard County as of 1991 (SCS data, Figure 1). Of this area, 27,370 acres (11,076 ha), or 78.8 percent, are protected and managed as three wetland areas that are administered by the U. S. Fish and Wildlife Service and the Missouri Department of Conservation (MDC). The remaining 7,367 acres (2,981 ha; 21.2 percent) of wetlands in the county are smaller isolated parcels in private ownership. Some wetlands are clumped along drainages but others are scattered throughout the county (Figure 1).

Although significant numbers and area of wetlands in southeastern Missouri have been lost, wetlands in Stoddard County still support 233 species of vertebrates at some time during the annual cycle, incuding 29 (12.4 percent) amphibians, 138 birds (59.2 percent), 12 mammals (5.2 percent), 26 reptiles (11.2 percent) and 28 (12.0 percent) fishes (MDC Natural History Database). Although more than 50 percent of the species are in the Class Aves, these species represent 26 Families, of which only 26 (20.0 percent) species are members of the Anatidae (i.e., ducks, geese, swans) (Table 1). Waders, shorebirds and rails are important members of the avifauna and account for an additional 46 species. Further, wetlands in the county support amphibians, birds, mammals, reptiles and fishes that are listed as state rare, threatened or endangered (Table 2). Many of these species only occasionally use wetlands in southeastern Missouri (e.g., anhinga [*Anhinga anhinga*]), but nevertheless, this comprehensive list illustrates that wetlands in the county remain important for a large, diverse group of wildlife.

Management of this diverse community is complicated not only by the number of different species and population sizes, but also because the life history requirements of many species are disparate both within and among seasons. For example, breeding habitat requirements of selected rare, threatened and endangered vertebrates differ not only in the type of wetlands (e.g., seasonal, semipermanent) and conditions (e.g., flooding depth, vegetation type) required, but also the season when these habitats must be made available (Table 3). For some species, such as the resident swamp rabbit (*Sylvilagus aquaticus*), habitat must be available throughout the year.

Information relating to life cycle needs for just a few species is suggestive of the complications that must be addressed. When habitat conditions required to successfully complete all annual cycle events are compared among species, the complexity of developing sound management strategies becomes obvious. Such complexity results because an individual species often requires multiple wetland types to complete all biological events. Thus, the interspersion and juxtaposition of habitats are as important as the types of wetlands available. The most valuable configuration and composition of a wetland complex varies depending on the species known to occur in the area of interest, and the mobility of those species. For example, providing life history requirements at the appropriate time for three common species (king rail [*Rallus elegans*], mallard [*Anas platyrhynchos*], bullfrog [*Rana catesbeiana*]) requires a diversity of: (1) wetland types, (2) water depths, (3) cover types, and (4) foods at various times during the year (Table 4). The correct configuration of different wetland types largely is dependent on the least

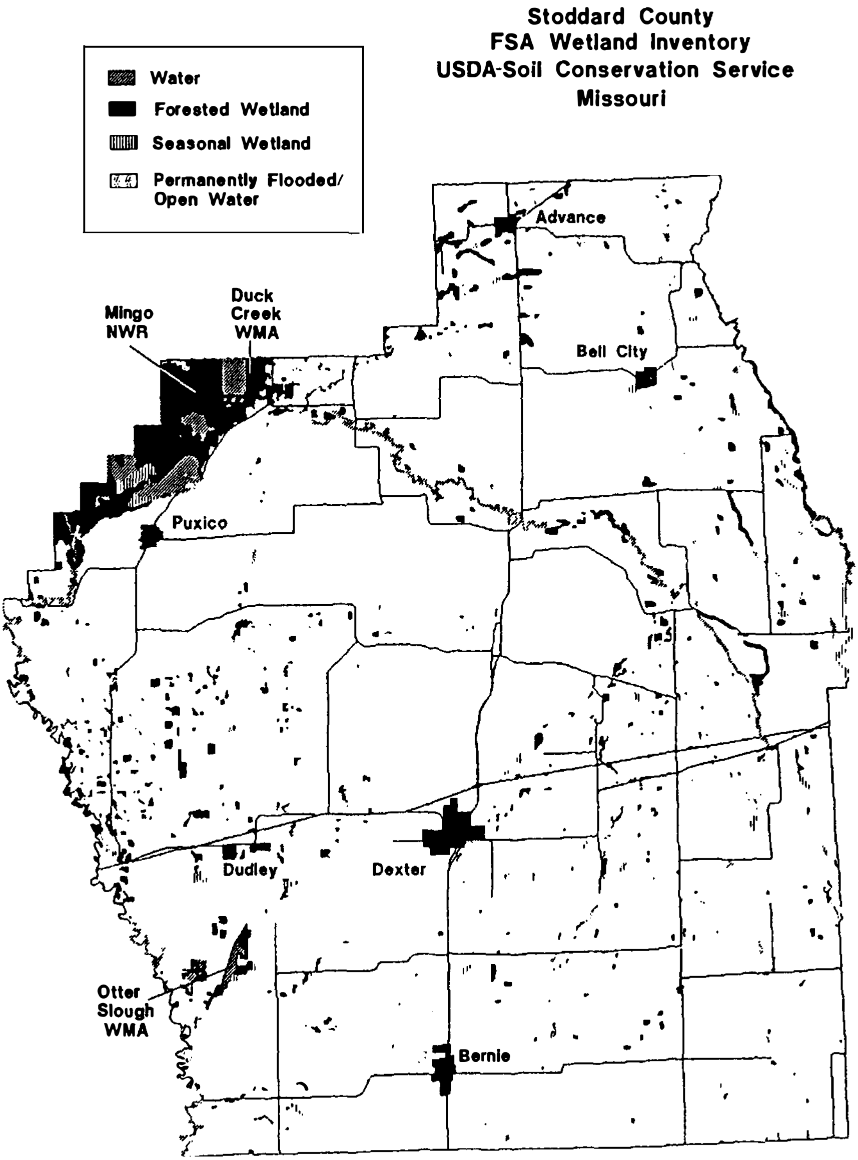

Figure 1. Wetland type and distribution in Stoddard County, Missouri, 1991.

mobile species, in this example bullfrog. Although mallards readily exploit wetlands within a 10-mile radius, the distance bullfrogs move is much more limited. Thus, providing adequate habitat for bullfrogs requires that wetland types used by this species be spaced more closely. This illustrates the importance of incorporating species ecology into the management approach to assure an acceptable configuration and creation/restoration of wetland types within a complex.

Providing Wetland Resources

Integrated management also provides opportunities to provide specific foods or habitats for species with very different needs. For example, wintering dabbling ducks require an abundance of high energy foods from arrival well into winter. The source of such foods might be acorns, annual moist-soil plants, or rowcrops. The best seed production of moist-soil plants occurs early in succession, thus soils must be disturbed by intensively feeding waterfowl or by using mechanical means. By carefully selecting the time and type of mechanical manipulations or water manipulations, habitats (e.g., mudflats) and foods (e.g., invertebrates) could be developed for shorebirds, while meeting the goal of increasing the production of high-energy foods (Rundle and Fredrickson 1981). Conversely, the use of flooding to control perennial vegetation also could create habitat for

Table 1. Families and number of species in Class Aves recorded using wetlands in Stoddard County, Missouri.

Family	Number of species	Percentage
Accipitridae (kite, hawk, eagle)	6	4.3
Alcedinidae (kingfisher)	1	0.7
Anatidae (duck, geese, swan)	26	18.8
Anhingidae (anhinga)	1	0.7
Ardeidae (herons, bittern)	10	7.2
Certhiidae (creeper)	1	0.7
Charadriidae (plover)	5	3.6
Ciconiidae (stork)	1	0.7
Corvidae (crow)	1	0.7
Emberizidae (warbler, sparrow)	21	15.2
Fringillidae (finch)	1	0.7
Gruidae (crane)	1	0.7
Hirundinidae (swallow)	5	3.6
Laridae (gull, tern)	7	5.1
Muscicapidae (thrush)	4	2.8
Paridae (chickadee)	2	1.4
Phalacrocorocidae (cormorant)	1	0.7
Phasianidae (pheasant, quail)	1	0.7
Picidae (woodpecker)	2	1.4
Podicipedidae (grebe)	2	1.4
Rallidae (coot, gallinule, rail)	7	5.1
Scolopacidae (sandpiper)	23	16.7
Strigidae (owl)	1	0.7
Sturnidae (starling)	1	0.7
Threskiornithidae (ibis)	3	2.2
Troglodytidae (wren)	3	2.2
Verionidae (vireo)	1	0.7

rails as an initial step in a plan to increase seed production (Fredrickson and Taylor 1982). Regardless of the specific strategy chosen, the ability to manage effectively for a diversity of wildlife requires multiple wetlands with the water control necessary for vegetation management.

Conclusion

Currently, a common approach to resolve conflicts among strategies for different target groups consists of designating management of a specific wetland basin to benefit a particular species. Although potentially successful in the short-term, such a strategy often requires stabilizing hydrologic regimens within and among years, and ultimately leads to lowered productivity of the basin. As a result, stabilized management is not a long-term management solution to benefit a diversity of species. Rather, the best approach is to incorporate species biology and wetland ecology principles into programs that are designed to benefit wildlife. Decisions concerning future wetland protection, acquisition, restoration and creation should be guided by the composition of existing wetland areas and the needs of a diverse fauna. Because the mobility of many non-avian species is limited, efforts also should concentrate on enhancing existing wetland complexes. In Stoddard County, restoration/creation efforts that focus on improving the distribution, interspersion and juxtaposition of various wetland types in the vicinity of established state and federal wetland areas have far greater potential to protect threatened and endangered species and provide resources for common species than devoting effort to con-

Table 2. State rare, threatened and endangered species occurring in Stoddard County, Missouri, that require wetlands to successfully complete at least one stage of their annual life history.

Class	Common name	Scientific name	Status
Amphibia	Eastern spadefoot	*Scaphiopus holbrookii*	rare
	Illinois chorus frog	*Pseudacris streckeri*	rare
	Wood frog	*Rana sylvatica*	rare
	Four-toed salamander	*Hemidactylium scutatum*	rare
	Mole salamander	*Ambysstoma talpoideum*	rare
Aves	American bittern	*Botaurus lentiginosus*	endangered
	Bald eagle	*Haliaeetus leucocephalus*	endangered
	Black-crowned night-heron	*Nycticorax nycticorax*	rare
	Common moorhen	*Gallinula chloropus*	rare
	Great egret	*Casmerodia albus*	rare
	King rail	*Rallus elegans*	endangered
	Little blue heron	*Egretta caerulea*	rare
	Northern harrier	*Circus cyaneus*	endangered
	Pied-billed grebe	*Podilymbus podiceps*	rare
	Short-eared owl	*Asio flammeus*	endangered
	Snowy egret	*Egretta thula*	endangered
	Swainson's warbler	*Limnothlypis swainsonii*	endangered
Mammalia	Cotton mouse	*Peromyscus gossypinus*	rare
	Swamp rabbit	*Sylvilagus aquaticus*	rare
Reptilia	Alligator snapping turtle	*Macroclemys temminckii*	rare
	Western chicken turtle	*Deirochelys reticularia*	endangered
Pisces	Bantam sunfish	*Lepomis symmetricus*	rare
	Lake chubsucker	*Erimyzon sucetta*	rare
	Taillight shiner	*Notropis maculatus*	endangered

Table 3. Habitat requirements for breeding of selected rare, threatened and endangered vertebrates in Stoddard County, Missouri.

			Hydrology		
Class/species	Breeding season	Wetland type	Duration[a]	Depth	Spawn/nest site
Class Amphibia					
Illinois chorus frog	February-April (Illinois)	ditch, ag fields, moist-soil, marsh, swamp	SP, SF, TF, IF	shallow	standing water
Wood frog	March-July (Illinois)	stream, marsh, pond, reservoir, lake, woodland pool	P, SP	shallow	standing water
Class Aves					
American bittern	April-May (Illinois)	marsh, bog, slough	P, SP	shallow-moderate	emergent vegetation
King rail	March-September (Arkansas)	marsh, slough, ditch, pond, lake, reservoir	P, SP	shallow	emergent/floating vegetation
Pied-billed grebe	April-July (Iowa)	marsh, bog, slough, pond, lake, reservoir, temporary pools	P, SP, IE	deep	emergent/floating vegetation
Class Mammalia					
Cotton mouse	January-December (Alabama)	vegetated streambank, swamp	TF	shallow	shrub, stump, log, tree
Swamp rabbit	February-April (Missouri)	vegetated streambank, swamp, marsh, slough	P, SP	shallow	depression, log
Class Reptilia					
Alligator snapping turtle	June-July (Missouri)	swamp, marsh	P, SP	moderate-deep	hole near water
Western chicken turtle	Spring/Autumn (South Carolina)	swamp, slough, stream, pond, lake, reservoir	P, IF, SF	shallow	hole near water
Class Pisces					
Lake chubsucker	March-May (Missouri)	stream	P	moderate-deep	aquatic vegetation
Taillight shiner	March-October (Florida)	stream	P	moderate-deep	
Bantam sunfish		swamp	P	moderate-deep	

[a]IE = intermittently exposed; IF = intermittently flooded; P = permanently flooded; SF = seasonally flooded; SP = semipermanently flooded; TF = temporarily flooded.

Table 4. Habitat conditions required by mallards, king rails and bullfrogs to complete annual cycle events that occur in Stoddard County, Missouri.

Annual cycle event	Wetland type[a]	Hydrology		Vegetation		Foods
		Type[b]	Depth	Type	Density	
Mallard[c]						
autumn migration/ prealternate molt	mh, ms, ss	sf, sp, p	<10 in (25.4 cm)	annual	high	invertebrates, seeds, tubers
pair/courtship	ms, f, ss	sf, sp, p	<24 in (60.0 cm)	perennial	log	seeds, acorns
prebasic molt	mh, ow, gtr, f, ss, ag	sf, sp, p	<10 in (25.4 cm)	perennial	low	seeds, invertebrates, rowcrops
spring migration	dt, f, mh, ms	sf, sp, p	<10 in (25.4 cm)	perennial/annual	moderate	invertebrates (crustaceans), acorns
King rail[d]						
spring migration	mh, ms	sf, sp, p	4 in (10.0 cm)	perennial	high	crayfish, aquatic insects
nest/incubation	mh, ms	sf, sp, p	3 in (7.5 cm)	perennial	high	crayfish
brood rearing						
young (1–3 weeks)	mh, ms	sf, sp, p	1 in (2.5 cm)	perennial	low	
old (4–8 weeks)	mh, ms	sf, sp, p	<1 in (2.5 cm)	perennial	low	leeches, beetles, oligochaetes
fall migration	mh, ms	sf, sp, p	3 in (7.5 cm)	perennial	high	crayfish, aquatic insects
Bullfrog[e]						
resident	mh, f, ow	p	>12 in (30.0 cm)	perennial	medium	vertebrates, amphibians, fish

[a]mh = marsh; ms = moist-soil; ss = scrub/shrub; f = naturally flooded forest, ow = open water; gtr = greentree reservoir; dt = dead timber; ag = agricultural fields.
[b]sf = seasonally flooded; sp = semi-permanent; p = permanent.
[c]Data from Reid (1989).
[d]Data from Heitmeyer (1985).
[e]Data from Johnson (1987).

struction of scattered, small wetlands. Various programs, although designed differently, should have a unified concept regarding the ultimate goal to be attained. Simply expanding the number of wetlands without regard to distribution, functions and values will minimize long-term success in managing diverse wildlife populations. Optimum success can be realized only if policy makers responsible for guiding the management of our natural resources cooperate in developing rational, organized, integrated methodologies of improving current wetland conditions. Additionally, administrators must grant field management personnel the autonomy to make decisions that are correct for the local area, provided such decisions adhere to approved long-range planning goals and objectives that have been established.

Adherence to the same general principals outlined for integrated management on a local scale also apply with regard to a flyway or continental perspective. The difficulty associated with developing strategies at a larger scale are complicated by the necessity for effective communication among resource agencies and private entities that span state and political boundaries. Available monies must be used to implement strategies that are connected to large-scale goals rather than satisfying political or private initiatives. Continued support of integrated management at this scale will require that benefits are derived from investments. Thus, a significant challenge will be to develop economical and suitable techniques to monitor progress and identify changes necessary for success.

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Enhancing the Management of Wetlands for Migrant Shorebirds

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Introduction

The loss of wetland habitats in North America has had detrimental effects on a myriad of wetland-dependent species. Wetlands in the U. S. alone have decreased from an original estimated 215 million acres (90 million ha) to approximately 103 million acres (42 million ha) by the 1980s (Dahl 1990). The majority of this loss has resulted from unsustainable agricultural practices in interior areas and from urban development in coastal areas. In California, for example, more than 70 percent of the coastal intertidal wetlands have been altered by human influence and more than 90 percent of the seasonally flooded wetlands of the Central Valley has been converted to agriculture (Tiner 1984). Population declines for numerous waterfowl species, especially Northern Pintail (*Anas acuta*) and Mallard (*A. platyrhyncos*), have been linked to this dramatic habitat loss (U. S. Fish and Wildlife Service [USFWS] and Canadian Wildlife Service [CWS] 1986).

Data on population declines for other wetland-dependant species is limited, although linkage between lower numbers and habitat loss has been suggested. Over 50 percent of U. S. coastal wetlands, for example, have been lost since the early 1900s, with some of the heaviest losses occurring along the Atlantic Coast of New Jersey, Florida and North Carolina (Tiner 1984). Ditching used in mosquito control programs further affected nearly 90 percent of all saltmarshes between Maine and Virginia before 1938 (Tiner 1984). Several shorebird species along the Atlantic coast have declined 40–80 percent between 1972 and 1983 (Howe et al. 1989). The cumulative impact of habitat loss and degradation therefore potentially has had an important impact on shorebird populations in coastal habitats. Little information exists on population trends of shorebirds throughout interior flyways where wetland losses are most dramatic. Although areas of large shorebird concentrations such as Cheyenne Bottoms, Kansas have shown declines of peak counts in recent years (Castro et al. 1990).

To counteract declines in waterbirds and wetlands, numerous organizations and agencies have developed programs to protect and enhance wetlands. One of the most important of these is the North American Waterfowl Management Plan (NAWMP), signed in 1986 by United States and Canada. The NAWMP is the largest initiative ever to protect, enhance and restore wetlands as wildlife habitats across North America. Although the Plan's primary focus is to address the problem of waterfowl population declines, it also will improve habitats for a myriad of other wetland-dependent species. Of the more than 165 species of waterbirds occurring throughout the U. S. and Canada, nearly 50 are shorebirds, followed closely by 43 species of waterfowl.

With the continuous decline of habitat and waterbirds, public and private wetland managers today are faced with challenges of managing habitats for multiple species groups, when little information may be available on life-history strategies and habitat requirements. The purpose of this paper is to provide information on species requirements and wetland management techniques to provide resources for migratory shorebirds which can be incorporated as part of an overall management scenario. In most cases, these techniques can be easily incorporated into a continuum of wetland management objectives ranging from regional NAWMP Joint Venture plans to the management of a single rice field in Arkansas.

Shorebirds

Shorebirds are a diverse group of birds occurring throughout the world. The Scolopacidae and Charadriidae families are found primarily in the western hemisphere. Shorebirds are morphologically diverse, with varying bill and leg lengths and body size, and ranging from the 0.75-ounce (20 g) least sandpiper (*Calidris minutilla*) to the over 1.5-pound (0.7 kg) long-billed curlew (*Numenius americanus*). Shorebirds also exploit diverse habitats—ranging from coastal beaches and marshes, mudflats and freshwater wetlands, to grasslands and savannahs (Myers et al. 1987). Their annual migrations can cover up to 18,000 miles (30,000 km) round trip, taking them from the tip of South America's Tierra del Fuego to the arctic tundra and boreal forest breeding grounds of Alaska and Canada (Morrison 1984).

Shorebird Migration

Although most neotropical migrants (songbirds) spread out along a wide migratory front, shorebirds come together from their dispersed breeding and non-breeding (wintering) grounds to concentrate along fixed pathways during migration (Myers et al. 1987). To fuel their nonstop flights of 40–60 hours (Castro and Myers 1989, Stoddard et al. 1983), several shorebirds rely upon a linked chain of a few, irreplaceable stop-over areas where they can rest and refuel. Few locations along their migratory pathways can provide enough food at the right time to support the requirements of these birds (Senner 1979, Morrison 1984). The availability of high densities of intertidal invertebrates in the Bay of Fundy and large concentrations of horseshoe crab (*Limulus polyphemus*) eggs in Delaware Bay are perfect examples of key wetland areas with an abundance of food resources available at the correct time to coincide with shorebird migration (Hicklin 1984, Myers et al. 1987).

The majority of shorebirds occur in temperate regions during migration. The timing of peak migration and species composition differs within geographic areas. Peak migration periods generally occur from March through May (spring), and from July through September (summer/autumn) (Helmers 1992). Generally, similar sized shorebird species, which exhibit overlap in habitat use and foraging techniques and depths, tend to show differences in timing of migration both in the spring and summer/autumn (Recher 1966, Helmers 1991). Several species of migrant shorebirds also show differential timing of migration between adults and juveniles during the summer/autumn migrations. Composition of species at stopover areas also can differ between spring and summer/autumn migration. Species such as white-rumped sandpipers (*Calidris fuscicollis*) and Hudsonian godwit (*Limosa haemastica*) migrate through the interior during spring and along the east coast during summer/autumn (Harrington et al. 1992, Morrison 1984).

Shorebirds spend up to 9–10 months of the year on non-breeding areas. During this time energetic requirements include maintenance, molt, and deposition of fat reserves before northward spring migration (Senner and Howe 1984). Although the majority of shorebirds winter in Central and South America, many winter in coastal and interior habitats of the U. S. and Mexico.

Reliance on Stopover Areas

During spring and summer/autumn, large numbers of shorebirds concentrate at coastal and inland staging areas (Senner and Howe 1984). Stopover areas provide shorebirds with sufficient food to nearly double their body mass during a relatively short stay (Castro and Myers 1989, Davidson 1984). This increased mass is mainly fat that will fuel the next stage of migration (Harrington et al. 1992). Because shorebirds have higher metabolic rates than non-passerines of similar size (Kersten and Persima 1987), and therefore must spend a high proportion of their daily schedule foraging for maintenance plus fat storage, the disappearance or degradation of spring stopover habitats may be an especially serious threat.

Shorebirds also must find resting areas free from human disturbance that provide protection from predators. When disturbance causes unnecessary flights, shorebirds attempt to meet their increased energy requirements by increasing foraging time. As food resources become limited, shorebirds must increase length of stay or be forced to depart at less than optimal body masses (Pfister et al. 1992).

Because shorbirds concentrate on these few, critical stopover areas, frequently large percentages of the population of a given species can be found in one location. For example, during spring migration, almost 80 percent of the east coast population of red knots (*Calidris canutus*) can be found in Delaware Bay (Harrington et al. 1984). This makes these birds extremely vulnerable to environmental degradation or habitat loss. Thus, the diminished ecological function of a single stopover area, due to development, an oil spill, disturbance, etc., could have tremendous consequences to entire populations.

Habitat Requirements

Shorebirds are a morphologically diverse group that exploit the shallowest end of the wetland continuum. During migrations, shorebirds are associated primarily with shallowly flooded coastal or freshwater wetlands or intertidal mudflats with over 70 percent using water depths less than 4 inches (10 cm) (Helmers 1992). Different species use a diverse range of habitat types including dry grasslands, sandy coastal beaches, natural wetlands and shallowly flooded agricultural fields (Johnsgard 1981). Migratory shorebirds show differences in foraging habitat use between species in relation to water depth and vegetation structure and distribution (Colwell and Oring 1988, Hands 1988, Helmers 1991). Foraging water depths for shorebirds range from 0–7 inches (0–18 cm), including the use of wet and drying mudflats. Vegetation density ranges from 0 percent to more than 75 percent cover, depending on species, but most species use sites with less than 25 percent cover (Burger et al. 1977, Colwell and Oring 1988, Hands 1988, Helmers 1991). Shorebirds also prefer vegetation height to be less than half their body height, although species such as the common snipe (*Gallinago gallinago*) can forage in taller vegetation (Hands 1988, Rundle and Fredrickson 1981). A range of habitat conditions from sparsely vegetated mudflats to moderately vegetated open shallows provide shorebirds with required habitats throughout their annual cycle.

Upland habitats associated with wetlands also are exploited by shorebirds. Shallowly flooded, short, sparse vegetation such as pastures maintained by mowing, grazing or fire provide feeding and nesting habitats for several species (Ryan and Renken 1987, Ryan et al. 1984, Cowell and Oring 1988).

Foods and Foraging

Macroinvertebrates are a key food resource for shorebirds. The migratory shorebird community at coastal sites generally exploits a benthic invertebrate fauna dominated by polychaetes, crustaceans or insects, within shallowly flooded mudflat habitats (Goss-Custard 1984). In interior areas, dipterans (fly larvae) are the main invertebrate prey consumed by shorebirds during migrations (Baldassarre and Fisher 1984, Eldridge 1987, Helmers 1991).

Shorebirds show a wide range of foraging techniques, both among and within species, depending on the habitat and available foods. These range from picking terrestrial insects from dry mud flats (plovers) to probing for molluscs in tidal mudflats (oystercatchers). Differences in body size, bill length and foraging technique allow shorebirds to partition themselves and avoid overlap in habitat use (Recher 1966, Baker and Baker 1973).

Shorebird Management

Effective management for migratory shorebirds therefore requires a knowledge of migration chronologies, habitat use, food requirements and foraging modes for different guilds within a specific geographic region (Fredrickson and Reid 1986, Helmers 1992). Here the emphasis is focused on the management of shorebird populations. It is recommended, however, that these strategies be a part of an integrated approach to waterbird management. Wetland use among different waterbird guilds separates both temporally and spatially, although considerable overlap does occur. Wetland managers should consider temporal separation in peak abundances between guilds and spatial separation in relation to water depth, vegetation distribution, foraging patterns and foods (Fredrickson and Reid 1986). Managing for a diversity of habitats will provide resources for wetland-associated organisms throughout their annual cycle.

Two major strategies can be used for shorebird management: (1) the protection of important breeding, migrating and wintering habitats (Senner and Howe 1984), such as the Prairie Pothole Region or the Central Valley of California; and (2) the reduction of disturbance, and increase in the accessibility of appropriate habitats in managed wetlands (Helmers 1992). Both techniques provide resources for migratory shorebirds in either coastal or interior wetlands, and easily can be incorporated into other management strategies. These techniques have been discussed in the recently published Shorebird Management Manual (Helmers 1992).

Protection

Many traditional habitats used by migratory shorebirds have been lost or degraded. The few remaining areas with high densities of shorebirds need to be protected by purchase or easement in order to protect them from further development or degradation. Fortunately, many of the wetlands that have been identified by the Joint Ventures of the NAWMP as priority areas for waterfowl also are used heavily by shorebirds. Plans which purchase, restore and enhance wetlands within these regions, such as those of the Gulf Coast and Prairie Habitat Joint Ventures, will provide additional protection of shorebird habitats. The coastal marshes and tidal flats of Delaware Bay, for example, support very high proportions (between 50 and 85 percent) of four species of shorebirds during spring migration and continues to be developed. Disturbance in this region could have serious effects on the entire species (Harrington et al. 1984). During 1992, a $4.1 million land acquisition program was approved by the North American Wetlands Conservation Council, to purchase habitats along the Maurice River in New Jersey. This project will protect valuable habitat for shorebirds and other species.

Although many areas, such as the Prairie Pothole region, have little potential for habitat management, unaltered natural wetland and upland habitats should have high priority for protection. Natural wetland complexes are dynamic and provide resources for a range of species during their hydrologic cycle. Although a single wetland cannot provide resources for all species during a single year, a complex of natural wetlands, each in a different phase of its hydrologic cycle, may provide a diversity of habitats for all waterbird species.

Disturbance

Management recommendations to maximize the temporal and spatial availability of habitats for foraging and roosting shorebirds need to be considered in relation to human recreational activities. Several species of shorebirds using coastal habitats require the use of staging areas, which also are prized habitats for human use (sun bathers, beach buggy enthusiasts, etc.). Resting areas, known as roosts, are necessary for rest and feather maintenance (Myers 1984). Shorebirds frequently roost on the tips of barrier islands, sandy beaches, saltmarshes or managed wetlands at night, or during periods of high tide when feeding areas are unavailable (Myers 1984).

Migratory shorebirds require substantial energy to replace depleted fat reserves that fuel the continuation of their migrations. As seen above, disturbance effects on migrating shorebirds can be energetically expensive. Limiting human access to areas with high concentrations of migratory shorebirds will decrease these unnecessary flights. The effects of disturbance caused by human activities can vary depending on species, type of disturbance and time of year (Burger 1986, Pfister et al. 1992). Levels of disturbance also tend to vary depending on the tidal cycle. For example, during high tide, shorebirds are limited to narrow stretches of habitat where they are exceptionally vulnerable to disturbance (Pfister et al. 1992).

Areas with high densities of roosting or foraging shorebirds, and with a limited amount of available habitats, should therefore be managed to avoid disturbance. This should be accomplished by total closure, or through restrictions on access for recreational activities. Areas that are known to function as roost sites, such as beaches, tips of barrier islands or portions of saltmarshes should be posted to reduce disturbance. Buffer zones should be a minimum of 165 feet (50 m) from the mean high tide mark (Howe 1989).

Federal agencies, state and local governments responsible for administering areas with high recreational use, especially coastal beaches, should develop signs, posters and leaflets as part of their public education programs. The information should provide explanations of the effects of disturbance on shorebirds and the purpose of closing or restricting certain areas.

Habitat Management

The diversity of wetland types used by shorebirds range from tidal flats and coastal beaches to permanent saline lakes. For the purpose of this section, management strategies will focus on only two wetland types: (1) seasonally flooded impoundments (moist-soil units), and (2) flooded agricultural fields. Managers can adapt these generalized techniques to other wetlands types by adjusting their management regimes to meet the life-history requirements of the species being targeted.

As generalizations, these recommendations require fine tuning in the manipulations because the timing and type of manipulations vary somewhat for different geographic areas. Managers are the true experts, and they understand the specific limitations and considerations for manipulations such as water availability, drawdown capabilities and time since disturbance. These considerations must be addressed when assessing the potential management capabilities for each unit. For example, drawdown dates for fields targeted for agricultural production will vary substantially, depending on the length of the growing season of the target crop, etc.

Managed Wetlands

Managed wetlands with water control structures are regularly used to grow natural and row crop foods for waterfowl. Until recently, seed production has been the major focus on migratory habitats and invertebrates have been a secondary consideration in waterfowl management (Fredrickson and Reid 1986). The timing, water depth and duration of drawdowns and flooding are important in creating habitats for all waterbirds. The water sources and movement capabilities for drawing down and flooding impoundments are important when considering management strategies.

Moist-soil Units

Moist-soil management is a term applied to drawing down or irrigating a wetland to create mudflat conditions which promote the germination of annual plants. Generalized strategies and techniques for the management of moist-soil units have been well summarized by Fredrickson and Taylor (1982) and Fredrickson (1991).

Spring. Moist-soil units suitable for spring shorebird management require autumn flooding approximately one month before the first heavy freeze, and maintenance of flooded conditions to enable chironomids (*Chironomus spp.*) and other invertebrates to re-populate, as well as to assure survival of larvae over winter. During the spring migratory period, units should be drawn down slowly 1 inch per week (2–3 cm/week) to allow for continuous availability of invertebrates (Rundle and Fredrickson 1981, Hands et al. 1991). Units planned for spring shorebird management should have extensive areas of open water, with generally less than 50 percent dense emergent vegetation. This will allow shorebirds to forage in open shallow water and mudflats as drawdowns occur. (Rundle and Fredrickson 1981, Hands et al. 1991, Helmers 1991). If more than one unit is being drawn down for shorebirds, staggering the initial drawdown dates will extend the availability of habitat and provide resources throughout the migratory period. For example, at Cheyenne Bottoms, Kansas, peak spring migration dates for Baird's sandpiper (*Calidris bairdii*) occur in early April whereas white-rumped sandpipers peak in late May (Helmers 1991). This slow and staggered drawdown of moist-soil units will not only provide resources for shorebirds and other species, but also will promote a diversity of vegetation communities (Frederickson 1991).

Summer/autumn. Management for summer/autumn shorebird habitats have two different strategies. Moist-soil units that remained flooded through spring and early summer can be drawn down, or units that are dry can be reflooded. If units were flooded through spring and early summer to provide habitats for breeding herons and rails then natural evaporation or slow drawdowns make invertebrates available to shorebirds and concentrate prey for other waterbirds (Reid 1989).

If dry units are to be flooded for shorebirds, units should be shallowly flooded 4–6 inches (10–15 cm) two to three weeks before summer/autumn migration begins. This will allow invertebrates to re-populate the newly created habitats. (Rundle and Fredrickson 1981, Hands et al. 1991, Helmers 1991). Usually, the vegetation must be manipulated by disking before re-flooding to assure shorebird response. The type of disking is critical, because the rationale behind disking is to convert plant biomass to a detrital base attractive to invertebrates. Deep disking that completely buries plant material is less desirable than shallow disking that only partially buries plant biomass. Thus, shallow disking acts as human-induced senescence and provides excellent substrates for invertebrates, whereas deep disking buries the plant biomass and reduces the availability of plant material for invertebrate processing (Fredrickson and Reid 1986).

Moist-soil units may need reconditioning every several years to remove undesirable vegetation. Reconditioning units through shallow disking and reflooding provides excellent opportunities for shorebird management during the summer. As with spring management, staggering the manipulations within several units extends the availability of habitats.

Agricultural Units

Agricultural lands in many areas are used to benefit waterfowl (Ringleman 1990, Reinecke et al. 1989) and may have the potential to provide resources for shorebirds. Freshwater wetlands managed for natural vegetation are preferred by shorebirds, especially in areas such as the Midwest. Although managed agricultural fields can be highly effective in providing shorebird habitat, especially in areas where managed wetlands are unavailable or where natural wetlands have been lost or degraded (Hands et al. 1991). If optimal water depths are available, shorebird use of agricultural fields can be extensive, especially during spring migration and winter. These habitats generally are not available during the summer/autumn migration period, although different lengths of growing seasons for crops and farming practices allow several options for enhancing agricultural fields for shorebirds (Sykes and Hunter 1978).

Winter. Between November and February, when the majority of wintering waterfowl occurs in southern regions, agricultural fields managed for waterfowl typically are flooded approximately 8 inches (20 cm) (Ringleman 1990), which is too deep for most shorebirds. Wintering shorebirds, such as long-billed dowitchers (*Limondromus scolopaceus*), require areas of 4 inches (10 cm) or less. Whereas, dunlin (*Calidris alpina*) and western sandpipers (*C. mauri*) require mudflats and water depths less than 2 inches (5 cm). Staggered water depths within and between fields during this period will provide foraging opportunities for a variety of waterbirds: dry or mud flats for geese, and shallow open water for pintail and teal. Fields not flooded by irrigation can have levees pulled up, or gates put in, for gradual flooding by winter rains. This maneuver will benefit several waterbird groups.

Spring. Agricultural fields flooded for waterfowl over winter generally are drawn down quickly in early spring to prepare fields for planting. These fields, planted in long-season crops, such as corn or rice, can be drawn down slowly beginning in late February through March so that early migrant shorebirds, ibis and late migrating waterfowl are provided with invertebrates.

Fields planned for crops with a shorter growing season, such as soybeans and milo, can be drawn down slowly in late March or early April to provide habitats for later-migrating shorebirds and waders.

During the spring, fields flooded for winter waterfowl that are to be left fallow (unplanted), and should not be drawn down completely until late May to ensure that habitat remains for late-migrating shorebirds. Water also should be held as long as possible before preparing fields for later crops such as cover crops or millet.

Summer/autumn. Agricultural fields are harvested from July to November, depending on the number of crops, the planting date and the type of crop. Between late July and September, several shallowly flooded fields (from < 1–6 inches [1–15 cm]) will provide foraging opportunities for southbound shorebirds such as the semipalmated (*Calidris pusilla*) and pectoral (*C. melanotos*) sandpipers as well as early migrating blue-winged teal (*Anas discors*).

Many fields, such as rice, have contour levees used to regulate water depths during the growing season. After harvest, rice fields can be rolled with a water filled drum or shallow disked to remove stubble, which will create open areas preferred by shorebirds. Flooding contoured fields to different water depths creates feeding opportunities for different shorebirds. Several level fields without contours should be flooded to different depths to provide foraging opportunities for different waterbird guilds (e.g., 2 inches [5 cm], 4 inches [10 cm], 6 inches [15 cm]).

During the summer, staggering the flooding dates between fields and water depths within fields can have a dual benefit. First, it will continuously provide new foraging habitat for migrant shorebirds and waders such as Ibis (*Plegadis spp.*). Second, early flooded fields that draw down from evaporation stimulate the germination of annual plants and, in turn, provide browse for wintering geese and possibly seeds for dabbling ducks (Helmers 1992).

Conclusions

The provision of quality habitat for migratory shorebirds requires correctly identifying current relationships among species requirements, the time required to meet these needs and the availability of required foods. Management plans for migratory shorebirds should focus on developing a food base that will be continuously available. Plans also should be sensitive to disturbance caused by human recreational activities. Habitat conditions required by shorebirds may be extensive, but food may not be readily available (water levels too deep) or cannot be extracted efficiently from the wetland (human disturbance) (Rundle and Fredrickson 1981, Hands et al. 1991, Helmers 1991).

Management of moist-soil units and agricultural fields for migratory shorebirds can easily be incorporated into currently used waterfowl management strategies. Minor changes in water depth, timing, and duration of drawdowns or reflooding within a managed complex can provide habitats for migrant shorebirds without changing the potential to provide habitat for other avian groups (Rundle and Fredrickson 1981, Hands et al. 1991, Helmers 1991).

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Managing Wetlands for Waterbirds

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Diversity of Waterbirds

Birds that require moist to flooded conditions in coastal or inland wetland systems are diverse in both form and function. Ecological separation occurs through differences in body size, bill shape and size, leg length, foraging behavior, and site selection of foraging zone. All these factors, plus nutritional requirements, impact the type of prey consummed. As an example of the range of sizes within waterbird groups, an African pygmy goose (*Nettapus auritus*) weighs under 300 grams, whereas a trumpeter swan (*Cygnus buccinator*) may reach 20 kilograms. Large assembledges of waterbirds of various sizes and forms may be able to exploit a single wetland by segregating along prey, foraging behavior, body form and microhabitat selection. For example, least bitterns (*Ixobrychus exilis*), the smallest of North American Ciconiiformes, may forage in the same marsh with great blue herons (*Ardea herodias*), the largest of North American herons. However, in order to do so, least bitterns must select different prey and shallower sites to feed, or use a behavioral response, such as grasping on emergent vegetation or constructing feeding platforms in order to forage at deeper sites (Weller 1961). Because of the great diversity of waterbird forms, humans have been interested in these birds since ancient time. Today, with increasing demands on wetland resources, there is a great need to better understand waterbird habitat use and avian response to human alterations in hydrology.

''Waterbird'' is a descriptive term for generalized habitat use rather than a specific taxonomic description. In fact, several avian families are placed in this group. The greatest diversity of species is found in the anatids (some 160 species world-wide) and rallids (some 140 species world-wide). Plovers, sandpipers, herons, gulls and terns also have great speciation in global occurrence. Nearly 800 species can be described as waterbirds and some 260 of these occur in North America. To understand waterbird habitat use, it is important to recognize the diverse group of birds that are represented in this description.

Three families in the order Pelecaniformes are separated from their seabird relatives and labeled waterbirds. These families consist of cormorants (Phalacrocoracidae—30 species world-wide, 6 species in North America), anhingas (Anhingidae—4 species world-wide, 1 species in North America) and pelicans (Pelecanidae—8 species world-wide, 2 species in North America) (AOU 1983). Nesting often occurs in coastal areas for these species, but also may occur inland in alkaline wetlands or riverine systems. Loons (Gaviidae—6 species world-wide, 5 species in North America) are holarctic in distribution and have great difficulty moving on land. Grebes (Podicipedidae—20 species world-wide, 8 species in North America), like loons, are found primarily breeding in inland lakes and marshes and wintering in coastal areas. Some grebes are found in tropical areas, and smaller species specialize on aquatic insects or crustaceans, while larger species tend to specialize on fish.

The swans, geese and ducks (Anatidae—160 species world-wide, 58 species in North

America) are the most diverse family of waterbirds. Foraging strategies range from fish- and crayfish-eating mergansers to grazing geese and swans. Habitats vary across a complete gradient of North American wetland types ranging from coastal marine systems used by eiders and scoters, to fast-flowing, montane streams used by harlequin ducks (*Histrionicus histrionicus*), to hardwood bottomlands, used by cavity-nesting wood ducks (*Aix sponsa*), to open prairie marshes used by breeding dabbling ducks, to terrestrial grasslands used by geese. Although world-wide in occurrence, the greatest diversity is found in the Northern Hemisphere.

The 10 tribes that compose the anatids are dominated by: dabbling ducks (Anatini) which have a mixed diet of invertebrates, seeds and roots; shelducks (Tadornini) which are primarily coastal grazers; seaducks (Mergini) which feed on molluscs, crustaceans, or fish in arctic breeding grounds or coastal lagoons in winter; pochards (Aythyini) which specialize on aquatic macrophytes; and geese (Anserini) which are mainly grazers and grubers of plant material. Lesser numbers of species are found in the perching ducks (Cairinini), whistling ducks (Dendrocygnini), stiff-tailed ducks (Oxyurini), swans (Cygnini), or monospecific tribe containing magpie goose (Anseranatini) of terrestrial Australia. The screamers (Anhimidae—3 species in South America) are semiaquatic relatives of waterfowl and specialize on vegetation.

The Ciconiiformes are large-bodied, long-necked, long-legged birds that wade in shallow wetlands. The most diverse family of this order is composed of the herons and bitterns (Ardeidae—62 species world-wide, 22 species in North America). Ibises and spoonbills (Threskironithidae—33 species world-wide, 7 species in North America) have probing or spatulate bills and are principally found pantropic. Storks (Ciconiidae—17 species world-wide, 2 species in North America) are heavy-bodied, heavy-billed waders that are pantropic in distribution with several species found in temperate Eurasia. Two other wader families are monospecific and found in Africa.

Flamingos (Phoenicopteriformes—4 species world-wide, 1 species in North America) are highly specialized filter feeders which breed in dense colonies and are found in alkaline lakes and lagoons of the tropics. Kingfishers (Alcedinidae—90 species world-wide, 6 species in North America) found in the Western Hemisphere are strictly piscivorous; whereas, many of the Old World species feed on terrestrial insects. Cranes (Gruidae—15 species world-wide, 2 species in North America) are large-bodied gruiforms which prefer marsh or wet prairie habitats and have generalized diets. Limpkin (Aramidae—1 species in North America), placed in a monospecific family, specializes on marsh gastropods and clams. Sun bittern and sungrebe families have four tropical representatives.

Second only to the anatids in breadth of species diversity, the rallids (Rallidae—140 species world-wide, 20 species in North America) are distributed throughout the world. Most species are compressed laterally in body shape as an adaptation for passing through dense vegetation (Ripley 1977). Musculature in the legs is well developed for walking. Although habitat use in this family crosses a transition from truly aquatic to terrestrial, most species are adapted to saturated or shallowly flooded areas. These secretive birds feed primarily on insects, crustaceans and seeds.

The 14 families, including nearly 300 species, contained in the order Charadriiformes all are waterbirds, or are species derived from waterbird archtypes. The gulls, terns, skimmers, skuas and jaegers (Laridae—94 species world-wide, 49 species in North America) are long-winged and capture prey at or near the water surface in the bill or by head-first dives. Scavenging is a common form of prey capture for many of these species.

The sandpipers (Scolopacidae—85 species world-wide, 48 species in North America), plovers (Charadriidae—64 species world-wide, 12 species in North America), oystercatchers (Haematopodidae—6 species world-wide, 2 species in North America), and stilts and avocets (Recurvirostridae—10 species world-wide, 2 species in North America) are globally distributed, most prefer open mudflat habitat, and commonly are called shorebirds. Aquatic and semi-aquatic invertebrates are the dominant prey consumed. The jacanas (Jacanidae—8 species world-wide, 2 species in North America) are found feeding in floating vegetation of tropical wetlands.

Declines in Waterbird Habitat

Over the last century, human modifications to the world's aquatic systems have been substantial. Most riverine habitats in North America, Europe and Asia have been modified by dam construction, constriction through levee development, alteration of floodplain habitat, or water quality degradations. Coastal areas have been altered by increasing urban and industrial expansion. Intensive agriculture, required to feed an ever-increasing world population, has devastated palustrine wetlands around the globe.

Recent losses of coastal, riverine and palustrine wetlands by conversion of forested and herbaceous habitats to agricultural, urban and industrial developments have had significant impacts on waterbirds. Degraded North American wetland and associated upland habitats and declining populations of several duck species have been well documented (Tiner 1984, Smith et al. 1989). The dramatic recovery of the whooping crane (*Grus americana*) is not mirrored by several crane species, and concern should exist over expanded human developments in northern China and southeastern Russia (Archibald and Miranda 1985). Perhaps the greatest declines of waterbird populations have occurred for ibises, spoonbills, cranes and rails. In recent history, some 10 species of insular rails have become extinct or extirpated from Pacific islands (Ripley 1977). Dramatic declines of small rails in the Rhone Delta were attributed to hydrologic alterations of that floodplain system (Reichholf 1982) and mirrors rail declines seen in North America (Eddleman et al. 1988). Many colonial species have faired better than solitary nesters, with some notable exceptions including the Chinese egret (*Egretta eulophotes*) (Hancock and Kushlan 1984).

Perhaps a greater challenge to waterbird management than direct wetland loss continues to be habitat degradation through hydrologic alteration of watersheds. These modifications to flooding cycles result in hydrologic stabilization, shifts in flood timing, and increased or decreased flooding (Klimas 1988). Modification of natural flood chronology and periodicity ultimately reduces long-term productivity of the wetland, limiting habitat availability and resulting in a decline of waterbird use (Fredrickson and Reid 1990). In order to protect and even restore waterbird populations, protection and restoration of critical habitats must be systematically accomplished in a continental approach.

Selected Management Options

Protection through public acquisition has been the chief mechanism to preserve key waterbird habitats. The initial establishment of a wildlife refuge in the United States in 1903 was for the protection of colonial waterbirds from plume hunters of the millinery industry. In untampered watersheds, such as much of arctic Alaska and Canada, several tropical systems in Mexico and Central America, and some montane systems in western

North America, management of pristine environments should be passive. Monitoring wetland function, waterbird habitat use and hydrologic cycles should be the emphases for resource agencies. Intensive management activities reserved for the rehabilitation of degraded systems may be diastrous on pristine habitats. Such activities disrupt the natural function of untampered wetlands (Fredrickson and Reid 1990).

Where hydrology has been altered, restoration and active management may be necessary. In some systems where long-term hydrologic patterns can be reestablished, such as large marsh complexes, passive management may be the best action. In other cases, in order to provide viable, dynamic waterbird habitat, active water management may be necessary (Fredrickson and Reid 1986, Smith et al. 1989). All natural wetlands have seasonal and long-term fluctuations in water levels. These hydrologic fluctuations maintain productivity, vegetation structure and function of wetlands. Variability in the timing of flooding or dewatering has an important influence on changes in germinating plant species composition and food availability for waterbirds. Managed systems should attempt to mimic regional hydrologic cycles and make habitats available during critical periods for migrant waterbirds.

To take advantage of predictable seasonal resources, many waterbirds have adapted long-distance migrations between wetland complexes. Arctic tern (*Sterna paradisaea*) demonstrate an extreme by flying from breeding colonies in the Arctic Ocean to wintering areas in the Antarctic. Buff-breasted sandpipers (*Tryngites subruficollis*) migrate more than 8,000 miles (13,000 km) from tundra habitats in the arctic to wintering grounds of the Argentine pampas. In one direct flight of 3,000 miles (4,800 km), pacific black brant (*Branta branta nigricans*) fly from Izembek Lagoon, Alaska to Baja, Mexico.

Acquisition of nutrients during migration is critical for many temperate waterbirds because nutrients must be obtained in a short period to maintain energy for migration and to potentially build body reserves for territorial defense or breeding. Body condition on depature from spring staging areas may be the critical factor limiting reproductive output (Drent and Daan 1980). This may be especially true for large-bodied waterbirds such as swans, geese, cranes and large herons which can gain nutrient reserves for breeding on wintering or staging areas (Ankney and MacInnes 1978, Raveling 1979, Alisauskas and Ankney 1985). The lipid demands for long hemispheric migrations of small-bodied waterbirds, such as arctic nesting sandpipers, limits nutrient storage capabilities during migration; however, staging areas are very important to rebuild lipid concentrations spent in migration (Ross 1979, Myers et al. 1987). American coots (*Fulica americana*), the largest of North American rallids, store all lipids required for egg production as reserves prior to arrival on breeding grounds (Alisauskas and Ankney 1985). This suggests that the condition of wintering or migrational habitats directly influences whether a coot will nest and the size of its clutch (Alisauskas and Ankney 1985). Reproductive performance of the purple heron (*Ardea purpensis*) in the Netherlands is influenced by water conditions on the wintering grounds in the Senegal and Niger river floodplains of Africa (den Held 1981). Other waterbird species well may have such requirements; thus, managers on wintering areas may play a key role in assuring that breeding on some distant wetland is successful (Fredrickson and Reid 1986).

Nutrients are obtained from a diverse range of foods. Management which tends to emphasize one form of food, e.g., seeds, may compromise the quality of habitat for many other groups of waterbirds. Preference of food types among waterbirds using four North American wetland types (Table 1) suggests that invertebrates and fish are important foods, besides plant material. Animal matter may be important to fewer inland waterbird species, however, in the arctic than in temperate wetlands.

Large-scale manipulations of watershed hydrologic regimes may be necessary for waterbird habitat under increasingly competing uses of water by humans (Kushlan 1987). Reducing water levels, either through natural drying or slow drawdown, provides a breadth of micro-habitat conditions so that many species of wading and shorebirds can forage in the same wetland. Increased foraging efficiency exists for individuals of flocks in areas of renewable food resources (Willard 1977). A single drawdown on a small wetland will not sustain a breeding heron population. Rather, a complex of seasonal wetlands, riverine sloughs and forested wetlands may be necessary to maintain a viable wading bird community. Wading bird response to drying or controlled drawdown on a given wetland is regulated by drawdown timing and length, and condition of the wetland complex (Reid 1989).

Water depth and vegetation structure are important cues for waterbird use of wetlands (Weller and Fredrickson 1974). In managed wetland complexes, avian species richness may be greatest in a 50:50 open/vegetated hemimarsh (Weller and Fredrickson 1974) and where complexes are present, rather than large isolated marshes (Brown and Dinsmore 1986). Ten of 25 avian species did not occur in marshes smaller than 5 hectares in a study of Iowa prairie marshes (Brown and Dinsmore 1986). Small wetland units or wetlands with large shoreline development that yielded greater ''edge'' area were more susceptible to king rail nest failures (Reid 1989). Human-impacted wetland area and travel lanes for predators have been implicated in wetland bird species declines. Whereas many of the mobile waterfowl species may be able to exploit small and isolated ephemeral wetlands, other wetland and grassland species are not as nomadic and face risks in isolated conditions.

Of the 800 species of waterbirds distributed around the world, some 33 percent breed, winter, or migrate into North America. Resource agencies need to address habitat considerations for waterbird species prior to their placement on endangered or threatened species lists. An integrated approach to wetland management should be applied where community structure and long-term productivity are the goals, rather than individual species management. Today, the most common problems facing resource biologists in much of temperate North America are that wetland systems are being managed too deep for most waterbird species to optimally forage, and the hydrologic regime has been stabilized. We should emphasize regional understanding and cooperation in developing strategies for management of watershed complexes and migration corridors. Continued demand for alternative uses of water will place more pressure on public refuges. Incen-

Table 1. Preference of food types among waterbirds using four North American wetland types.

	Number of species	Percentage food[a]				
		Roots	Browse	Seeds	Invertebrates	Vertebrates
California seasonal wetland	72	15	15	29	76	32
Florida seasonal wetland	62	10	13	32	81	35
Minnesota marsh	52	10	13	31	79	38
Alaska coastal tundra	48	15	15	21	67	21

[a]Food values represent approximate percentages of waterbirds that consume that item.

tives should be made available for modification to cultural practices in agriculture which allow true conjunctive use of grain production and waterbird survival and recruitment. For many waterbird species, quality wetland complexes along migration corridors are needed or extirpation will result.

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Managing Wetlands for Biodiversity: An Audubon Approach

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Introduction

Managing wetlands for biodiversity requires a thorough understanding of how individual wetlands function, their relationship to the surrounding environment and their place within the bioregion. In south Florida, National Audubon Society (Audubon) offers an example of what it means to manage wetlands for biodiversity. Highlighting Corkscrew Swamp Sanctuary, this paper demonstrates how extensive ecosystem studies determined the swamp's hydrological regime, plant communities and fire frequency. Understanding the natural processes that are operating at Corkscrew provides the basis for managing the sanctuary's biodiversity. Monitoring key factors that shape these processes allows for management assessment and alerts us to changes in the system.

However, Corkscrew Swamp Sanctuary, with only 10,500 acres (4,400 ha), is part of a much larger wetland ecosystem, and to maintain biodiversity, surrounding environments must be brought under the management umbrella. Corkscrew Swamp wetlands are part of the southwest Florida wetland complex known as the Big Cypress. Audubon is part of an initiative designed to acquire 55,000 acres (34,375 ha) of wetland and associated habitat between the Big Cypress National Preserve, the Florida Panther Wildlife Refuge and Corkscrew Swamp Sanctuary. This public/private effort, known as the Corkscrew Regional Ecosystem Watershed (CREW) Trust, is designed to buffer Corkscrew's old-growth cypress and to create corridors of wetland habitat between these core wildlife areas.

Yet, Corkscrew and the Big Cypress are themselves only one part of a much larger wetland system, and to preserve biodiversity the bioregion's natural processes must be managed properly. South Florida was once a vast network of wetlands moving water from central Florida through Lake Okeechobee, southward across the vast sawgrass marshes to Florida Bay. Today, the hydrological regime of south Florida has been drastically altered, impacting wetlands and diminishing biodiversity. Audubon has launched a major campaign to restore the Everglades. Using scientific information to develop environmental management recommendations, Audubon will establish political and citizen activist support for sustainable water resource development in south Florida that includes the restoration of critical waterflows to the Everglades system.

Managing wetlands for biodiversity not only must consider the individual wetland functions to maintain habitat on a particular site, but also must regard the surrounding area with the intent to preserve corridors between major core natural areas. And, finally, the bioregion as a whole must be considered when managing wetlands for biodiversity.

Case History: Audubon in South Florida

Corkscrew Swamp Sanctuary

Corkscrew Swamp Sanctuary is a 10,500 acre (4,400 ha) preserve located in southwest Florida, approximately 28 miles (50 km) northeast of Naples, in northern Collier County and southern Lee County. It occupies about 20 percent of the greater Corkscrew Swamp, which originates near Immohalee and extends southwest for approximately 20 miles (30 km). Corkscrew Swamp lies in a pine flatwoods region and is interspersed with open marshes, cypress stands, pine islands and hardwood hammocks.

Although the pine flatwoods and some of the cypress have been logged, cattle have been grazed in portions of the marsh, and a few small areas have been developed for management of the Sanctuary and a visitor education program, much of the Sanctuary still is relatively undisturbed and inaccessible (Duever et al. 1974).

National Audubon Society has owned and managed the Corkscrew Swamp Sanctuary since the first parcel was purchased from the Lee Tidewater Cypress Company in 1954. The Sanctuary contains the largest stand of virgin bald cypress (*Taxodium distichum*) in the United States. It also has a large wood stork (*Mycteria americanus*) colony which uses these giant trees for nesting. The Sanctuary is comprised of a variety of south Florida habitats including pine forest dominated by slash pine (*Pinus elliottii*) and saw palmetto (*Serenoa repen*); cypress forest with old growth bald cypress reaching heights of 130 feet (40 m) with diameter of breast height (DBH) of 10 feet (3 m) estimated to be over 700 years old; and pond cypress, a smaller ecotype, found along strand margins, in domes or scrub associations; wet prairie, grassland zones found between pine/palmetto uplands and the cypress strands, dominated by cordgrass (*Spartina bakerii*), muhly grass (*Muhlenbergia capillaris*), St. John's Wort (*Hypericum* spp.), was myrtle (*Myrica cerifera*) and buttonbush (*Cephalanthus occidentalis*). Marsh species include sawgrass (*Cladium jamaicensis*), maidencane (*Panicum hemitoma*), pickerel weed (*Pontederia cordata*) and coastal plain willow (*Salix caroliniana*). Ponds and sloughs have aquatic floating plants that include water lettuce (*Pistia stratiates*), floating fern (*Azolla caroliniana*), water fern (*Salvinia rotundifolia*) and duckweed (*Lemmma* spp.) which are found in deeper water; emergent plants include pickerel weed (*Pontederia cordata*), arrowhead (*Sagittaria lancifolia*), fireflag (*Thalia geniculata*) and coastal plain willow. Temperate hammocks have live oak (*Quercus virginiana*), water oak (*Quercus nigra*), laurel oak (*Quercus laurifolia*), cabbage palm (*Sabal palmetto*), swamp hay (*Persea palustris*), myrsine (*Rapanea guianensis*) and red maple (*Acer rubrum*). West Indian species associated with tropical hammocks are characterized by gumbo limbo (*Bursera simaruba*), Simpson's stopper (*Myrcrianthes fragrans*), wild coffee (*Psychotria undata*), marlberry (*Ardisia escallonioides*) and dahoon holly (*Ilex cassine*), (Cutlip 1981). Hammer (1989) compiled a checklist of the vascular plants found at Corkscrew Swamp Sanctuary.

Corkscrew Swamp Sanctuary has a faunal complement that depends in part upon the healthy condition of the above-mentioned plant communities. Twenty-five species of fish; 24 species of amphibia; 45 species of reptiles; 248 species of birds, including 114 nesting at Corkscrew; and 33 mammal species are thought to be present on the sanctuary (Bantz 1979). Largemouth bass (*Micropterus salmonides*), mosquito fish (*Gambusia affinis*), tree frogs (*Hyla* spp.), salamanders (*Diemictylus* spp.), alligators (*Alligator mississippiensi*), coral snakes (*Micrurus fulvius*), swallow-tailed kites (*Elanoides forficatus*), red-shouldered hawks (*Buteo lineatus*), barred owls (*Strix varia*), pileated woodpeckers (*Dryocopus pileatus*), pine warblers (*Dendroica pinus*), grasshopper sparrows (*Ammodramus savannarum*), river otter (*Luter canadensis*), white-tailed deer (*Odoroileus virginianus*) and black bear (*Usrus americanus*) are a few examples of the wildlife species found at Corkscrew Swamp Sanctuary. The endangered Florida panther (*Felis concolor coryi*) have been sighted regularly and at least two individuals use Corkscrew as part of their home range (Roof and Maehr 1988, Maehr 1990b). The wood stork, another endangered species, still nests regularly at the Sanctuary. Last year 1,200 pairs of wood storks fledged 2,750 young (Carlson personal communication).

National Audubon Society has been protecting wildlife in south Florida since the turn of the century. Early wardens enforced fledgling wildlife laws that protected plumed birds from being shot in their nesting colonies. Three Audubon wardens were shot by plume hunters. The most famous was Guy Bradley, killed in the line of duty off Flamingo, in 1905. As wardens watched the cypress forests fall to the saw, and wetlands drained for agriculture and ranching, Audubon officials realized that if the great colonies of wetland birds were to thrive in south Florida, not only would commercial hunting need to be controlled, but protecting habitat would be essential. The purchase of Corkscrew Swamp Sanctuary was an emergency action to (1) prevent remnant old-growth bald cypress forest from being cut and, with it, (2) prevent the loss of a significant habitat for wood storks. While the preservation of these two key species—bald cypress and wood stork—prompted action, Audubon soon recognized the greater ecological value of the Sanctuary. Its biodiversity was acknowledged (Sprunt 1961) and management objectives were designed to protect the integrity of the Sanctuary's biota.

In the late 1960s, a massive drainage and residential development scheme to the south of Corkscrew Swamp Sanctuary was perceived to be a major threat to the Swamp (Matthieson 1963). Additional lands were purchased to buffer the bald cypress stand. A dike was constructed across our southern Swamp boundary and six wells were drilled to provide groundwater to the surface in times of drought or low water. We began to control water outflow from the site in response to drainage in the lower portion of the watershed.

In the early 1970s, trends in wood stork nesting showed a very definite decline with frequent reproductive failures. Attempting to augment food supplies for nesting storks, Audubon constructed an elaborate fish farm which operated for five years to increase reproduction in years when natural food supplies were limited. This project was abandoned after we learned that it was not practical to artificially support the nesting colony when natural wetland conditions were unfavorable for foraging.

It took us longer, however, to discover that Corkscrew Swamp was not, in fact, being drained by development activity downstream. In 1973, Dr. Michael Duever, associated with the Center for Wetlands at the University of Florida, was contracted by National Audubon Society to study the ecology of the Sanctuary (Duever et al. 1974). The study team identified hydrology as a key factor in understanding the Swamp. Waterflow direction, water quantity and quality, water level fluctuations, seasonal timing, and hydroperiod were compiled for the different plant communities within the Sanctuary. Relative community elevations, soil types, depths and composition, as well as dominant vegetation were recorded (Duever et al. 1975, 1976, 1978, 1984, Duever 1980, 1988, Gunderson 1977, 1984, Kropp 1976, Stone and Gleason 1976). Throughout the 1970s, as the results of the research became available, our management activities responded. It was found that our dike at the south boundary was not necessary, and pumping during dry times also was not required. In fact, the recently gained hydrological information indicated that we were drowning our Swamp. We learned that Corkscrew Swamp had evolved with a natural periodicity between dry and wet. Understanding the natural hydroperiods has been instrumental in our maintaining the mosaic of plant communities found on the Sanctuary.

Audubon has had an ecological science staff based at Corkscrew Swamp Sanctuary since 1973. Their on-site work on natural areas management has had important impact on water and land-use management in the region and has had an influence on water management decisions throughout Florida.

At Corkscrew Swamp Sanctuary, the research has led to an extensive management plan. Understanding the factors which control Corkscrew plant communities is the key to managing for biodiversity. National Audubon operates the Swamp under four management priorities (Carlson 1991), and they are, in order of importance:

1. *Hydrology*. Maintaining the hydrologic function of Corkscrew Swamp Sanctuary is the first priority. Because we understand how water influences the mosaic of plant communities at the Sanctuary, we can predict the effect of off-sanctuary activities on surface hydrology and water table. At the Sanctuary, we have an intensive hydrologic monitoring system in place. Wells are located in key water flowages and throughout different plant communities. Automatic recorders monitor water level fluctuations and sanctuary staff collect these data periodically and transfer them to a computer database; they are analyzed by our science staff on an annual basis for subtle inferences. Major disturbances or events would be evaluated immediately. Water is the heartbeat of a wetland system. Too little or too much water at the wrong time or outside natural rhythms can have catastrophic effects on the biota. The biodiversity of Corkscrew Swamp depends on these natural hydrologic rhythms, and our job is to preserve them by making sure that the watershed continues to function naturally.

   The Corkscrew Audubon staff are on the public mailing list to receive notification of all permit applications for projects relating to surface or groundwater activities within the surrounding watershed. We review proposals to determine what impact the activity would have on the Sanctuary, its plant communities and ultimately its wildlife. Our expertise concerning hydrology of Corkscrew Swamp allows us to make recommendations at local and regional land-use hearings. Often, our input prevails when nearby surrounding water-use permits are considered. As the owners of Corkscrew Swamp Sanctuary, we are prepared to escalate actions to protect the hydrologic integrity of the Swamp. Protecting biodiversity requires managers to utilize legal, political and social actions to keep ecological processes functioning.

2. *Exotics*. Controlling exotic plant and animal invaders at Corkscrew is our second priority. It is a major undertaking, both of staff time and expertise. Exotic plants at Corkscrew can greatly alter natural plant communities and very quickly reduce biodiversity. Melaleuca (*Melaleuca quinquenervia*) is a tree introduced to Florida from Australia. It thrives in a variety of south Florida habitats, including wetlands. This plant very quickly forms dense stands which outcompete virtually all native plants. Mature stands are impenetrable. At Corkscrew, we have constantly stayed ahead of this potential disaster by individually treating melaleuca trees by injecting a systemic herbicide into the cambian layer. To search out and destroy plant exotics is a never-ending process at Corkscrew. The consequences of allowing them a secure foothold would be disastrous. In fighting exotic invasions, we are forced to use

chemical treatments. However, we constantly are looking for biological or other integrated ways to treat pests.

Other exotics include Brazilian pepper (*Schinus terebinthifolius*), which we contain with a Garlon Four herbicide/diesel fuel mixture applied as a basal bark treatment. Japanese climbing fern (*Lygodium japonicum*) is a newly arrived exotic which was found climbing up cypress trees. We have treated it with the herbicide ''Rodeo'' and are waiting to see how serious a pest it will become.

At Corkscrew, exotic animals have less of an influence on biological diversity but we have had a long-term control program against feral hogs (*Sus scrofa*).

3. *Fire*. South Florida is a fire subclimax system. Lightning strikes, prevalent in the wet season (May–September), probably accounted for historic upland and ephemeral wetland burns while deeper marsh burned at the driest time of the year (March–June). Drought years proved fire to be a major factor in plant succession. Since European settlers brought cattle to south Florida in the middle of the nineteenth century, cattlemen have been burning annually each winter. Perhaps Indians burned extensively prior to that. The result, however, is that present vegetative stages and associations depend on fire, its timing and frequency being crucial. At Corkscrew Swamp, we burn plant communities (excluding cypress forest and hardwood hammock) on a three-to-five year fire frequency in order to maintain a mosaic of diversity.
4. *People*. We approach people at Corkscrew in two ways. The first is protecting the Sanctuary plants and animals from unwanted or illegal uses, such as poaching deer, bear or cougars, or collecting orchids, indigo snakes or other species within the ecosystem. We are on guard against vandalism and all of the other detrimental abuses some people commit in a natural area if left to their own devices. Our warden patrols have been an effective deterrent.

   The second way we approach people is to provide educational means to observe the natural wonders of the Sanctuary that will not adversely affect the natural resources. At Corkscrew, we provide an opportunity for visitors to walk into the bald cypress swamp on an elevated one and one-half mile long boardwalk. Over 100,000 visitors came last year. Naturalist interns are available to help educate visitors about wetlands generally and cypress forests in particular. The purpose of Corkscrew's visitor program is to develop a constituency that advocates protection for wetlands and biodiversity. We believe people will come to appreciate the exceptional value of biodiversity when they are exposed to an incredibly rich and diverse habitat and are assisted by Audubon's interpretation program.

Integral to all of our management efforts is the importance we place on systematic monitoring of the key elements of the natural system. Staff regularly monitor water levels, conduct cruise surveys for locating exotic plant infestations, photograph plant communities from historic ''photo points'' and aerially census the nesting wood stork colony. Monitoring the key features and driving forces surrounding the Sanctuary enables us to detect changes at early stages and tells us how well our management activities are performing.

Finally, Audubon has been fortunate in recruiting scientists and land managers to work at Corkscrew Swamp Sanctuary over an extended period of time. Our current manager and chief scientist have 45 years combined service to Audubon and the Corkscrew Sanctuary. It is this long-term commitment, coupled with intimate knowledge acquired through decades of experience in south Florida, that allows Audubon to protect and manage biodiversity on the Sanctuary and to influence land-use activities and biodiversity conservation on surrounding lands. Corkscrew staff participate in two off-site programs (described below) which exemplify the type of activities needed to protect, restore and manage biodiversity. Even incredibly diverse sanctuaries such as Corkscrew will become relics unless surrounding environments are brought under a broader management umbrella. The wood stork and Florida panther will not survive without considering southwest Florida as one ecosystem (Maehr 1990a). Audubon's Corkscrew staff are regional advocates for biodiversity.

The Corkscrew Regional Ecosystem Watershed Land and Trust Program

In 1985, Audubon employees Ed Carlson, manager of Corkscrew Swamp Sanctuary, and Michael Duever, Director of the Corkscrew Science Center, proposed to the South Florida Water Management District (SFWMD)—the principal state water management authority in south Florida—that a critical wetland area known as Bird Rookery Swamp adjacent to Corkscrew Swamp be acquired with funds available from the State of Florida's Conservation and Recreation Lands (CARL) program. At the same time, agents for Lee County and private landowners submitted a concurrent proposal that the state acquire the Flintpen Strand. Since then, those two initial proposals have been combined and expanded to include acquisition of the remaining undeveloped Corkscrew Swamp, including a downstream corridor between it and the Florida Panther National Wildlife Refuge and the Fahkahachee State Preserve flowageways to the south (Figure 1). If

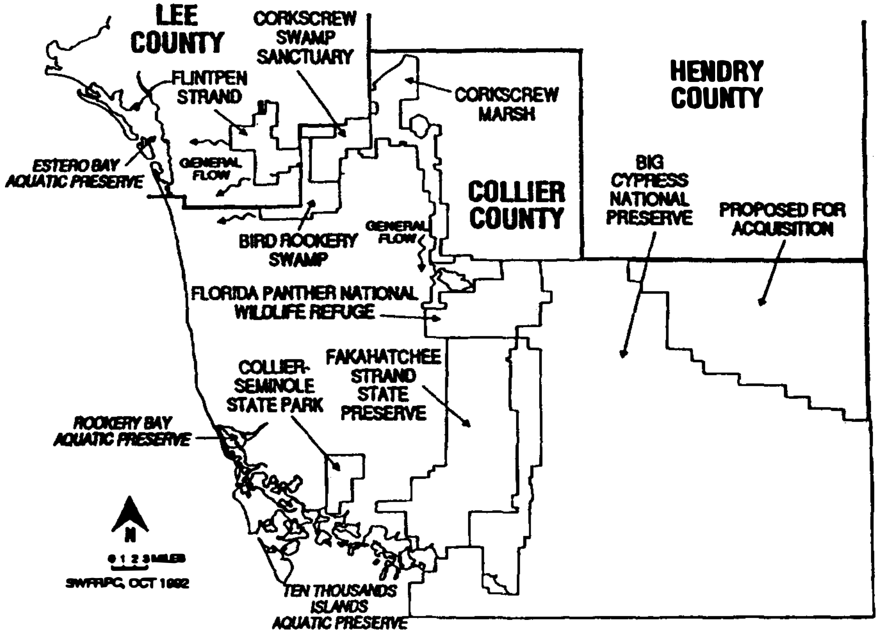

Figure 1. The Corkscrew Regional Ecosystem Watershed (CREW).

completed, the proposed acquisition project would connect, through conservation status and management goals, Corkscrew Swamp and the conservation units Big Cypress National Preserve, Everglades National Park and the Ten Thousand Islands Aquatic Preserve.

This ambitious regional plan to provide a proximate historical water regime from Corkscrew Swamp Sanctuary over 50 miles through flowageways, endangered species habitat, and wildlife corridors to 100,000 acres of existing publicly owned wetlands downstream is largely the vision and work of the Corkscrew Regional Ecosystem Watershed Land and Water Trust (CREW Trust). Founded in September 1989, the CREW Trust is coordinator and facilitator of a 55,841 acre wetlands acquisition and land-use management program that focuses on the interface between southwest Florida's Lee and Collier counties. Twenty-one CREW Trustees represent county, regional and state governments, and private agriculture, business, conservation and development interests. In the 36 months since startup, member agencies have committed twenty million dollars in land acquisition funding. In July 1990, the first CREW Trust-recommended purchase was made in Lee County. In December of 1990, the first purchase was made in Collier County. Overall, 15,800 acres have been acquired in the two counties to date, with additional lands currently under option (Kuperberg 1993). The Corkscrew watershed ecosystem is a major component of the south Florida bioregion.

Local public agency support for the CREW Trust program, however, stems significantly from its concerns and responsibilities for future municipal water supply in the region. The CREW Trust areas also are important for aquifer recharge. In turn, Flintpen Strand, Bird Rookery Swamp and Corkscrew Marsh, all lie within the Corkscrew Watershed and buffer Corkscrew Swamp Sanctuary. The conceptual management plan for all of the acquired CREW Trust lands was prepared by a planning team led by Corkscrew Swamp Sanctuary manager Ed Carlson. (CREW Management Planning Team 1992). The importance of these regional acquisitions and land uses is well understood by the wide spectrum of interests that comprise the CREW Trustees, and managing for biodiversity is well-accepted by the 10-member Management Subcommittee.

Perhaps of equal importance to the region's biodiversity is the decision to acquire a corridor between the Corkscrew watershed and the Florida Panther National Wildlife Refuge. The Florida panther has a large home range. Habitat corridors will be an important factor in restoring this endangered species.

Lower West Coast Water Supply Plan

The second major area where Audubon Corkscrew refuge managers and scientists are participating and taking a leadership role in promoting biological diversity in south Florida is in the Lower West Coast Water Supply Plan (LWCWSP). The South Florida Water Management District is developing the LWCWSP to assist it in regulating water use in this region. As part of the planning process, SFWMD also has formed the LWCWSP Advisory Committee to assist with the plan. The advisory committee includes private citizens, representatives of environmental groups, business interests, water resource scientists, and government agencies affected by the plan. Audubon refuge managers and scientists joined the Advisory Committee to speak for natural area values. Agricultural, municipal and industrial water use in the future will have major effects on the wetland systems of southwest Florida.

Audubon's participation on the LWCWS Advisory Committee is critical for managing biodiversity in wetlands associated with the Corkscrew Swamp watershed. Through the

Sanctuary's hydrological studies, our scientists have reported that the water regime within the sanctuary approximates historical levels and conditions (Duever et al. 1975, 1976, 1978, 1984, Duever 1980, 1988). Currently, Audubon's database serves as a valuable hydrological benchmark for the planning, designing and implementing of land and water projects and programs by local and regional government agencies and business interests alike. Because of our extensive hydrological studies and monitoring programs, our scientists and managers make a valuable contribution to long-term sustainable water resource development in the region.

The Greater Everglades System

Audubon's approach to management of biodiversity is not limited to a single species, or an individual wetland or sanctuary. It requires a bioregional approach. South Florida is a vast wetland system linked through its biology and hydrology (Gleason 1974, Myers and Ewel 1990). Corkscrew Swamp Sanctuary and the Big Cypress forests of south Florida are only one part of this larger wetlands system. To preserve biodiversity the bioregion's natural processes must be managed properly.

The Greater Everglades System once covered an area more than 250 miles long and, at its widest point, more than 100 miles across (Light et al. 1989). A wet year blurred the transition from the central marshes of the Everglades to the prairies and deeper-water cypress forests of the Big Cypress Swamp. As in other parts of the Everglades, rainfall created a continuous, slowly moving sheet of water, flowing south and west and, in times of particularly bountiful rainfall, also feeding east into the "River of Grass."

Though hurricanes have been a major feature of the natural environment of south Florida for hundreds of years, in this century, intensive human development has resulted in flooded farms and communities. Following a devastating hurricane in 1947, Congress responded by authorizing the Central and Southern Florida Flood Control Project in 1948 (Light et al. 1989). Its primary objective was to drain wetlands for agriculture and provide flood protection to the communities around Lake Okeechobee. A secondary objective was to combat saltwater intrusion into the aquifer for the communities of Florida's lower east coast (Light et al. 1989). When this project was completed, the greater Everglades system had been altered forever, its waters diverted and controlled by a massive plumbing system made of canals and dikes, gates and pumps, its flow regulated by the South Florida Water Management District.

The result has been four major changes to the hydrology of the Greater Everglades System: the Everglades Agricultural Area (EAA) separates the system into two poorly connected watersheds, Kissimmee-Okeechobee and Everglades-Florida Bay; large wetland areas have been lost entirely; vast volumes of water that historically flowed through the system are now diverted to the sea and dumped from the system; and the natural timing, volume and distribution of water throughout the system has been altered severely. In addition, runoff from agriculture has polluted parts of the remaining natural system (Orians et al. 1992).

Now water rapidly flushes through the system following rains, which results in shorter periods of inundation and longer, more frequent periods when some wetlands are dry. While some areas are over-drained, others are flooded too deeply and for too long. Everglades National Park dries out in many more years than when a more natural hydrologic system was operating (Walters 1992).

It was estimated that 125–150 thousand pairs of wading birds nested in the Everglades system as recently as the 1930s (Bancroft 1989). Today, water diversion for agriculture, water supply and flood control has so altered the water flow and sequencing that the greater Everglades system supports 90 percent fewer woodstorks and white ibis, and 50 percent fewer nesting herons and egrets (Ogden in press). It is the preservation of biodiversity that moves Audubon to advocate a restoration of the great south Florida wetland ecosystem. Corkscrew Sanctuary and all of south Florida are linked ecologically and, if we are going to manage for biodiversity in wetlands, we cannot stop at the Sanctuary's boundaries, or the Corkscrew Swamp watershed boundaries.

Water for People and Wildlife: National Audubon Society's Principles for Restoring the Endangered Greater Everglades System

As devastating as the human-induced changes have been in this century, Audubon staff believe that the Everglades system can be restored. Enough of the system remains to bring its wetlands back to health if we begin to treat the system as a hydrological whole, clean up the water and restructure the water distribution system to replicate historic flows. The Greater Everglades System including Big Cypress can again be a self-sustaining ecosystem, smaller than it once was but containing its historical components and rich biodiversity. Through careful management, the sheet flow of water through the wetlands must be returned to historic patterns.

What follows are the principles that Audubon believes should guide restoration efforts, devised by our scientists in consultation with the environmental community, and drawing on research by scientists at Audubon, other environmental groups, Everglades National Park, the South Florida Water Management District, the Army Corps of Engineers and various universities. Audubon's members and staff have worked to protect the Everglades and its wildlife for 100 years and, over this time, they have witnessed changes that have led the ecosystem to near-collapse and threaten the Florida economy. We believe that restoration efforts based on these principles will bring the system back to life.

Everglades Restoration: Guiding Principles

1. Restore pristine water quality throughout the system.
2. Conserve water entering the system and increase the self-sufficiency of urban and agricultural water supplies.
3. Replicate the essential features of the natural hydrology—the amount, flow, depth, timing and distribution of water that once flowed through the system.
4. Maximize the number and size of, and connections among wetland communities to preserve restoration options.
5. Develop restoration plans that address the entire physical, chemical, hydrological and biological system.
6. Recreate and maintain a mosaic of natural plant types in a way that mirrors the unique biodiversity of the historic system.
7. Make restoration decisions with full public participation and with equity to all water users in south Florida.

Audubon's Team

National Audubon will use its time-tested methods—science, public education and advocacy—to pursue biodiversity protection for the Everglades system. In 1992, Audubon put together an Everglades Team that utilizes each of its departments—Science and Sanctuaries, Education, Public Affairs, and Regional Affairs and Government Relations. In addition, Audubon has agreed to chair the Everglades Coalition—a confederation of

28 national and Florida conservation organizations, working together to assure that all federal and state agencies meet their responsibilities to preserve the natural life of the Everglades ecosystem. The Coalition was organized in 1968 to fight for Everglades National Park water rights and to place Big Cypress watershed under the National Park System.

Conclusions

Audubon's 100 years of experience in Florida protecting wildlife, managing habitat and restoring biodiversity allows us to make some general statements about managing wetlands for biodiversity.

- Wetland management requires a thorough understanding of the natural processes operating on the system, e.g., hydrology, fire, soils, topography.
- Management priorities must focus on the key factors which control the wetland system.
- Monitoring key factors in wetlands allows for management assessment and provides an early warning system for detecting changes.
- Professional wetland managers and scientists must have a long-term commitment to preservation of biodiversity.
- Wetland managers and scientists must use their expertise in natural areas to influence local and regional land-use plans.
- Entire watersheds must be considered when managing wetlands for biodiversity. Core wetlands must be buffered and habitat corridors created to link core wetland areas.
- Management of biodiversity on individual wetlands can only be successful if the ecological processes are functioning in the bioregion.
- Degraded bioregions should be restored where possible.

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North American Waterfowl Management Plan: Shorebird Benefits?

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Introduction

Is the North American Waterfowl Management Plan doing anything for shorebirds? How could it, if it is just a "duck plan?" Because it is the biggest thing underway in North America for improving the status of wetland habitats. It is a "Ducks Plus" operation and that means good things for shorebirds too.

The designers who launched the North American Waterfowl Management Plan (Plan) in 1986, did recognize the related benefits for wetland functions and other wetland species, although their focus was clearly to increase waterfowl populations to the levels of the 1970s (Anonymous 1986). However, now in its sixth year of implementation, the Plan is being increasingly touted by state, provincial, private, corporate and federal conservation organizations in Canada, Mexico and the U. S. as the leading catalyst for broad, cooperative wetlands habitat conservation activities designed at the landscape level. Management actions increasinly are being taken under the Plan to specifically benefit species in addition to waterfowl. New partners are joining for reasons that go well beyond those to restore waterfowl populations. Original Plan geographic boundaries are being stretched and reshaped. Impressive numbers of wetland acres already have been protected, restored and enhanced. At the joint venture level, where the action really is located, the partnerships clearly have carried the on-the-ground program to a greater breadth than that needed only for waterfowl.

The Plan Committee, the international body serving as the keeper of the Plan, has gone to considerable lengths over the past few months to solicit opinions and views in an ongoing process to update the Plan. So much has changed that, in some circles, calls have come to expand the Plan beyond waterfowl—a new name, new species objectives, broader geographical coverage. From other quarters, voices counsel to not lose the roots, don't drive off the constituents that have been the primary financial supporters, or don't stray off the original course set by waterfowl experts. Perhaps surprising to some, the overwhelming majority of opinions have advised to stay the course. Although not implemented solely to benefit waterfowl, the basic tenants of the Plan are correct, the waterfowl goals and clear focus on priority wetland habitats across North America should stand. It is serving its purpose. It is working. It still is the most focused, long-range, visionary, successful wetlands habitat program in existence.

In this paper, we will highlight what is right with the Plan, what makes it work and what is being done specifically for shorebirds. We will highlight lessons drawn from its success and encourage further input from shorebird and biological diversity interests on how to continue to implement the Plan at local levels to provide the maximum benefits to all interested partners.

The Plan in Action

The Plan has established long-term goals for restoring waterfowl populations to levels measured in the 1970s. These include reaching for a breeding population of 62 million ducks resulting in a fall migration of 100 million ducks, and restoring 1970s levels of goose and swan populations. Wetland and associated habitat conservation are recognized as the overriding action needed to meet these goals. Habitat protection, restoration and enhancement are focused in delineated, priority waterfowl production, migration and wintering areas. Nearly 20 million acres of priority wetland and associated habitats have been identified for conservation work over the next 10 years. Since no single organization or agency can take on this massive responsibility, 12 habitat joint ventures, partnerships of state, federal and private conservation organizations, corporations, and individuals, have formed to implement habitat actions at the local level (Figure 1).

In just the initial three years of actual habitat work, Plan partners report protecting more than 1 million acres of existing wetlands and associated habitats. Restoration and enhancement work has been done on another 1 million acres (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1993a). Recently compiled 1992 figures point to an additional 1.6 million acres of habitat conservation accomplishments (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1993b). More than $512 million of partnership funds have been leveraged to complete this work to date. The success of the work is attracting attention from many organizations and agencies, drawing in new partners and reinforcing the need to continue the current program set by existing partners.

Figure 1. North American Waterfowl Management Plan joint venture areas.

What is right with the Plan is that it has specific goals, defined geographic targets, relies on partnerships and has local implementation. This is a winning formula for success in today's management environment.

The Plan and Shorebirds

Shorebird and waterfowl habitat overlap in many of the most important wetland areas of North America (Figure 2). Losses of wetlands and associated upland nesting cover have affected shorebirds as well as waterfowl, although we do not have the survey data for shorebird populations that exist for waterfowl. However, when wetlands and associated habitats are protected for any reason, especially along the Pacific and upper Atlantic coasts and in the prairie pothole regions of Canada and the U. S., the Gulf Coast, and the west coast of Mexico, shorebirds and waterfowl both benefit. For example, 13 shorebird species commonly nest in the interior pothole country (Helmers 1992), and 40 species are common migrants through the mid-continent prairie states, some in large numbers (Eldridge 1992). Virtually entire populations of some species like the red knot (*Calidris canutus*) move through the tidal flats of Delaware Bay during migrations (Meyers 1986). Biologists estimate that a large proportion of the total populations of lesser yellowlegs (*Tringa flavipes*), long-billed dowitchers (*Limnodromus scolopaceus*), lesser golden-plovers (*Pluvialis dominica*), white-rumped (*C. fuscicollis*), stilt (*C. himantopus*), pectoral (*C. melanotos*) and buff-breasted (*Tryngites subruficollis*) sandpipers depend on

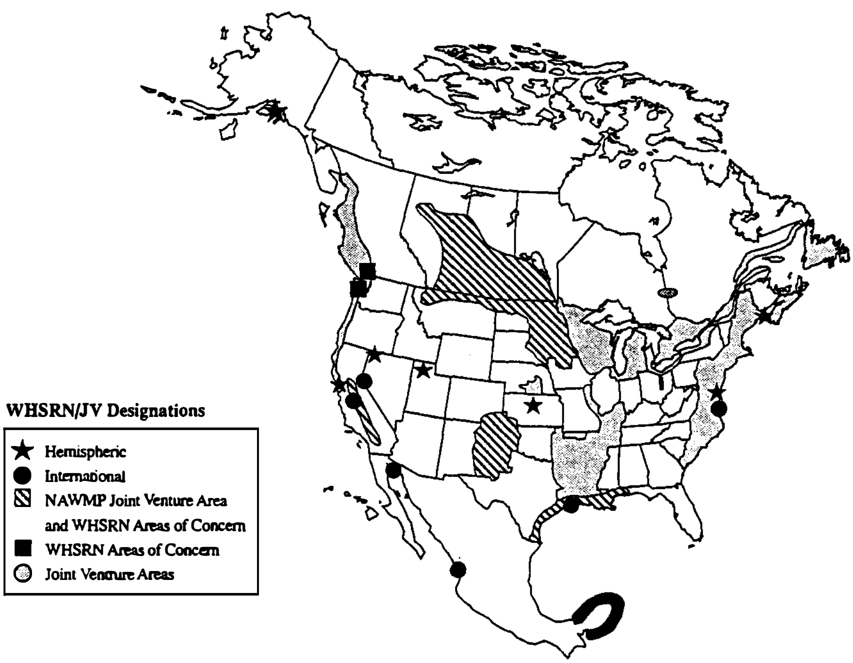

Figure 2. Overlap of important shorebird sites with North American Waterfowl Management Plan joint venture areas.

the Gulf Coast wetland habitats as stopovers on their spring migrations (Rosenberg and Sillett 1991). Thus, both shorebird aficionados and waterfowl enthusiasts clearly have a natural alliance to conserve areas of common interest.

The Plan partners are going farther than just protecting existing wetlands and associated habitats that benefit both shorebirds and waterfowl. More and more frequently we are seeing Plan managers design restoration and enhancement actions for several different species of migratory birds, not just ducks. A recently published shorebird management manual (Helmers 1992) sponsored by Plan partners was designed to provide wildlife managers with the knowledge of wetland management principles and techniques to benefit both shorebirds and waterfowl. Several shorebird management workshops being provided by Plan partners this spring, summer and fall will build upon this manual and introduce state, provincial, federal and private wetland complex managers to more detail and practice in managing wetlands for shorebirds. We have learned how nesting cover enhancement, shoreline and emergent vegetation manipulation, substrate management and protection from disturbances can be oriented to both shorebirds and waterfowl with little additional cost. We also know that managing water depths can provide increased numbers of aquatic invertebrates needed to build the fat reserves required by all wetland-dependent, long-distance migrating species. The manual and training sessions will aid managers to manipulate wetlands to provide a variety of water depths at different times of the year to meet the needs of the mix of species present at a given time.

The U. S. Prairie Pothole Joint Venture has developed educational posters and brochures to call both public and private land managers' attention to the groups of shorebirds dependent on the prairie wetlands and surrounding habitats. The Izaak Walton League of America, Ducks Unlimited, and many other state and private partners have published feature stories and photo essays highlighting the plight of wetland losses and called for conservation actions to be taken for shorebirds along with other wetland-dependent migratory birds. Experts on the threatened and endangered piping plover (*Charadrius melodus*) have been invited to provide specific management input to the design and implementation of projects to ensure the Plan will contribute as much as possible to the full recovery of the interior populations of this popular species. Plan partners in Canada have created piping plover nesting habitats in the Quill Lakes region of Saskatchewan.

North American Wetlands Conservation Act (Act) funds are supporting a biodiversity restoration project in Saskatchewan that will have major benefits to breeding and migrating shorebirds. In Alberta's short-grass prairies, shallow lakes and ponds have been created by diking uplands and then flooding with irrigation water to create feeding habitats for several species of shorebirds. Proper grazing management on lands adjacent to these wetlands provides extensive breeding habitats with low predation rates for all ground-nesting migratory bird species. Having witnessed the diversity and large numbers of migratory birds supported by these wetlands, we know the technique works. As further evidence of the broad spectrum of conservation actions occurring under the Plan, Alberta partners have just published a field manual to encourage and guide their efforts to enhance biodiversity on Plan landscapes in prairie and parkland wetlands (Sadler 1992). The manual contains construction techniques that provide benefits to shorebirds as one of the major target species groups.

In California's Central Valley, public and private wetlands acquired and managed as part of the Plan provide rich food resources for more than 30 species of shorebirds bound for as far south as Tierra del Fuego in the southern tip of South America enroute from the Alaska, Canada and Siberia arctic regions. The Central Valley has lost more than 95 percent of its original wetland acreage. Habitat protection and improvement of the remaining wetlands, and more importantly wetland restoration, therefore is absolutely critical to the millions of shorebirds and waterfowl that use this region.

On the New Brunswick shores of the Bay of Fundy, Act funds have assisted in securing critically threatened intertidal wetlands that serve as resting and feeding areas, especially for semipalmated sandpipers (*Calidris pusilla*). Plan partners in the U. S. Atlantic Coast Joint Venture have secured extensive acres of wetland habitats in the Morris River and Cape May areas of New Jersey and Milford Neck area of Delaware to benefit both shorebirds and waterfowl dependent on Delaware Bay wetlands.

At the other end of North America, Ducks Unlimited, Inc. and Ducks Unlimited-Mexico partners, completing studies along coastal wetlands of Laguna Madre, Tamaulipas, Mexico, have identified critical areas for wintering and migrating shorebirds. As a result of these studies funded by the Act, an area has been delineated and soon will be proposed as a protected refuge area for all migratory birds. A system of federal/state-protected areas is being established along the Sonoran coast and baseline studies along the Sinaloa coast and across the north coast of the Yucatan also are funded by the Act and other Plan partners. The Canadian Wildlife Service is completing a shorebird site atlas further contributing to the Plan and its far-reaching wetlands conservation actions.

A priority objective of the Pacific Coast Joint Venture is to secure 137,000 acres of coastal wetlands from the mouth of the Skeena River in British Columbia, southward towards the U. S. border. About 1 million ducks, 51,000 geese and 7,300 swans winter in the area while a higher population stage there each autumn. The area also is essential staging area for millions of shorebirds, including the major share of the world's population of western sandpipers (*C. mauri*), numbering more than 1.5 million (Central Valley Joint Venture Implementation Board 1990).

Plan partners have supported Act funding for the restoration and enhancement of Cheyenne Bottoms in central Kansas, assuring the availability of water to protected public and private wetlands. Protection of this continentally unique wetland complex designated as a Ramsar Wetland of International Importance and as a Western Hemisphere Shorebird Reserve Hemispheric Site ensures spring migration stopover and refueling for 45 percent of North America's shorebirds east of the Rocky Mountains, including over 90 percent of five species (Harrington 1984). In addition, the "Bottoms" have been designated by the U. S. Fish and Wildlife Service as Whooping Crane Critical Habitat (U. S. Fish and Wildlife Service 1978).

Each joint venture has been asked by the Plan Committee to provide greater consideration of shorebirds as implementation begins. The Wetlands for the Americas' staff have been contracted to review each U. S. joint venture plan and to recommend modifications to ensure greater shorebird benefits. Other U. S. federal partners like the U. S. Forest Service (USFS) and the Bureau of Land Management (BLM) have implemented wetland management projects as corollary to the Plan. For example, Mono Lake on the Inyo National Forest in California was designated as an International Site in the Western Hemisphere Shorebird Reserve Network in 1991. With funding under the USFS Taking Wing program, wetland restoration work on DeChambeau Ponds in this area soon will be completed to ensure long-term benefits to the 35 species totaling nearly 150,000 in number that use the area each year (C. Ragland personal communication). The BLM has made creative land exchanges, and teaming with The Nature Conservancy, Ducks Unlimited, other partners and with Act funds, is protecting a 1,100-acre wetland area along the Cosumnes River near the Sacramento River Delta. Here many species of shorebirds now will be assured permanent migratory stop-over habitats (U. S. Fish and Wildlife Service grant files).

Evaluation of success of Plan projects has been expanded to include measures of impacts of the project activities to shorebirds. Partners participating in the Plan are evaluating the habitat manipulations to ensure that funds are being spent efficiently and accomplishing intended benefits. The Plan Evaluation Team has developed a set of guidelines for joint venture and continental evaluations that include examining Plan effects on migratory birds including shorebirds. Over the next year, biologists in Canada and the United States will examine the habitat manipulations expected to be produced by Plan activities. Ornithologists with expertise on migratory birds that breed, winter or migrate through joint ventures will then predict the effect of these habitat activities on non-waterfowl migratory birds in each joint venture. Field studies will follow to determine how well these predictions hold true on selected joint venture project areas. From this exercise, new management prescriptions will be developed.

The Plan and the Future for Shorebirds

The Plan is being updated to acknowledge accomplishments and changes based on expanded joint venture operations. Most certainly it will be expanded into Mexico. The Plan will be implemented there specifically to protect wetlands to maintain biological diversity and sustainable use. Thus, in Canada, Mexico and the U. S. additional benefits will be seen for shorebird populations.

It is difficult to manage any group of species without quantitative objectives. We do not know what the shorebird population goals should be, nor the quantity, quality and location of habitat to support these population objectives under varying weather patterns. However, even if quantifiable objectives cannot be established at international or even national levels, what about at regional levels? Managers can manipulate various complexes for a diversity of habitat conditions, but without management objectives and prescriptions, they can do little but what just "feels" right for shorebirds. Shorebird biologists need to become partners in the joint ventures. They must identify the priority areas needed for shorebirds and the management actions that will best serve the biological needs of the various species. Local and regional population objectives and the kinds and amounts of habitats must be identified. Shorebird partners must get involved in fundraising, implementing management actions and in grass roots political actions to further increase protection, restoration and enhancement actions. There is room under the Plan operations for shorebird biologists and enthusiasts to be full partners.

Conclusion

The Plan, a "Ducks Plus" program, has proven value as a blueprint for wetlands conservation serving a broad range of interests, not only those that support waterfowl. Its strengths of specific objectives, focus, partnership and local action are serving as a model for 20th century wildlife and habitat management. It also is a model landscape-level program designed to protect and restore biological diversity. The Plan has evolved at the implementation level as a broad wetlands conservation action program. Shorebirds are benefitting from current actions by the partners, but opportunities for increased shorebird partner involvement in joint venture activities still abound.

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Wetland Management for Shorebirds and other Species—Experiences on the Canadian Prairies

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The implementation of the North American Waterfowl Management Plan (NAWMP) identifies the need and the opportunities for undertaking a multi-species and integrated approach to wetland management. In the prairie provinces of Canada, we see this approach reflected in new projects that range from: songbird and shorebird evaluation/assessment programs for addressing the NAWMP; to coordinated land purchases for the protection of both waterfowl and piping plover (*Charadrius melodus*) habitat; to programs that manipulate habitat for the benefit of waterfowl, shorebirds and songbirds. We must ensure that this integrated multi-species approach to wetland management continues and grows, as we strive to ensure the health of our wetland ecosystems.

Overview

As a result of information provided in the historical literature (Gardner 1981, Serr 1978, Harris 1988 and Decker 1982), surveys conducted throughout prairie Canada in the mid 1980s (Dickson and Smith 1988, Smith and Dickson 1989) and publications related to the Western Hemisphere Shorebird Reserve Network (WHSRN) (Morrison et al. 1991), various sites in prairie Canada became acknowledged as very important wetlands for staging shorebirds. Morrison et al. (1991) reported that 18 sites in the prairies meet the biological criteria required to designate the sites as reserves under the WHSRN, an international program dedicated to the protection of significant shorebird areas throughout the western hemisphere. At the same time, reserach being conducted throughout North America on the piping plover, a wetland species listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), was demonstrating that prairie Canada is a stronghold of breeding habitat for this species in North America. In addition, the report by Poston et al. (1990) identifies key sites throughout prairie Canada for all migratory birds including waterfowl.

But the idea of addressing wetland management needs for shorebirds really took hold in prairie Canada with the advent of the NAWMP.

This plan, signed in 1986, recognized that the pothole region of Canada and the United States was the highest ranked of 32 habitat priorities, in terms of importance to breeding mallard (*Anas platyrhynchos*) and northern pintail (*Anas acuta*) populations. As part of the NAWMP, it is not surprising that the main objectives for the prairie Canada portion of the plan, known now as the Prairie Habitat Joint Venture (PHJV), is waterfowl oriented. "The objective is to restore waterfowl populations in prairie Canada to levels of the 1970's . . ." (PHJV no date).

The PHJV, despite being a waterfowl directed program, has provided, we believe, an impetus for many multi-species management related programs.

Since 1986, we have seen the PHJV implement a plan in a manner which addresses not only waterfowl needs but also attempts to address other wildlife needs as well. One example relevant to all prairie grasslands is the *Landowner's Guide*, developed to "encourage and provide ideas on how to retain native grass holdings in a productive condition . . . for the benefit of the wildlife which depends on that habitat" (Trottier 1992). In addition, the PHJV has recognized that the habitat surrounding wetlands are an integral part of the wetland complex and hence much of the PHJV implementation reflects this approach.

These two broad approaches to implementation have attracted cooperators to the PHJV that might otherwise have remained critics to a plan directed solely at one species group in habitats utilized by many species.

Today each of the prairie provinces see the PHJV implementation not "growing ducks" under a narrow focus, but "growing ducks" while showing concern and interest for the needs of other wildlife.

Alberta

One of the first multi-species programs developed in the province was the prairie falcon (*Falco mexicanus*) project designed to provide advice on how landowners can integrate the habitat needs of prairie falcons into their land management practices. The project would, therefore, determine habitat use by prairie falcons in irrigated agricultural lands adjacent to southern prairie rivers, ponds and wetlands. This project demonstrates that prairie falcons are feeding in areas which may be over 2 miles (3.2 km) from the nest site. Also, the prairie falcons' diet is made up of 75 percent ground squirrels and 25 percent small birds. A landowner/raptor booklet has been drafted and will be published in 1993.

Today in Alberta, the concept of a multi-species approach to meeting NAWMP/PHJV goals is addressed directly by having at least one staff member in each of four biomes dedicated to addressing multi-species concerns for all project proposals. This not only helps to ensure a multi-species approach to developing and planning land management projects, but also provides a basis to develop and conduct projects directed at multi-species management issues.

Some examples of this are the "Multi-species Habitat Enhancement Techniques" manual (Alberta NAWMP Centre 1992) which, like the WHSRN "Managing Wetlands for Shorebirds: The Shorebird Management Manual," (Helmers 1992) provides land managers, be they federal or provincial governments, industry or local landowners, with directions on how to help manage or enhance habitat for wildlife. The manual also provides information to land managers which alerts them to the needs of various wildlife groups (such as shorebirds and rails) when considering landscape enhancements of various types.

The development of a Piping Plover Management Plan for Alberta is underway with the involvement of NAWMP cooperators and other land management agency programs such as Nature Conservancy of Canada and the provincial "Buck for Wildlife" program. The plan will address a variety of management needs for piping plovers at 12 priority lakes in Alberta (Minutes of the Piping Plover Management meeting, July 17, 1992). Management needs include: securement of priority nesting habitat; controlling cattle damage to shoreline habitat; vegetation encroachment onto beach habitat used for nesting and feeding by the plovers; water level controls to address issues such as loss of nesting and feeding habitat due to drought or flooding; nest predation control; and controlling human disturbance. Some of the techniques being tried to address these issues are: land purchase, to secure habitat fencing to control human and cattle habitat disturbance; electric fencing for predator control and habitat disturbance; burning and snow packing techniques for controlling vegetation growth; and water control structures to address flood/drought related issues. Education of landowners and users also will be a key factor in helping this program succeed.

This piping plover project is encompassing many sites which are prime NAWMP sites as well. For example, the Buffalo Lake/Rockeling Bay and Ryder Lake sites have been identified as a "priority area" for management under the PHJV. In addition, many of the priority sites are internationally important staging areas for shorebirds (Morrison et al. 1991).

Alberta, like the other provinces in the PHJV, already has taken steps to expand its evaluation program beyond waterfowl in order to determine if habitat treatments undertaken by the NAWMP, particularly the upland communities, are beneficial to a variety of species and to guide or change treatment techniques. This evaluation strategy (Alberta NAWMP Centre 1992a) includes four components:

"1) an audit, by recognized experts, of all vertebrate species in Alberta that may be associated with the implementation of NAWMP land programs;
2) an overview to determine the existing relationship of NAWMP landscapes (priority delivery areas) to the provinces migratory/vulnerable, threatened, or endangered species;
3) a monitoring program at one or more project sites in each biome to document trends in species composition/abundance as a result of habitat changes with NAWMP program implementation;
4) a detailed multi-species assessment program to determine responses to selected species/species groups to individual or combined NAWMP land treatments."

Steps are presently underway to initiate, in 1993, coordinated and cooperative evaluation strategy between three provincial centers and the Canadian Wildlife Service (CWS).

Alberta also is approaching land purchase as a means not only to secure waterfowl habitats but also to incorporate and secure key native habitats within each biome and key management areas. Acquisition of these lands will help to secure the unique and often rare communities and the wildlife they support. This approach sees the expansion of active partners in the PHJV to agencies such as the Nature Conservancy of Canada who can help in securing lands in priority areas to benefit waterfowl and other wildlife.

Saskatchewan

In Saskatchewan, a number of projects are underway or planned which, while directed mainly at waterfowl, will enhance management opportunities for other wetland species.

The Thunder Creek Heritage Marsh project is one such project which will see water from Lake Diefenbaker pumped into the Riverhurst Irrigation Project then diverted to the Thunder Creek Marshes: a series of 38 wetland segments. This diversion of water to the Thunder Creek Marshes will provide a net increase of 800 acres (324 ha) of wetland, the proportion of this wetland considered to be permanent will increase from 37 to 949 areas (15 to 384 ha, respectively), an increase in duck broods by 4,300 broods annually and, through water management, improved shorebird breeding and migration staging habitat particularly at Pelican Lake. This lake is known for its importance to staging shorebirds and has been dry for a number of years as a result of drought conditions in prairie Canada (Morrison et al. 1991). In addition, the project will improve habitat for staging whooping cranes (*Grus americana*) and other wetland and upland wildlife (Saskatchewan 93–3 NAWMP Project Proposal).

At the Quill Lakes, which includes the Quill Lakes Mount Hope Heritage Marshes, designated as a RAMSAR wetland in 1987, a project to identify shorebird migration phenology, wetland use, habitat/food requirement and migration routes of birds using the area has been underway since 1989. This area is comprised of a series of PHJV managed wetlands adjacent to large saline lakes. The site also is the most important staging area for both spring and autumn migrating shorebirds in prairie Canada (Morrison et al. 1991), as well as being the largest wetland complex in Saskatchewan and, hence, supports vast numbers of staging waterfowl and geese.

Ultimate completion of the shorebird project in 1994 will present a shorebird management plan for the Quill Lakes and adjacent wetland basins which would enable land managers within the PHJV not only to manage the area for the benefit of waterfowl but also ensure that the value of the area for staging shorebirds is maintained and enhanced.

The Saskatchewan Habitat Diversity Project, known as the Fairy Hill Marsh Project, will see reestablishment of this significant wetland for waterfowl production and staging, increased nesting cover for waterfowl production, creation of shallow water and mudflat areas during the spring for shorebirds on migration, increased habitat for a variety of nongame migratory birds, and enhanced game fish production in the Qu'Appelle Lakes by permitting passage up the Qu'Appelle River along the spring spawning run.

From a shorebird point of view, the Fairy Hill Marsh was one of the most important spring shorebird staging areas in prairie Canada prior to it being channelled and drained in the mid 1980s (Saskatchewan Habitat Diversity Project Proposal 93–1). If successful, this project will be an example of the capabilities for multi-species management approaches in wildlife management.

As in Alberta, critical piping plover wetlands which fall in key waterfowl production areas have been identified in Saskatchewan and a proposal has been developed to address cattle grazing activities through acquisition of shoreline and adjacent habitats, and development of improved grazing schemes which restrict cattle access to shoreline during the breeding season. These activities also will improve 4,200 acres (1,700 ha) as waterfowl nesting cover adjacent to wetlands within key waterfowl production areas. The project also will enhance habitat for grassland birds including upland sandpiper (*Bartramia longicauda*), Sprague's pipit (*Anthus spragueii*) and the threatened Baird's sparrow (*Ammodramus bairdii*) (Saskatchewan Habitat Diversity Project Proposal 93–1).

Another component of the piping plover program will be conducted at the Quill Lakes, where drought has seen the water receding to distances of up to one mile (1.6 km) from the beach line. This separates piping plover breeding sites from primary feeding area. The project will create small foraging ponds along the beach and solar pumps will be used to pump water onto the beach and lakebed, thus creating small shallow basins as the water flows and fills low areas. This project will be maintained from May 1 to August 15 to ensure feeding areas are available throughout the breeding and brood rearing period and during the peak of the autumn shorebird migration.

A graduate student project at Lake Diefenbaker will determine how flooding or other factors affect piping plover reproduction success at Lake Diefenbaker (Espie et al. 1992). Lake Diefenbaker water levels are controlled by hydroelectric structures at the lake outlet. Suggestions have been made that piping plover fledgling success is negatively affected by increased water levels during the breeding season in response to water regime requirements needed for hydroelectric production. This project will provide the answers needed to address this issue.

Piping plover work in the Missouri Coteau area of Saskatchewan is looking in detail at piping plover breeding habitat site requirements. It is hoped that results of this directed study can be used in developing techniques for creating piping plover habitat in other areas and also allowing the recognition of nesting habitat on sites where the species itself is not seen; a very important management tool for wetland managers.

From 1991 to 1992, upland habitat evaluation was conducted in Saskatchewan which looked at upland bird response to various habitat treatments directed at waterfowl production.

Dense nesting cover and planted fescue-blue grass (adjacent to dense nesting cover) treatments were compared to fallow field controls. Both treatments being types used by the PHJV to enhance waterfowl production. The work also allows for provision of feedback to improve future PHJV implementations. This work provided the basis for developing a coordinated and cooperative upland multi-species evaluation program throughout the PHJV region (Dale 1992). As mentioned previously, each of the three provincial coordinating agencies under the PHJV and the CWS are presently working to develop this prairie-made evaluation and monitoring program.

Manitoba

In Manitoba, piping plovers also have been directly addressed in a nesting island construction project at West Shoal Lakes. As in the Quill Lakes of Saskatchewan, the drought in the prairies has caused the high water mark of the lake to recede up to one-quarter of a mile (1.6 km) from nesting areas. To address this problem, nesting islands were constructed four feet (1.2 m) above lake level adjacent to the present high water mark. Unlike Saskatchewan, where gravel was transported to the site, parent gravel material from the lake were used in Manitoba (Bob Jones, Manitoba Habitat Heritage Corporation, personal communication).

Manitoba, like Alberta, has produced a species audit for wildlife in the province. The audit prepared by a group of wildlife specialists indicates what the expected effect (positive or negative) of each type of PHJV treatment is on various wildlife species. Audit results will, in the least, alert field staff and project planners to possible problems and benefits associated with each treatment type (Bob Jones, Manitoba Habitat Heritage Corporation, personal communication).

At Whitewater Lake in southwestern Manitoba, efforts have been made to trap winter and spring runoff from uplands adjacent to the lake through the use of dykes (Bob Jones, Manitoba Habitat Heritage Corporation, personal communication). This lake, which has been dry in the spring for several years now, is an important waterfowl and shorebird area. In spring 1988, over 10,000 white-rumped sandpipers (*Calidris fascicollis*) were seen on the lake in a single day (Morrison et al. 1991). Acquisition of runoff in holding basins created by dykes will provide suitable and long-lasting habitat for waterfowl, while areas of grassy flats, also set up for spring flooding (to reduce hay production), will provide some shorebird habitat which is presently unavailable. Overflow from the reservoir also should provide shorebird staging habitat presently unavailable at the site due to the drought.

One small project has seen improvements of nesting habitat for Wilson's phalarope (*Phalaropus tricolor*) in the Shoal Lake area. A simple electric fence (predator fence) placed across the base of a small peninsula not only increased waterfowl production but also resulted in what appeared to be a major increase in fledging of Wilson's phalaropes and eared grebes (*Podiceps nigricollis*). Although no specific counts were conducted, young of both species appeared to be in much larger numbers than had previously been noted (Bob Jones, Manitoba Habitat Heritage Corporation, personal communication). It is possible that ground predators were having a major negative effect on nest production by these species and simple removal resulted in positive results.

Evaluation and monitoring work which examines the effects of PHJV upland treatments on waterfowl and other wildlife species also has begun in Manitoba. This year, studies using point count sampling in both dense nesting cover and unused native prairie were conducted. No major differences have been noted to date although the sedge wren (*Cistothorus platensis*) is showing an increase in numbers in dense nesting cover (Bob Jones, Manitoba Habitat Heritage Corporation, personal communication).

Further upland evaluation work is planned and expected to expand as the cooperative upland evaluation plan is developed with the other two PHJV provincial implementation agencies and the CWS.

Summary

The PHJV has come a long way in addressing multi-species concerns since its inception in 1986 with an estimated $400,000 spent on multi-species programs. Where do we go from here?

It appears that a number of singular efforts now are leading to more coordinated and cooperative programs. From numerous piping plover projects in Alberta to an adhoc committee developing a Piping Plover Management Plan for PHJV lands in the province. The same could be developed in the other provinces or for the PHJV region as a whole.

A shorebird program at Quill Lakes starting out as an assessment program for the PHJV could become a multi-agency cooperative project which will propose a shorebird management plan for one of the largest wetland complexes in prairie Canada.

Specific upland evaluation projects throughout the PHJV region coming together under a cooperative multi-agency coordinated program would result not only in increased power in the results but also shared knowledge and improved management techniques which will benefit both waterfowl and other wildlife in upland habitat. This effort is underway today with plans for actual fieldwork initiation in 1993.

We must encourage future programs to seek and incorporate multi-species programs within wetland development proposals from their early stages. This can only be accomplished through increased partnerships between the various agencies. We already have seen that partners such as the Nature Conservancy of Canada can truly enhance our opportunities.

Other opportunities fall within the development of data bases to enable PHJV implementation staff to have access to multi-species data whether it be shorebird, passerine or amphibian distribution data. This would enhance the chances for multi-species concerns to be adequately addressed in all PHJV projects.

One area not handled to date is botanical interests. The PHJV could address or acquire data related to the distribution of rare habitat types and plants throughout the region. This not only would protect against the inadvertent destruction of rare habitat and plants but could provide the data needed to seize opportunities to protect, possibly through land purchase, parcels of such habitat.

We must not lose sight of the fact that, as the name suggests, the NAWMP is a waterfowl plan and that waterfowl are the targeted species. But we also must not lose sight of our responsibility to ensure that PHJV/NAWMP programs do not, while enhancing waterfowl opportunities, negatively affect other wildlife species presently using NAWMP lands. In addition, let us not lose this opportunity to enhance and manage habitat for the betterment of all species. We are pleased that in prairie Canada programs are expanding to meet non-waterfowl requirements with significant budgets being allocated for nongame purposes.

To date, the PHJV has contributed to the Prairie Conservation Action Plan in a number of areas including: work on endangered species; protecting native habitat; promoting public awareness of wildlife and wild place values; working to have governments conserve native prairies; and promoting research related to prairie conservation.

Program approaches by the PHJV clearly contribute to biodiversity and help to ensure a sustainable prairie landscape. By continuing and enhancing these contributions, the PHJV programs will meet the challenge of providing a true multi-species approach to wildlife management.

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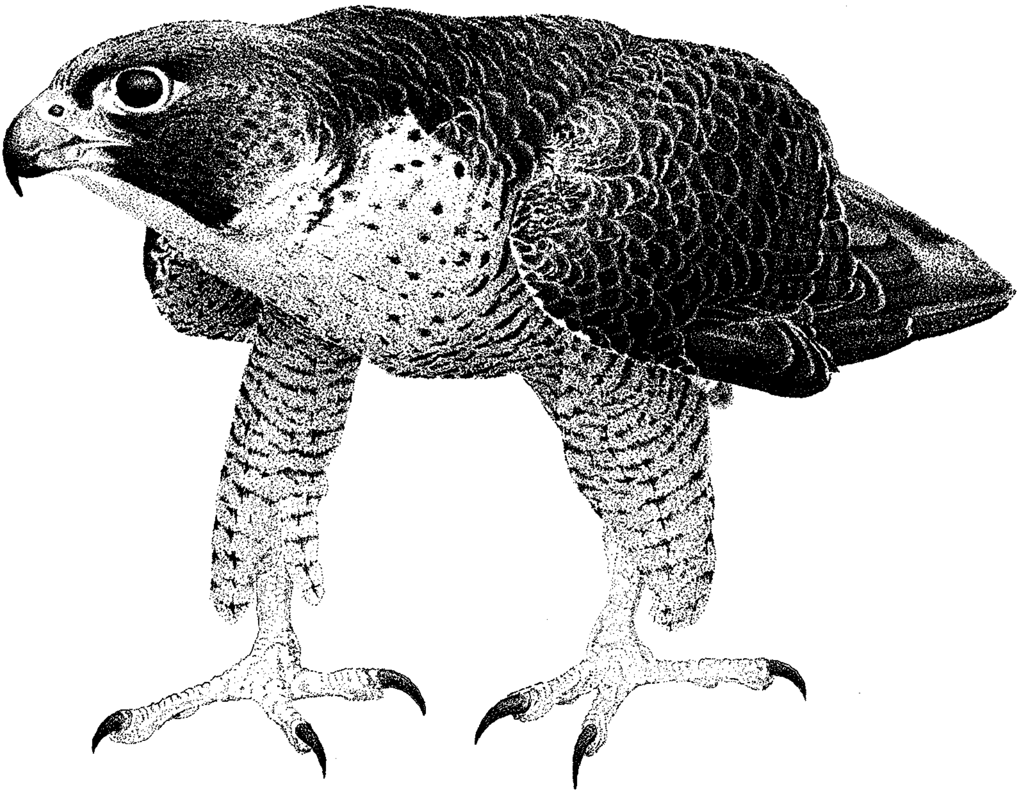

Special Session 7. *The North-South Connection: Neotropical Migratory Birds*

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Conservation Problems of Neotropical Migrant Land Birds

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Introduction

The recent surge of interest in the conservation of migratory land birds reflects a potential change in attitudes toward wildlife management. Most of the 255 or so species that breed in North America and winter in Central and South America and in the Caribbean ("Neotropical migrants") are not yet in any imminent danger of extinction, nor are they subjected to consumptive use. Neotropical migrants dominate the forests and many open habitats of eastern North America throughout the breeding season and their annual migrations still form one of the greatest spectacles in wildlife viewing. During spring migration, the bird diversity of small agricultural woodlots in the Midwest can rival that of tropical forests. Conservation efforts on behalf of Neotropical migrants therefore present an opportunity to preserve abundance, not rarity (Hagan 1992), and link conservation efforts in North America and in the Neotropics. Tropical deforestation can directly affect the birds in North America just as the fragmentation of breeding habitat can change the composition of tropical bird communities. Migratory birds have the potential to be valid biological indicators of both hemispheric and local conservation problems.

Concern for migratory birds has been generated by several lines of evidence that populations of many species may be declining. Long-term censuses of small, isolated woodlots have shown remarkably consistent population declines of forest-dwelling Neotropical migrants over the last 10–30 years. In contrast, populations of year-round residents and short-distance migrants have remained stable or increased (reviewed in Askins et al. 1990, Johnston and Hagan 1992, Wilcove and Robinson 1990). Evidence from the continent-wide Breeding Bird Survey (BBS) also shows recent declines of many Neotropical migrants (e.g., Robbins et al. 1989b, Sauer and Droge 1992), although there is considerable disagreement about how widespread many declines are (e.g., James et al.

1992). Gauthreaux's (1992) discovery of huge reductions in the number of "waves" of migrant birds crossing a section of the Gulf Coast of North America has added even more urgency to concerns about population declines. Many Neotropical migrants also are "area sensitive," i.e., they are absent from smaller woodlots even when the woodlots contain appropriate habitat and are large enough for many pairs (e.g., Lynch and Whigham 1984, Robbins et al. 1989a). When small woodlots contain Neotropical migrants, many have proven to be unmated males (Gibbs and Faaborg 1990). These data have confirmed the nearly universal impression among birdwatchers (at least in the East) that migrants are not as abundant as they used to be, a concern reflected by the title of Terborgh's (1989) book, "Where Have All the Birds Gone?"

As a result of concern over population declines and their appeal as potential biological indicators, Neotropical migrants have become the focus of one of the largest conservation efforts ever directed at "nongame" wildlife that are not yet endangered. Neotropical migrants have been the subject of several huge recent meetings, one sponsored by the Manomet Bird Observatory summarized in Hagan and Johnston (1992), one sponsored by the National Fish and Wildlife Foundation that spawned the huge, multi-agency "Partners in Flight" program, and a recent management workshop in Estes Park attended by over 800 scientists and managers. The Estes Park workshop will be followed by two volumes, one aimed at providing management recommendations, the other aimed at providing comprehensive reviews of conservation problems faced by migrant birds in North America. The Smithsonian Institution also has recently created the Migratory Bird Center to study the ecology and conservation of migrant birds on both the breeding and wintering grounds.

The success of these new programs is reflected in the increase in studies of Neotropical migrants and in the incorporation of migrants in national forest management plans. A recent ornithological newsletter contained 23 requests for assistants to help with studies of Neotropical migrants, a sure sign that funding has become available. The recent management plan of the Shawnee National Forest of southern Illinois contains provisions for "Forest Interior Management Units" designed to create and maintain habitat for migrants by reducing habitat fragmentation following the recommendations of Robbins (1979) and Harris (1984). Many scientists accustomed to working alone with minimal funding now are becoming familiar with the logistical demands of hiring and administering large field crews and with serving on various committees of the "Partners in Flight" program. As a result of these programs, we are learning a great deal about the natural history of previously little known species, and also are beginning to identify critically threatened habitats (e.g., floodplain forests and grasslands), species (e.g., cerulean warbler [*Dendroica cerulea*]), and geographical areas (e.g., the Adirondacks and Blue Ridge Mountains) that can lead to more focused research and management efforts. We also are beginning to understand the importance of the landscape context and of basic data on population dynamics, demography and natural history.

The purpose of this paper is not to provide a comprehensive review of the problems faced by Neotropical migrants, such as those provided by Askins et al. (1990), Finch (1981), Robinson and Wilcove (in press), Rosenfeld et al. (1992), Terborgh (1989), and Wilcove and Robinson (1990). Rather, I will draw heavily on the Manomet Symposium (Hagan and Johnston 1992) and the recent Management Workshop at Estes Park to emphasize what I consider to be some of the most crucial conservation problems of migratory land birds, their possible management needs and some promising research directions.

Problems on the Breeding Grounds

There is compelling evidence that problems on the North American breeding grounds are at least partly responsible for the declines of many Neotropical migrants. Sherry and Holmes (1992) have linked variations in American redstart (*Setophaga ruticilla*) populations with the previous year's reproductive success in unfragmented forests. At first glance, their result might not seem surprising, but Sherry and Holmes' (1992) study provides one of the first causal links between breeding-season events and population trends. Parallel studies of the annual reproductive output of black-throated blue warblers (*Dendroica caerulescens*) (Holmes et al. 1992) also have provided a baseline for comparisons with studies showing much lower productivity in more fragmented forest habitats (e.g., Robinson 1992).

In addition to the nest predators found in any habitat, fragmented forests have augmented populations of such edge-preferring predators as raccoons (*Procyon lotor*) and the brood parasitic brown-headed cowbird (*Molothurs ater*) (Brittingham and Temple 1983, Wilcove 1985). Nesting success of Neotropical migrants in small (<250 acre [100-ha]) woodlots in central Illinois was extremely low as a result of high levels of brood parasitism (76 percent of all nests) and nest predation (80 percent of all nests) (Robinson 1992). Subsequent studies from larger (up to 5,000-acre [2,000-ha]) tracts in the Shawnee National Forest of southern Illinois have shown comparably high levels of nest predation and brood parasitism for most, but not all species (Robinson and Wilcove in press, S. Robinson unpublished data). The wood thrush (*Hylocicha mustelina*) is particularly hard hit through Illinois and southern Wisconsin with parasitism rates averaging over 80 percent in all areas studied to date (Brittingham and Temple 1983, Robinson 1992, C. L. Trine, R. Jack, and S. Robinson unpublished data). Perhaps most surprisingly, there are no clear indications from the Shawnee National Forest data that parasitism or predation levels decline away from edges as has been found in Wisconsin (Temple and Cary 1988) and Maryland (Gates and Gysel 1978). It appears that the Shawnee National Forest is "saturated" with cowbirds and nest predators (Robinson and Wilcove in press).

The results of concurrent studies of nesting success demonstrate the importance of the landscape context in studies of the effects of fragmentation on Neotropical migrants. In the much more extensively forested landscapes of the Missouri Ozarks (J. Faaborg and R. Clawson unpublished data) and the Hoosier National Forest of Indiana (D. Whitehead unpublished data), levels of parasitism and nest predation are much lower than in the Shawnee, and may be higher near edges, at least in the Hoosier National Forest. These comparisons of nesting success in different landscapes provide the best indications to date that landscape fragmentation is a major threat to many Neotropical migrants (Sherry and Holmes 1992, Holmes et al. 1992). The reduced nesting success of many Neotropical migrants in small fragments might explain why population declines have been so much more severe in small fragments than in larger tracts (Wilcove 1988, Askins et al. 1990, Wilcove and Robinson 1990, Johnston and Hagan 1992) and why many Neotropical migrants are area-sensitive (Robbins et al. 1989a). Similar problems have been associated with small, edge-dominated grasslands (e.g., Johnson and Temple 1990, Bollinger and Gavin 1992).

In addition to habitat fragmentation, breeding habitat loss also has played a likely role in the declines of many species. Floodplain forests in the southeast have been converted to cropland at the cost of floodplain-nesting species such as the cerulean warbler (*Dendroica cerulea*) (Robbins et al. 1992). Similarly, loss of riparian habitats in the southwestern United States has contributed to declines of species such as the Least Bell's vireo (*Vireo bellii pusillus*) (Goldwasser et al. 1980). Grassland birds have suffered from much greater habitat loss than forest birds, especially in the Midwest (Herkert 1991), as have birds of second-growth habitats of New England (R. Askins personal communication). The destruction of coniferous forests by acid rain might be playing a role in the localized declines of many Neotropical migrants in the Blue Ridge Mountains and the Adirondacks (F. James personal communication).

Problems on the Wintering Grounds

There is little doubt that tropical deforestation (reviewed in Hartshorn 1992) will greatly change the composition of North American breeding bird communities (Terborgh 1980, 1989) and already may be responsible for population declines of species that winter mostly in primordial forest (Robbins et al. 1989a). Neotropical migrants are far more concentrated on the wintering grounds than on the breeding grounds, which makes them potentially more vulnerable to habitat loss in the tropics (Terborgh 1980). The declines of the Bachman's warbler (*Vermivora bachmanii*) (Terborgh 1989) and the cerulean warbler (Robbins et al. 1992b) have been linked to the deforestation of Cuba and the eastern Andean foothills, respectively. Many Neotropical migrants are well integrated in tropical forest bird communities; they defend territories and are site-faithful between years (Winker et al. 1990, Holmes and Sherry 1992). Many migrants, however, also tolerate, or even prefer second-growth and disturbed habitats on wintering grounds in South America (Robinson et al. 1988), the Caribbean (Arendt 1992) and Central America (Greenberg 1992, Lynch 1992, Robbins et al. 1992a). Wood thrushes winter in both the forest interior, where individuals defend territories, and along habitat edges, where individuals wander widely (Winker et al. 1990). Nonterritorial wood thrushes apparently suffer higher mortality rates than territorial individuals (Winker et al. 1990). Other studies, however, have not found differences in the condition and survival rates of species wintering in primary and secondary habitats (e.g., Greenberg 1992, D. Niven personal communication). Clearly, there is considerable interspecific variation in the tolerance of Neotropical migrants for disturbed habitats. There is, however, nearly universal agreement that the conversion of tropical forests to extensive pastures destroys their value as winter sites for all but a few species. Greenberg (1992) has argued, however, that even extensively agricultural landscapes can be used as wintering grounds for Neotropical migrants if scattered trees, hedgerows and shrubby watercourses remain. Wintering migrants, which do not have the additional energetic demands of breeding, may be more tolerant of habitat disturbance than Neotropical residents.

Problems During Migration

As McCann et al. (1993) discusses later in this session, migrant birds are particularly vulnerable at stopover sites because of the huge concentrations that occur in a few critical areas. Coastal areas are likely to be the most important stopover sites, particularly along the Gulf Coast of Texas, Louisiana, Mississippi and Alabama (Moore and Simons 1992). Real estate development poses a direct threat to these stopover sites because of the popularity of beach-front property. Small, isolated woodlots in the Midwest, however, also attract dense concentrations of migrants (Blake 1986). Migrants use these woodlots for rest and to replenish depleted energy reserves. We know little as yet about the relative value of particular kinds of habitats in stopover sites, although Graber and Graber (1983) showed that oaks (*Quercus* spp.) may be especially important during spring migration in the Midwest. Microwave towers, windows, buildings with reflective glass, cars and other man-made structures kill large numbers of migrants each year. Increases in the number of towers may be one of the causes underlying some recent population declines, but we have no way of evaluating the relative magnitude of this source of mortality.

Research Needs

Because significant research funding has only recently become available, we are just now beginning to study many of the most crucial questions about the ecology and conservation of Neotropical migrants. Below I review what I consider to be some of the most promising research directions.

1. *Demographic studies*. At the recent Estes Park meeting, there was widespread agreement among researchers that our greatest need is for more information on the demographies of Neotropical migrants. Until we know more about age-specific survival, annual productivity of individual females and the decision rules that govern adult dispersal, it will be difficult to interpret the impact of varying levels of nest predation and brood parasitism on population dynamics (May and Robinson 1985). Studies of bobolinks (*Dolichonyx oryzivorus*) (Bollinger and Gavin 1989), prairie warblers (*Dendroica discolor*) (Nolan 1978, Jackson et al. 1989), yellow-breasted chats (*Ictera virens*) (Thompson and Nolan 1973), black-throated blue warblers (Holmes et al. 1992), wood thrushes (Roth and Johnson 1993) and song sparrows (*Melospiza melodia*) (Smith 1981) provide examples of detailed demographic studies that can enable researchers to model the impact of management on Neotropical migrants. Increases in parasitism rates, for example, might have relatively little impact on a migrant with high annual survival rates, but might convert a former "source" habitat for a shorter-lived species into a population "sink" where reproduction is insufficient to compensate for mortality (Pulliam 1988). Current estimates of adult survival rates of Neotropical migrants based on return rates to study sites (Greenberg 1980) might be conservative if adults are more prone to disperse within (Jackson et al. 1989) or between seasons (Bollinger and Gavin 1989) following the loss of nests to predators. Decisions of whether or not to settle in a habitat also may be influenced by the presence of conspecific neighbors if dispersing birds use the presence of conspecific as cues of habitat quality (conspecific attraction: Smith and Peacock 1990). Conspecific attraction combined with high return rates to sites with low nest predation rates might guarantee continuous occupancy of high quality habitats (Bollinger and Gavin 1989), but also might impede recolonization of patches where populations have become locally extinct (Smith and Peacock 1990, Villard et al. 1992). In the absence of detailed demographic data, the application of metapopulation theory to Neotropical migrant birds (e.g., Villard et al. 1992) will have to remain tentative. Detailed demographic studies also will enable researchers to determine the relative importance of the problems caused by nest predation and brood parasitism (Martin 1992).
2. *Landscape-level studies*. Evidence is growing that the landscape surrounding a site exerts a major influence on area-sensitivity (Freemark and Collins 1992), nest parasitism and predation rates, and the magnitude of the edge effect (Brittingham and Temple 1983, Robinson and Wilcove in press). Edge effects and area-sensitivity,

for example, may be most pronounced in moderately fragmented landscapes because birds can choose among patches of varying sizes and because cowbirds and nest predators have not yet saturated the available landscapes. In mostly unfragmented landscapes, there may be too few cowbirds and edge-associated nest predators to cause problems. In extensively forested landscapes, for example, cowbird populations are likely to be limited by the availability of feeding areas rather than the availability of hosts. In highly fragmented landscapes, on the other hand, cowbirds and edge-associated nest predators may saturate the available habitat and cowbird populations might be limited by host availability rather than foraging sites (Robinson 1992). Paradoxically, Neotropical migrants may be less area-sensitive in fragmented landscapes because dispersers seeking breeding opportunities have no opportunities to choose larger tracts (Freemark and Collins 1992). The likely success of cowbird trapping and efforts to reduce edge habitat and cowbird and nest predator feeding areas also depends critically upon the landscape context (e.g., Rothstein et al. 1987).

3. *Habitat selection of predators and cowbirds.* As a result of studies using radiotelemetry, we are beginning to understand how brown-headed cowbirds use different landscapes (e.g., Rothstein et al. 1985, F. Thompson unpublished data). We know remarkably little, however, about the habitat preferences of most nest predators; most studies still cite Bider's (1968) pioneering study as the only evidence that mammalian predators prefer edges. Artificial nest studies have provided considerable insights, but may not sample snake predation, which may be particularly important in southern forests. Studies of habitat selection of snakes and other predators will provide important insights into edge effects.
4. *Effects of logging on nesting success.* Census results show that forest birds persist in tracts subjected to various logging practices (e.g., Thompson et al. 1992), but we still lack data on productivity in relation to logging. Of particular importance are studies of nesting success near the smaller (0.1–1.0 ha) openings created by group selection in comparison with larger openings created by clearcuts and the minimal openings created by single-tree selection. If group-selection cuts are large enough to attract and increase populations of cowbirds and nest predators, they may have a much greater negative impact on forest birds than single-tree selection os a smaller number of larger cuts. The relative costs and benefits of different logging practices also are likely to vary among different kinds of landscapes.
5. *Effects of plant species composition and vegetation structure.* The effects of changes in plant species composition generally have been ignored in spite of widespread evidence that some plant species are used more by birds than others (e.g., Franzreb 1983, Holmes and Robinson 1981, James and Wamer 1982, Lynch and Whigham 1984). Successional changes in vegetation structure and plant species composition have been suggested as causes of local population declines in New York (Litwin and Smith 1992) and New Hampshire (Holmes et al. 1986). Reduction in understory foliage density near edges caused by deer herbivory has been implicated as a cause of increased nest predation rates (Alverson et al. 1988). Cerulean warblers have been hypothesized to need old-growth forests because they prefer tall trees (Robbins et al. 1992b). Additional studies of microhabitat use by nesting and foraging birds could provide managers with specific guidelines for particular species and communities.
6. *Research in agricultural landscapes.* Agricultural landscapes and grasslands gen-

erally have fewer Neotropical migrants than forested landscapes, but still contain several declining species such as the bobolink and dickcissel (*Spiza americana*) (Bollinger and Gavin 1992). Research into the effects of hay mowing, conservation reserve programs, grazing and burning on nesting success can provide direct management guidelines for some species (e.g., Best 1986, Bollinger and Gavin 1992). Intensive grazing changes vegetation structure and may increase parasitism rates by increasing feeding opportunities for cowbirds, which follow cattle preferentially (Mayfield 1965, Elliott 1978).

7. *Condition and survival in winter and at stopover sites.* The crucial variables in studies of nonbreeding Neotropical migrants are condition and survival rates in habitats of varying degrees of disturbance (e.g., Holmes and Sherry 1992, Moore and Simons 1992). Migrant birds might be able to use disturbed habitats, but if survival rates and condition are lower than in forested areas, disturbed habitats might act as population sinks (e.g., Winker et al. 1990).
8. *Habitat needs of second-growth species.* We know little about the nesting success, area sensitivity and habitat requirements of second-growth species. There is some evidence that many second-growth species are less vulnerable to parasitism and predation than forest-interior species (Mayfield 1965). Nevertheless, populations of many species are declining as a result of changes in land-use patterns and, possibly, levels of nest predation and cowbird parasitism.

Management Needs

Given our limited understanding of the basic population ecology of most Neotropical migrants, there is understandable reluctance on the part of researchers to commit to definite management recommendations. Nevertheless, there is a need for tentative guidelines until new data become available to provide more specific recommendations. Many management recommendations will be made in the proceedings volume of the Estes Park workshop; here I summarize some of the most frequently mentioned management practices.

1. *Consolidation and maintenance of large tracts.* There is strong evidence that the reproductive success of forest and grassland birds is much higher in large than in small tracts. By purchasing private inholdings and reducing openings in forest that provide edge habitat and feeding areas for nest predators and cowbirds, managers can increase productivity of likely "source" areas for habitat-interior species. Because cowbirds feed anywhere there is short grass, stopping roadside mowing, eliminating pack stations and stopping the mowing of campgrounds and picnic areas might substantially reduce the negative impact of openings that already exist. Riparian corridors also should be as wide as possible to reduce edge effects and should not be subjected to intensive grazing.
2. *Habitat protection and acquisition.* In addition to acquiring inholdings that fragment larger tracts, acquisition and protection of key coastal stopover sites (McCann et al. this symposium) and tropical forest habitats will have obvious conservation benefits. Acquisition and restoration of grassland habitats in the Midwest, floodplain forests in the Southeast and riparian corridors in the Southwest also should be of high priority.
3. *Logging practices.* Because we know so little about the use by cowbirds and nest predators of small openings created by group selection, it might be better to use

low-volume single-tree selection rather than group cuts when selective logging replaces clearcutting. Group cuts maximize edge habitat per volume of timber removed and might therefore represent a worst-case scenario for forest-interior species. This recommendation rests on the as-yet unverified assumption that the openings around group cuts are used preferentially by cowbirds and nest predators. Longer rotations and lower targets for timber removal will inevitably reduce the extent to which logging activities fragment forests and provide more habitat for old-growth species. "Core" areas of large tracts should remain uncut following the recommendations of Robbins (1979) and Harris (1984) to provide habitat for species that need old-growth habitat.

4. *Cowbird removal.* In addition to reducing cowbird feeding areas, cowbird trapping might be an effective way to reduce parasitism in areas targeted for the management of habitat-interior species. In some landscapes, there may be no areas large enough to provide a refuge from cowbirds, which commute up to 5 miles (8 km) from breeding to feeding areas (Rothstein et al. 1984). Local trapping in the largest available tracts might increase their effectiveness as "source" populations. Larger-scale trapping in fragmented landscapes, however, may not be practical (Rothstein et al. 1987).
5. *Management of agricultural landscapes.* Management of temperate and tropical agricultural landscapes has a high potential to increase productivity and survival rates of many species. Maintaining isolated trees, hedgerows and wooded waterways greatly increases use of agricultural landscapes by wintering birds in the tropics (Greenberg 1992). Delaying mowing of hayfields and conservation reserve fields can increase productivity of species such as the bobolink (Best 1986, Bollinger and Gavin 1992). Maintaining a diversity of grazing and burning schedules in grasslands can insure the continued presence of species that need grasslands of different heights and densities. Wider crop borders and riparian strips also may improve nesting habitat by reducing nest predation rates (Best 1986).

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Partners in Flight Species Prioritization Scheme—Why Do We Need a Priority Scheme and How is One Implemented for Neotropical Migrants and their Habitats?

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Introduction

Clearly stated goals and objectives are critical components of any conservation effort. Likewise, a system for setting priorities for allocation of limited logistical and financial resources is especially important during initial phases of those efforts. A well-designed priority scheme allows land managers to organize available information in a format that better justifies decisions, especially when there are conflicting priority needs.

The species targeted in the Partners in Flight Program are linked together by breeding (at least partially) in North American temperate zones and migrating (at least partially) south of the continental United States during the non-breeding seasons. This similarity aside, geographical distributions, life-history traits and taxonomic affinities of Neotropical migratory landbirds cover the range of avian biological potential. From the management standpoint, some species are declining seriously and their continued survival is in doubt, others still are relatively numerous but show signs of recent widespread decline, while others are doing relatively well. Of critical importance to managers is identifying the species in each of the above categories within their area of jurisdiction and the habitats these species depend on for specific management attention.

To date, most conservation efforts have been aimed at individual species (e.g., game, endangered species, management-indicator species) rather than biotic communities. However, management emphasis is beginning to include multiple-species initiatives as there is increasing evidence of widespread degradation of entire biological communities. Thus, the ultimate intent of a good priority scheme should be to avoid ''single-species'' management programs by identifying habitats used by assemblages, including many high-priority species.

In the development of any prioritization scheme the question of scale must be addressed. The fact that the golden-cheeked warbler (*Dendroica chrysoparia*) is an extremely high-priority, globally endangered species is of little relevance to land managers in the United States outside of central Texas. Also, efforts in peninsular Florida to protect short-tailed hawks (*Buteo brachyurus fuliginosus*) may not be critical from a hemispheric perspective, but land managers may make conservation of this species a higher priority than peripherally occurring species of greater hemispheric priority. Making sure that conservation efforts undertaken at the local level are consistent with the goals and objectives set at larger spatial scales (i.e., physiographic area, state, region, nation, hemisphere, etc.) is the challenge we face in designing a priority scheme for Neotropical migratory landbirds.

The following discussion is intended to introduce the reader to the structure and function of this proposed prioritization scheme. A more detailed manuscript has been prepared (complete with tables) for the proceedings of the Neotropical Migratory Bird Workshop held at Estes Park, Colorado, during September 1992 (Finch and Stangel in prep.). Although the scheme presented here has received much review and input from knowledgeable ornithologists, some elements are subject to modification and improvement as experience is gained through direct application (e.g., determining local threats and distribution during migration, classifying priority habitats and scoring population trends). Nevertheless, the intent of this scheme is to complement (and not compete with) existing lists of legally protected threatened and endangered species at both state and federal levels, candidate species for legal protection, species of management (or special) concern and sensitive species. In fact, use of this scheme should assist in the conservation of those species placed on these lists.

Development of a Prioritization Scheme for Neotropical Migrants

Several prioritization schemes developed for conservation purposes have influenced the development of our scheme (Master 1991, Millsap et al. 1990, Rabinowitz 1981, Reed 1992). However, previous schemes do not allow simultaneous consideration of different levels of emphasis at different spatial scales, or during an annual cycle for species having different seasonal distributions. Our prioritization scheme allows for better consideration of migratory species by setting priorities from local to global spatial scales.

The Management Steering Committee of the Partners in Flight Program defined criteria that reflect a species' potential to be extirpated from an area or throughout its range. Seven factors are considered directly or indirectly (depending on the spatial scale) for ranking the concern for each species relative to other species within an area of specific interest. An individual species is assigned a rank score for each criterion ranging from 1 (low concern) to 5 (extremely high concern). A total concern score can range from 7 to 35 for each species. We also use mean concern score (total concern score divided by number of factors), which ranges from 1 to 5, for easier interpretation of the relative need for conservation attention among species and ultimately for ease of comparison among different geographic scales.

In addition, there is variability in the confidence with which concern scores are assigned. As a result, a system of supplemental action scores (*sensu* Millsap et al. 1990) has been devised whereby reliable scores can be differentiated from scores in which we have less confidence. These supplemental action scores cover survey/inventory, management, monitoring and research needs to help direct conservation activities for each species, regardless of their respective concern score. Each supplemental action variable is scaled from low uncertainty (little need for more information or action) to extremely high uncertainty (great need for more information or action).

Supplemental scores serve the priority-setting process in two ways. First, they protect managers from prematurely investing time and effort on a species with a high concern score that may be based on insufficient information, or on a species not requiring additional attention over and above what already is taking place. Second, supplemental scores indicate the extent and location of gaps in our knowledge of Neotropical migratory bird biology. When there is high uncertainty as to status or habitat needs of a species, more effort must be invested in making an accurate determination of conservation needs. Further, the need to focus attention on groups of species, as opposed to scattered efforts on individual species, may become evident if species within an assemblage all are poorly monitored or the factors leading to their declines are poorly understood. Focusing on species assemblages should result in greater efficiency in use of limited resources needed for increased survey, monitoring, research or management efforts at any spatial scale of interest.

The most important scale for use by most land managers is the smallest that allows for reasonably consistent and reliable estimations of concern for all species of interest. Since most local data bases are poor or nonexistent, this spatial scale must cover a relatively large area that can be either ecologically (e.g., physiographic area) or politically (e.g., province or state) based for Canada, the United States and the larger Latin American nations. Nations, commonwealths and territories of the West Indies and the smaller Latin American nations are analogous to physiographic areas or states for reliable and consistent ranking of species. Information at these ecological and poltical levels allows determination of priorities on properties under single or cooperative ownership and management at local levels.

Consideration at a larger spatial scale allows tracking activities among different physiographic areas and states. For this purpose, temperate North America has been divided into four regional management working groups based on the organizational structure of the International Association of Fish and Wildlife Agencies. This structure allows for better coordination among states, provinces and physiographic areas that share similar resources.

Concern Score Criteria Definitions

Global Abundance

The score given for global abundance is a constant value used at all spatial scales. The abundance criterion is a crude measure of a species' (hereafter to include subspecies and populations specifically identified for conservation purposes) vulnerability to catastrophic stochastic environmental events and, to some extent, demographic stochasticity. In general, global abundance is recognition that those species with the greatest population bases are most capable of absorbing adverse environmental and internal population dynamic effects. Since the total population size of all but a few species is unknown, global abundance is based on relative abundance in appropriate habitat(s), with an understanding of how widespread these habitats are within the range of the species, relative to all other species.

Breeding and Wintering Distributions

Scores for breeding and wintering distributions, two constants used at all spatial scales, are based on a review of range maps in various field guides, the American Ornithologists' Union Checklist of North American Birds (1983), and other sources (particularly, Rappole et al. 1983). These criteria also measure a species' vulnerability to stochastic environmental variation. Generally, species with wide distributions are less subject to naturally occurring or human-induced local effects. Some species may receive higher scores when they occur locally within a wide distribution.

Threats during the Breeding Season

This criterion, adapted with modifications from Millsap et al. (1990), in its simplest form is a qualitative measure of threat to each species in the area of interest. In a more complex form, this criterion can quantitatively incorporate three different aspects of the breeding biology of the species in question: (1) demographic vulnerability, (2) ecological vulnerability, and (3) habitat loss and disruption. Demographic vulnerability is the inability of a species to recover from population loss due to low reproductive rate, juvenile mortality, adult mortality or combinations of these parameters. Ecological vulnerability is an index of the species' level of ecological specialization. Species that are associated with one or a few habitats, or which have specialized feeding and breeding requirements, are given a higher rank. Finally, habitat loss and disruption can be caused by any of several factors, including forestry, water management, development and grazing practices that are detrimental to a species under consideration. The effects of these practices can be direct (habitat loss) or indirect (increased brood parasitism and nest depredation).

Scoring this criterion should be specific to the area of consideration for each breeding species. However, threats to local populations usually are not well known for most species in most areas. Therefore, degree of threat within a specific area of interest may be based solely on inference from larger spatial scales (Ehrlich et al. 1988, Finch 1991, Gradwohl and Greenberg 1989, Hagan and Johnston 1992). Breeding threat scores set at higher spatial scales therefore are likely to remain constant at more local scales until better local information becomes available for each species. Clarification of local breeding threats would be treated under the research supplemental action score.

Threats during the Non-breeding Seasons

This criterion, treated similarly to that for threats during the breeding season, takes both migration and wintering threats into consideration. Two of three factors discussed for breeding threats (ecological specialization and habitat loss/disruption) are included here as well. This score remains constant for assessing all areas where a species primarily breeds, and also can be constant in additional areas where the species primarily migrates through or winters, unless available data locally indicate otherwise. Vulnerability due to the constraints of distribution during migration can be addressed indirectly under this criterion (*see* Rappole et al. 1979). Needs for additional data on threats during the non-breeding seasons can be identified under research supplemental action scores.

Population Trend

Population trend is weighed independently in each area considered. A number of approaches to track population trends are used today, but only the Breeding Bird Survey (BBS) has broad utility across landscape, state/physiographic area and regional spatial scales (Robbins et al. 1986). Although BBS data are available throughout temperate North America, interpretation of these data below the grossest spatial levels in many areas is problematic and nearly impossible for species inhabiting poorly sampled habitats such as riparian areas or high elevations. Further, population trend data for these species in the tropics are non-existent beyond localized study sites.

Localized bird-banding or long-term monitoring studies (e.g., Christmas Bird Counts, Breeding Bird Censuses, hawk counts) in both temperate and tropical areas may be important for determining local priorities. However, application of locally collected data beyond specific study areas should be done cautiously since there can be extensive variation among intensively samples areas with similar arrays of habitats and species (e.g., Hunter et al. 1987). There also is high potential for lack of correspondence between locally collected data and regional patterns discerned from BBS data, where such data are adequate. For example, populations sampled during migration often are different from locally breeding populations (e.g., Hagan et al. 1992). Also, a local study area may or may not represent the average habitat condition for all breeding species using the area covered by the corresponding BBS analysis (Holmes and Sherry 1988, Witham and Hunter 1992). Interpretation of these and other trend data is clearly a complex issue and the degree of reliability of data sets must be identified through supplemental action scores concerning monitoring needs.

Importance of Area

The importance of area criterion is determined specifically for the area under consideration. Both the distribution and abundance of a species within an area are reflected in the importance of area score relative to the total distribution of the species during either breeding or non-breeding seasons. For example, a species whose distribution is restricted to the area under consideration and another species that is abundant within the same area, but globally widespread, both would score high under this criterion. However, the total concern score would likely be much higher for the first species because it would have a limited global distribution and perhaps a lower global abundance and greater levels of potential threat as well. Recognizing the importance of an area for both types of species allows focus of conservation efforts on both local and widespread species where they need it most. Keeping species common is as important in the Partners in Flight effort as recovering or stabilizing species that are rare.

Importance of area at the physiographic area/state scale is the most subjective criterion used in this prioritization scheme. However, scoring this factor stimulates important discussions between coordinators and experts at the regional level with those at the state or physiographic area level. These discussions should include pertinent Breeding Bird Atlas results, when these data are available. Emphasis should be on the relative importance of each area for maintaining or enhancing the full variation found within each species. Need for additional information on distribution, range of habitats used and relative abundance can be identified with a survey/inventory supplemental score.

Implementation of this Priority System

Developing Priorities for Habitats

Priority setting for habitats consist of identifying the optimal and suitable habitats used by each species and determining the sum of the mean concern scores for all species in a particular habitat for each state or physiographic area. Broadly defined habitats should include most of the species generally occurring together, even though each species has its own specific habitat needs. Rankings based on this procedure identify the top habitats needed for effective Neotropical migrant conservation. Once identified, these habitats and their relative priorities become subject to review and discussion by local bird experts and land managers in the development of management plans.

While detailed management plans are being developed, there are actions that can be taken in all states and physiographic areas to gain familiarity with the Neotropical migratory landbird resource and their habitats under the respective jurisdictions of each land manager. Through an eight-step process, local problems that high-priority species and habitats may face can be identified and potential solutions to these problems implemented:

1. survey/inventory and classify habitats available on management unit;
2. survey/inventory birds found in these habitats and determine which species expected to occur are absent or occur in lower than expected numbers;
3. search for commonality among species occurring in lower than expected numbers, review the literature on their specific habitat needs, and/or confer with local experts;
4. develop and implement management plans to benefit target species while minimizing harm to other presently stable priority species or groups of species, all in coordination as much as possible with adjacent landowners and the state and/or physiographic area coordinator;
5. establish a monitoring schedule to track the response of both target and co-occurring non-target species;
6. if, through monitoring, target species are not responding as expected or other species or groups of species are showing unacceptable declines, reevaluation of management prescriptions should occur;
7. if adjustments are not inherently obvious, then research needs should be identified to determine if there are other management alternatives or whether declines of target species may be for reasons other than those at the land-management unit under consideration; and
8. implement revised management prescriptions as necessary, continue to monitor target and non-target species, and determine if and when priorities need to be reevaluated.

An approach similar to organizing land-management activities can be taken to identify high-priority habitats for land acquisition if such areas are not already protected. The adequacy of either active or passive (or a combination of both) management approaches can be determined as well for these lands ahead of their acquisition. Such determinations are important to define the likely potential and focus of conservation efforts for targeted species or habitats. These determinations in turn allow for clearer assessments of the logistical and financial resources that would likely come to bear in conservation efforts.

Comparisons Among States and Physiographic Areas

An advantage of a standardized approach for setting priorities is identification of differing levels of conservation attention needed for individual species, groups of species and habitats shared among adjoining states and physiographic areas. For example, discovering why declines are not as evident in some states or physiographic areas for a species, or a species assemblage, is as important as discovering what processes are at work in other areas where declines are widespread. Understanding the processes in all states and physiographic areas is necessary to gain a more complete picture, regardless of differences among these physiographic areas in the number and types of species showing declines.

Although we encourage comparisons among states and physiographic areas to search for patterns in the development of specific management recommendations, we urge that the use of sum or mean concern scores not be used to pit states or physiographic areas against each other in setting priorities. Each state and physiographic area contains unique sets and combinations of Neotropical migrants and habitats. Concentration on one area rated above another could lead to unfortunate gaps in overall conservation efforts.

Conclusion

We agree with Millsap et al. (1990) that priority ranking systems should not replace human judgment in the allocation of conservation resources. Priority schemes should: (1) serve as guides toward the local resources in greatest need for conservation attention, (2) help identify where there are gaps in information, and (3) be flexibile in allowing for revision when new and better information becomes available. We believe the scheme presented here fulfills these elements and allows managers to both identify species or groups of species of concern, and the primary causes leading to their high-concern scores. The prioritization scheme presented here allows for feedback by which effective actions (i.e., management successes) can be identified and exported to other areas suffering from similar problems.

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A Regional Study of Coastal Migratory Stopover Habitat for Neotropical Migrant Songbirds: Land Management Implications

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Introduction

Widespread concern over declines in populations of neotropical migrant songbirds (e.g., Robbins et al. 1989, Terbough 1989) has sparked state (e.g., Maryland's Chesapeake Bay Critical Area Law; *see* Therres et al. 1988), national and international conservation initiatives (e.g., Partners in Flight Program). To date, most research and protection efforts have focused on breeding and wintering grounds. Migratory stopover areas, the connecting link between nesting and "wintering" habitats, have received relatively little attention yet represent a third and perhaps as critical a component in the conservation of neotropical migrants songbirds.

Migration is a period of extreme stress for neotropical migrants (Berthold 1975, Dawson et al. 1983). During stopovers, the need to replenish fat reserves, rest and find adequate cover from predators and adverse weather is essential. The availability of suitable stopover habitat can have a profound impact on population viability by influencing the ability of birds to complete migration and ultimately reproduce successfully. Unfortunately, little information is available on the location, extent or characteristics of critical stopover habitat for neotropical migrant songbirds.

The Cape May and Delmarva Peninsulas are among a number of locations in North America that traditionally have been viewed as important concentration areas for migrant passerines. This phenomenon is thought to be related to local and regional geography, the direction of prevailing winds and innate avian behavior (Dunne et al. 1989). The mid-Atlantic coastal region is, however, faced with unprecedented development pressures, especially on waterfront properties. Continued habitat loss and fragmentation on the two peninsulas may have serious consequences for neotropical migrant songbird populations.

To help develop a protection strategy for stopover habitat in this region, a four-state (Delaware, Maryland, New Jersey and Virginia), multi-agency study was implemented during 1991 along the coastal areas of the Cape May and Delmarva Peninsulas. Our goal was to examine landscape-scale patterns in "fall" migrant songbird distribution and abundance. Specifically, the study addressed five main questions in an attempt to characterize, in terms of geography and habitat, coastal areas that support the greatest abundance and species richness of neotropical migrant songbirds during fall migration. These questions were: (1) do migrants concentrate near the coast; (2) does migrant abundance differ among the bayside coast (Chesapeake and Delaware bays), Atlantic ocean coast, and peninsula interior; (3) do migrants concentrate near peninsula tips; (4) is migrant abundance greater on barrier islands than the adjacent coastal mainland; and (5) is migrant abundance related to habitat type?

In this paper we present a summary of our findings and discuss possible land-management implications. For additional information, refer to Mabey et al. (1993). Study funding was provided by the National Oceanographic and Atmospheric Administration's Office of Coastal Resource Management, The Nature Conservancy, National Fish and Wildlife Foundation and U. S. Fish and Wildlife Service. We also would like to extend our sincerest thanks to all of the members of the study team, including the hundreds of volunteers who graciously donated their time and birding expertise as field observers.

Methods

The study design and methodology are described in detail by Mabey et al. (1993). Briefly, migrant surveys were conducted during August through October 1991 at 487 sample points located randomly within the coastal region of the Cape May and Delmarva Peninsulas. The relative abundance of neotropical migrant songbirds was determined at each sample point using, simultaneously, a standardized audio-lure (tape recording of Carolina chickadee [*Parus carolinensis*] calls and human pishing and hand-squeaking noises) and a 10-minute long, fixed radius (82 feet [25 m]) point count. Point counts took place two days per week and each sample point was visited once per day. All counts occurred between two hours after sunrise and one hour before sunset to insure that birds had completed morning flight and already selected stopover habitat (Wiedner et al. 1992), and to avoid counting birds that had initiated nocturnal migration.

Most sample points were located within a continuous 1.9-mile (3 km) wide "coast" band that paralleled both the bay (Delaware and Chesapeake bays) and ocean coastline. This band was further divided into a "near-coast" zone (0–0.9 miles [0–1.5 km] from mean high tide line]mhtl]) and an "inland" zone (0.9–1.9 miles]1.5–3 km] from mhtl). We also established a 1.9-mile (3 km) wide band in the mainland "interior" (6.2–14.3 miles]10–23 km] from mhtl) in Delaware, Maryland and New Jersey. Sample points were randomly located within each band at a density of approximately 1 per 1.9 miles^2 (2.7 km^2). Although the small size of most barrier islands precluded the delineation of 1.9-mile (3 km) wide bands, sample point density was similar to that on the mainland. All points occurred in forest or scrub habitat patches that were > 2.5 acres (1 ha) in size,

≥ 492 feet (150 m) wide, and dominated by woody vegetation ≥ 1.7 feet (0.5 m) tall. To avoid sampling edges, points were placed in the interior of the habitat patch or ≥ 164 feet (50 m) from the habitat edge. Based on a standard vegetation assessment, the habitat surrounding each point was categorized as either coniferous forest, deciduous forest, mixed forest or scrub-shrub.

Bird abundance was defined as the mean number of birds observed per point count. Species richness was the mean cumulative (during August through October 1991) number of species observed per sample point. All statistical comparisons presented in this paper are based on analyses of variance and Tukey's standardized student range tests to separate means.

Findings

A total of 11,583 point counts were conducted, during which 37,301 neotropical migrant songbirds comprising 79 species were observed. We refer collectively to these species as songbirds even though several non-passerine species are included (black-billed cuckoo [*Coccyzus erythropthalmus*], yellow-billed cuckoo, ruby-throated hummingbird, and yellow-bellied sapsucker; all other scientific names are provided in Table 1).

A primary question was whether or not migrants concentrate near the coast. Although the mid-Atlantic coast long has been considered an important concentration area for migrant passerines, this premise had not been investigated quantitatively prior to this study. Our data indicate that such a concentration does occur based on comparisons between the near-coast and inland zones; migrant abundance ($P < 0.0001$, Figure 1a) and species richness ($P = 0.006$, Figure 2a) both were significantly greater near the coast. In fact, on a regional scale, migrant abundance averaged 17 percent greater in the near-coast zone than in the inland zone.

A clearer picture of this ''coastal effect'' emerges in comparisons among the bay and ocean coasts (0–1.9 miles [0–3 km] from the mhtl), and mainland interior areas. These analyses revealed that bird counts were significantly ($P < 0.0001$) higher along the Chesapeake and Delaware Bay coasts than either the ocean coast or mainland interior and there was no difference between the latter two areas (Figure 1b). Species richness showed a similar pattern ($P < 0.0001$, Figure 2b). Although bird counts were higher ($P < 0.0001$) in the near-coast zone on both the bay and ocean sides of the peninsulas, species richness (Figure 2c) and migrant abundance (Figure 1c) were particularly high in the bayside near-coast zone. The same trends were evident when comparisons between geographic areas (i.e., near-coast versus inland zone, bay coast versus ocean coast) were controlled for habitat type (coniferous forest, deciduous forest, mixed forest and scrub).

The tendency of migrants to concentrate near the coast, especially on the bayside coast, probably is due to a combination of factors: (1) a west to northwest reorientation by birds drifted offshore and the subsequent return of these birds to the mainland coast during the early morning hours (Baird and Nisbet 1960, Drury 1960, Drury and Keith 1962, Drury and Nisbet 1964, Murray 1976, Able 1977); (2) fat-depleted birds migrating over the mainland may ''drop out'' along the coast rather than continue offshore under increasingly difficult flight conditions during daylight hours (Kerlinger and Moore 1989); and (3) morning flight behavior, resulting in large numbers of birds dispersing westward around the peninsula tips and then northward up the bay coast, and birds moving inland from both the bay and ocean coasts (Alerstam 1978, Gauthreaux 1978, Wiedner et al. 1992).

Birds migrating in a southerly direction would be expected to concentrate at barriers to southerly flight. Observations at two well-known bird research stations (Cape May Bird Observatory, Cape May, New Jersey, and Kiptopeake Bird Banding Station, Kiptopeake, Virginia) suggest that as birds move southward and eastward toward the coast they concentrate near the southern tips of the Cape May and Delmarva peninsulas (Virginia Heritage Program 1988, U. S. Fish and Wildlife Service 1984). Such concentrations have been documented for diurnal migrants (e.g., raptors, Kerlinger 1989) but only speculated for nocturnal passerine migrants. Our data show no evidence ($P > 0.05$) of this

Table 1. Stopover habitat associations of neotropical migrant songbirds during fall migration in the coastal region of the Cape May and Delmarva Peninsulas. Associations are based on comparisons of migrant abundance[a] among four major habitat types: coniferous forest; deciduous forest; mixed forest and scrub-shrub habitat.

Common name[b]	Scientific name	Stopover habitat[c]
Yellow-billed cuckoo*	*Coccyzus americanus*	$Forest_{d,m}$
Ruby-throated hummingbird	*Archilochus colubris*	$Forest_c$
Yellow-bellied sapsucker	*Sphyrapicus varius*	$Forest_g$
Eastern wood-pewee	*Contopus virens*	$Forest_g$
Eastern phoebe	*Sayornis phoebe*	Scrub
Eastern kingbird	*Tyrannus tyrannus*	Scrub
Great-crested flycatcher	*Myiarchus crinitus*	$Forest_c$
House wren	*Troglodytes aedon*	Scrub
Ruby-crowned kinglet	*Regulus calendula*	$Forest_c$
Blue-gray gnatcatcher	*Polioptila caerulea*	$Forest_c$
Veery*	*Catharus minimus*	$Forest_g$
Hermit thrush	*C. guttatus*	
Wood thrush*	*Hylocichla mustelina*	$Forest_g$
Gray catbird*	*Dunetella carolinensis*	Scrub
White-eyed vireo*	*Vireo griseus*	Scrub
Solitary vireo	*V. solitarius*	
Red-eyed vireo	*V. olivaceus*	$Forest_d$
Northern parula*	*Parula americana*	
Chestnut-sided warbler*	*D. pensylvanica*	
Magnolia warbler	*D. magnolia*	
Cape May warbler	*D. tigrina*	
Black-throated blue warbler	*D. caerulescens*	
Yellow-rumped warbler	*D. coronata*	Scrub
Black-throated green warbler*	*D. virens*	$Forest_g$
Pine warbler	*D. pinus*	$Forest_c$
Prairie warbler	*D. discolor*	$Forest_c$
Black-and-white warbler	*Mnioltilta varia*	$Forest_g$
American redstart	*Setophaga ruticilla*	$Forest_g$
Ovenbird*	*Seirus aurocapillus*	$Forest_g$
Common yellowthroat*	*Geothlypis trichas*	Scrub
Scarlet tanager*	*Piranca olivaceus*	
Northern oriole*	*Icterus galbula*	$Forest_d$

[a]Mean number of birds per point count. Habitat associations based on analysis of variance and Tukey's studentized range test for mean separation.
[b]Asterisks indicate species with significant ($P < 0.05$) population declines, based on 1978–87 Breeding Bird Survey data (Robbins et al. 1989).
[c]Forest subscripts: c-coniferous, d-deciduous, m-mixed, g-forests in general (i.e., abundance greater in forest than scrub habitat but not significantly associated with a particular forest type).

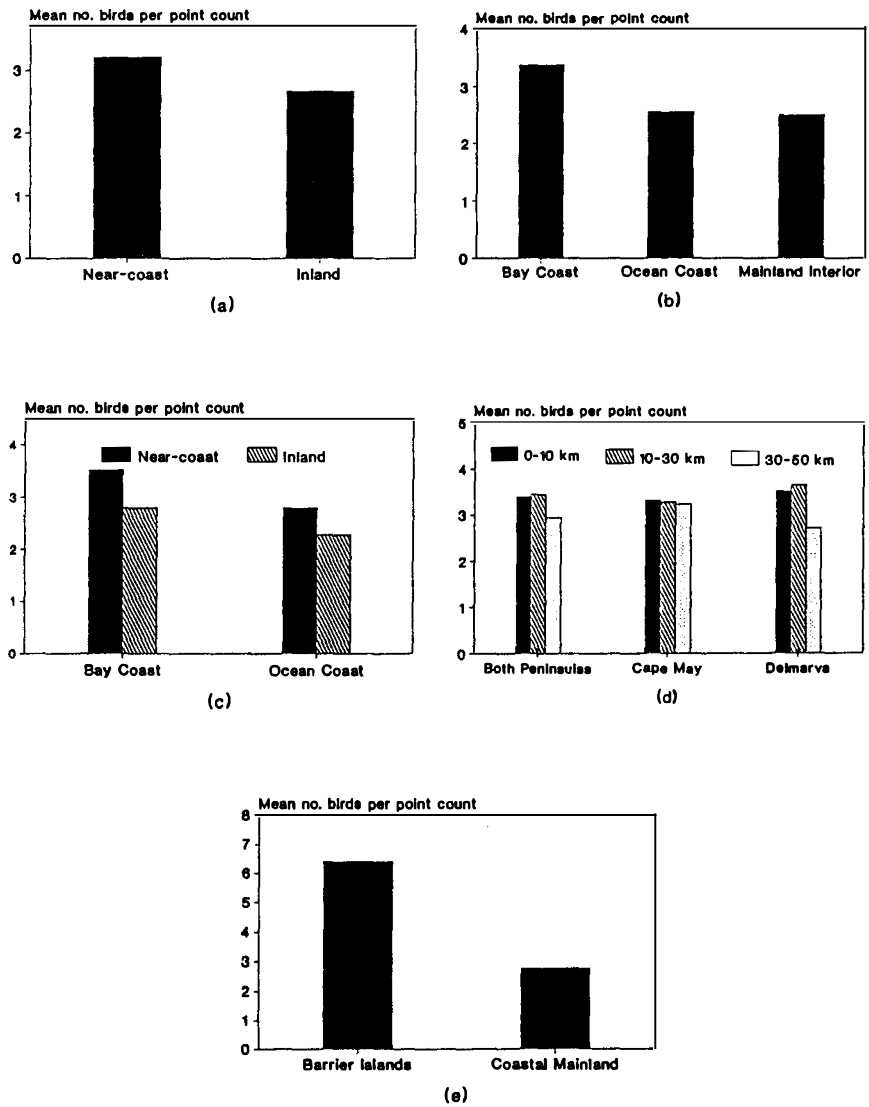

Figure 1. Comparisons of neotropical migrant songbird abundance during fall migration in the coastal region of the Cape May and Delmarva Peninsulas: (a) near-coast zone versus inland zone, (b) bay coast versus ocean coast versus mainland interior, (c) 'a' by bay coast and ocean coast, (d) comparison between coastal areas at different distances from the southern tips of peninsulas, and (e) barrier islands versus adjacent coastal mainland.

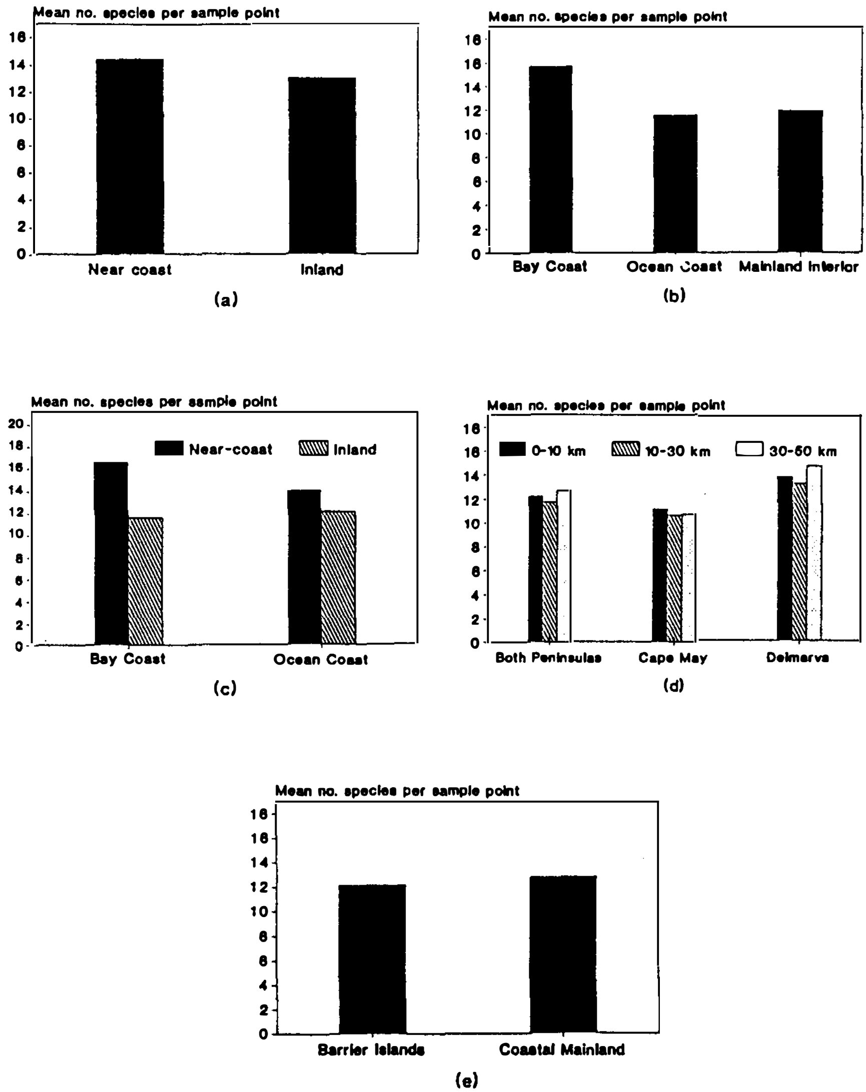

Figure 2. Comparisons of neotropical migrant songbird species richness during fall migration in the coastal region of the Cape May and Delmarva Peninsulas: (a) near-coast zone versus inland zone, (b) bay coast versus ocean coast versus mainland interior, (c) 'a' by bay coast and ocean coast, (d) comparison between coastal areas at different distances from the southern tips of peninsulas, and (e) barrier islands versus adjacent coastal mainland.

relationship on either peninsula (Figures 1d and 2d), based on regression analyses, comparisons of migrant abundance among three discrete distance categories (0–6.2, 6.2–18.6 and 18.6–31.1 miles [0–10, 10–30 and 30–50 km, respectively] north of the southern tips of the peninsulas), and analyses that accounted for variation from other geographic features (i.e., proximity to coastline, bay versus ocean coast) and habitat types. We believe that while large numbers of birds do occur near the peninsula tips during early morning hours, most are engaged in morning flight and relatively few stopover due to a lack of suitable resting and feeding habitat (Wiedner et al. 1992, Niles and Kerlinger unpublished data; Watts and Mabey unpublished data). It also is possible that our study design was only appropriate for investigating peninsular concentrations at a regional level and was simply ineffective (e.g., by random chance, few sample points were located directly at the peninsula tips) at detecting patterns that may be operating at a much more local level. For example, limited ancillary data from Virginia (Mabey unpublished data) suggest that birds do concentrate near the Delmarva Peninsula tip but only within the distal 1.9 miles (3 km). These and other explanations (e.g., migrant abundance is related, in part, to landscape-level habitat distributions) are currently being investigated further on both peninsulas (Watts and Mabey unpublished data; Kerlinger and Niles unpublished data).

Barrier islands supported a remarkably high abundance of migrants that was over two times greater ($P < 0.0001$) than on the adjacent mainland (Figure le). Although 54 percent (26 percent on the adjacent mainland) of the migrants recorded on barrier islands were yellow-rumped warblers, analyses without this species still showed higher ($P = 0.024$) bird counts on barrier islands; there was, however, less disparity. We also found greater abundance on barrier islands, with and without yellow-rumped warbler data, in comparisons by habitat type. Although there was no difference in species richness (Figure 2e), both areas supported a nearly complete assemblage of migrant songbird species that were observed during the study (76 of a possible 79 species occurred on both barrier islands and the adjacent coastal mainland).

Barrier islands apparently are an important stopover area for migrants. Similar observations, although not quantitatively compared to a nearby mainland, have been made on other islands near ocean coasts (Baird and Nisbet 1960, Able 1977, Moore et al. 1990). To a large degree, these concentrations can be attributed to the geographic position of barrier islands. As the most seaward stretch of land along the mid-Atlantic coast, they represent the last possible stopover area for birds that are engaged in nocturnal migratory flights and departing from the mainland, and the first potential landfall for birds offshore and attempting to regain land. Habitat conditions also may have influenced migrant abundance since most sample points on barrier islands were located in extensive, relatively undisturbed interdune scrub and woodland habitat. The dense cover and abundant food in these plant communities may provide ideal stopover habitat for a variety of migrant songbird species.

Finally, is migrant abundance related to habitat type? We found that, on the average, bird abundance was highest ($P < 0.0001$) in scrub-shrub habitat, but there were no differences between the three forest types. Species richness showed a different pattern; values were highest ($P < 0.0001$) in coniferous forest, followed by deciduous and mixed forests, and scrub-shrub habitat had the lowest species richness. A tally by habitat type of the total number of species present revealed that species numbers were lowest in coniferous forests (61 species), highest in deciduous and mixed forests (73 and 75 species, respectively), and intermediate in scrub-shrub habitat (68 species). In an attempt to examine habitat associations more closely, data for 32 species with adequate sample sizes ($n > 100$ birds observed) were analyzed individually. Twenty-three of these 32 species showed significant ($P < 0.1$) habitat associations (Table 1). Generally, species preferred either forest (16 species) or scrub-shrub habitat (7 species). However, of those species preferring forested areas, six were most commonly associated with coniferous forests, two were strongly associated with deciduous forest, and one seemed to prefer either deciduous or mixed forest; the other eight species tended to be equally abundant in all three forest habitat types. Although our data did not permit fine-scale analyses of habitat use, it is significant to note that species requiring forests during the breeding season also are strongly associated with forest habitats during migration. Likewise, species that nest in early successional forest and scrub-shrub vegetation used similar habitat during stopovers.

Management Implications

Although the data provide evidence of several important landscape patterns in migrant abundance, the study also points to the complexity of developing an effective protection strategy for stopover habitat for neotropical migrant songbirds. Clearly, no single landscape feature or habitat type will provide suitable stopover areas for all migrants or all species. Effective conservation requires a mosaic of different natural habitat patches distributed across an entire region, as suggested by Sprunt (1975). Findings by Winker et al. (1992) suggest a similar strategy. However, certain coastal landscape features, such as barrier islands and bay coastal areas, are particularly important to migrants and should receive priority protection measures. Many barrier islands in our study area are currently under private, state or federal protection and, with proper management, will likely continue to provide suitable stopover areas for neotropical migrants. However, for most other barrier islands, little natural upland vegetation remains due to human development. Similar situations exist along parts of the coastal mainland. Management recommendations for these and other coastal areas are outlined below.

Ideally, conservation efforts should focus on large forest blocks. Large forests tend to contain a greater diversity of habitat types than smaller forest blocks (Buckley 1982, Forman and Godron 1986) and therefore will support not only a greater absolute number of migrants, but greater species diversity. Also, species such as veery, wood thrush and black-throated green warbler (all of which are experiencing population declines, *see* Robbins et al. 1989) prefer forest habitat during migration and scrub-shrub vegetation may not contain adequate stopover habitat. For some migrants, especially species like white-eyed vireo, gray catbird and common yellowthroat, adequate stopover habitat may exist in small woodlots, coastal scrub (i.e., dominated by bayberry [*Myrica* sp.] and high tide bush [*Iva frutescens*]), hedgerows, and filter strips. It is worth noting that although some species apparently prefer certain habitat types during migration, none of the 32 species listed in Table 1 were entirely absent from any of the four habitat categories.

Ultimately, the protection of stopover habitat (i.e., native forest and scrub habitat) must be addressed through environmental policies and conservation programs. On the Cape May Peninsula, songbird stopover areas currently receive some protection through the New Jersey Freshwater Wetlands Act and Coastal Areas Facility Review Act. Our findings should strengthen and focus the habitat protection recommendations made under these laws. Critical stopover habitat also should be introduced as significant coastal areas in state Coastal Zone Management (CZM) Program plans. In Maryland, for example, the

Chesapeake Bay Critical Area Law provides considerable protection for forests along the Chesapeake Bay coast (within 1,000 feet [301 m] of mhtl) and specifically addresses the need to conserve breeding habitat for forest interior dwelling bird species (*see* Therres et al. 1988), the majority of which are neotropical migrant songbirds. Through the cooperation of local Critical Area Programs, the conservation of migratory stopover habitat also could be addressed in these areas.

A number of non-regulatory options (e.g., open space easements and state Natural Areas Registry Programs) also are available for protecting coastal stopover habitat. In addition, state and federal incentive programs, such as the Conservation Reserve Program (CRP), Acreage Conservation Reserve Program (ACR) and Forest Stewardship Programs, offer many opportunities for educating and encouraging private landowners to consider the stopover needs (and breeding habitat requirements) of neotropical migrants. In many coastal areas, the only available stopover sites consist of landscaped vegetation in suburban and urban environments. The best opportunity for providing resting and feeding habitat in these situations may be through landscaping recommendations to developers, land planners and private homeowners (e.g., in some areas, local ordinances already exist that provide specific guidelines for retaining native vegetation and replanting: *see* Sutton 1989). However, by themselves, these piecemeal attempts to provide stopover habitat must be incorporated into a regional, proactive land-management plan that protects a mosaic of natural habitats.

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The National Wildlife Refuge System's Role in Conservation of Neotropical Migratory Birds

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Introduction

The National Wildlife Refuge System (System) is the only federal land base devoted primarily to protect and manage fish, wildlife, and their habitats. Encompassing 91 million acres, the System contains over 480 refuge units, ranging in size from 0.25 acre to over 19 million acres. The system harbors hundreds of wild animal and plant species native to the North American continent, including 220 mammals, 600 birds, 250 reptiles and amphibians, and uncounted numbers of fish, invertebrates and plants (Clark 1992).

Recognized primarily for its contribution to protect and manage waterfowl and wetland habitats, the System does protect important breeding, migration and wintering habitats for nongame migratory birds. Coastal refuges provide important breeding sites for colonial nesting waterbirds, and they also serve as major migratory and wintering habitats for shorebirds. With over 16 million acres of forestlands and 4.5 million acres of grasslands, the system is important to the conservation of hundreds of Neotropical migratory bird species.

Many refuges have programs and projects devoted to conservation of nongame migratory birds and their habitats. The number of refuges contributing to conservation of nongame migratory birds continues to grow. For example, refuge staff at the Hakalau Forest National Wildlife Refuge (NWR) in Hawaii are restoring native Koa forests for several native and endangered species of songbirds. The Balcones Canyonlands NWR in central Texas recently was acquired to protect habitat for seven endangered species, including two endangered Neotropical migratory bird species: the black-capped vireo and golden-cheeked warbler.

From a nonconsumptive recreational perspective, several refuges throughout the country are nationally and internationally recognized as top-quality birding locations. Aransas NWR in Texas, one of the most popular birding sites in North America, has a bird list of 390 species (Jones 1992). In 1992, over 34 million visits to national wildlife refuges were related to nonconsumptive wildlife-oriented recreation. Although complete figures are not available, it is safe to assume that a large percentage of these visits were related to birdwatching. Refuges such as Chincoteague in Virginia, Ding Darling in Florida, Santa Ana in Texas, Malheur in Oregon and Salton Sea and San Francisco Bay in California bonjure up the ultimate outdoor experience for millions of birders.

Historical Perspective

During the first 25 years of its existence, the System primarily was used as a sanctuary system for depleted species (W. Reffalt personal communication). The system began in 1903 with an Executive Order signed by President Theodore Roosevelt establishing the

Pelican Island Federal Bird Reservation in Florida (Reed and Drabelle 1984). Pelican Island was not established to protect waterfowl, but instead, to protect colonial nesting waterbirds.

By the time President Roosevelt left office in 1909, he had established, through Executive Orders, 51 wildlife reservations in 12 states and 3 territories. These reservations were established to provide refuge and breeding grounds for native birds, which, at the time, referred primarily to waterfowl and colonial nesting birds such as pelicans, egrets, herons, spoonbills, terns and gulls. Protection was needed to stem impacts that the millinery (feather) trade exerted on colonial nesters. In essence, these bird reservations actually were a successful recovery action preventing the extinction of several waterbird species—a precursor to our present-day efforts to recover endangered species through the Endangered Species Act.

The system's primary emphasis up to the late 1920s focused on protecting habitat for colonial nesting birds. Other refuges were established for big game species such as elk and bison; nevertheless, protection for nongame birds was the typical reason for establishment. The System's emphasis on protecting and managing waterfowl and wetland habitats became the driving force of the system's acquisition program during the Dust Bowl Era and after passage of the Migratory Bird Hunting and Conservation Act in 1934. Even during the peak period of waterfowl emphasis (1934–late 1960s), many refuges were established to protect endangered species or simply as units to conserve biological diversity.

Though most refuges during this era were acquired and managed for waterfowl, they were legislatively established to protect migratory birds. From a realistic standpoint, however, these "waterfowl" refuges still afforded protection to many other wildlife species, including nongame migratory birds. Many wetland-dependent nongame species, such as herons and egrets, benefitted. Nevertheless, other nongame species, such as early migrating shorebirds, also may have been negatively impacted due to water manipulation techniques favoring later arriving migrating waterfowl. Regardless of whether the primary management emphasis was directed at waterfowl, one only has to imagine the dismal consequence to our wildlife if these sites had never been protected.

Passage of the Land and Water Conservation Fund in 1964, the growing concern for protecting endangered species and the increasing focus of the conservation community to protect biological diversity started a trend in refuge acquisitions to protect species and habitats other than waterfowl and wetlands. Since the 1930s, the refuge system has gone through the same evolution as other wildlife agencies: from game management in the 1930s, to endangered species and nongame management in the 1970s, to the present direction to protect biological diversity. Mechanisms presently are in place giving refuge managers a mandate to protect nongame wildlife.

The overall purpose of national wildlife refuges is "to provide, preserve, restore, and manage a national network of lands and waters sufficient in size, diversity, and location to meet society's need for areas where the widest possible spectrum of benefits associated with wildlife and wildlands is enhanced and made available" (U. S. Fish and Wildlife Service 1982). This purpose is further divided into four discrete management goals. Three of these goals relate to conserving biological diversity, including protecting nongame wildlife: "To preserve, restore, and enhance in their natural ecosystems (when praticable), all species of animals and plants that are endangered or threatened with becoming endangered"; "to preserve a natural diversity and abundance of fauna and flora on refuge lands"; and "to perpetuate the migratory bird resource."

Legislative authorities used to acquire refuge lands usually have one or more purposes for which the land can be acquired. The purposes establishing each unit of the system dictates, to a large degree, what species and habitats the refuge protects and manages. Many refuges may be managed primarily for waterfowl, but a closer inspection of the legislative purposes for which these refuges were established reveals that the primary purpose was for "migratory birds." Even refuges established for a specific purpose other than migratory birds still provide for many other species and, in many situations, complete biological communities or ecosystems.

With or without a specific purpose to protect migratory birds, other mechanisms offer an opportunity or, more clearly, a responsibility to protect nongame migratory birds. Legislative mandates such as the Migratory Bird Treaty Act, Wilderness Act, Endangered Species Act, and the Fish and Wildlife Conservation Act of 1980 (the "Nongame Act") provide some degree of responsibility to protect and manage nongame wildlife.

Refuges or portions of a refuge may further yield benefits for nongame migratory birds through special land-protection designations. Such designations include wilderness, research natural areas, wild and scenic rivers, and sites listed by the Western Hemisphere Shorebird Reserve Network. Inherent to each of these special designations is the responsibility to incorporate a community or ecosystem approach to land protection and management. Such designations benefit nongame resources because an ecosystem management approach produces the fullest array of benefits to these species.

Ongoing Neotropical Migratory Bird Projects within the National Wildlife Refuge System

Many refuges historically have developed and implemented programs to protect and manage nongame migratory birds and their habitats. For example, the Santa Ana and Lower Rio Grande NWRs in southern Texas have been involved with protecting and restoring important nongame bird habitats long before the Partners in Flight Program was initiated. By the very enormity of their size, Alaska refuges protect breeding habitats for boreal-nesting Neotropical migrants and other nongame migratory birds. Coastal and barrier island refuges, such as Cape Romain in South Carolina and Matagorda Island in Texas, serve as important staging habitats for Neotropical migrants during spring and autumn migrations. These sites also are important breeding, wintering and migration sites for wading birds, shorebirds and raptors.

Many refuges have been indirectly involved with nongame management, and more are taking a much broader landscape and ecosystem approach to management. Refuges are starting to focus management efforts toward restoring degraded, declining or rare ecological communities and ecosystems. This new direction in land management helps to enhance or reestablish historical composition, distribution and abundance of native wildlife species, including Neotropical migrants.

At the Bosque Del Apache NWR in New Mexico, intensive manipulation of wetlands and moist soil units provides important habitats for wintering waterfowl, cranes, wading birds and shorebirds. There is nothing atypical here from a perception of traditional refuge management programs; however, the refuge also is aggressively restoring native riparian communities along the adjacent Rio Grande. A variety of techniques are used to eradicate exotic species such as salt cedar and Russian olive along the riparian areas and replant these sites with native willow and cottonwood species. Such efforts result in direct benefits to Neotropical migratory birds that use the river as breeding habitat and as a migratory corridor. The refuge also protects substantial areas of upland habitats as designated wilderness; another benefit to Neotropical migrants as well as resident nongame species.

Refuge managers and their biological staff are becoming better trained at developing and implementing management programs to enhance, restore and maintain biological diversity, including nongame habitat. Over 50 refuge managers and biologists attended the Status and Management of Neotropical Migratory Birds National Training Workshop held at Estes Park, Colorado in September 1992. Refuge managers and their biologists are receiving training and exposure to topics such as conservation biology, restoration ecology and nongame management techniques at regional refuge biological workshops. The annual Basic Refuge Training Academy now has sessions devoted to endangered species, biological diversity and nongame management. Many refuge managers and biologists are active participants in national, regional and state Partners in Flight programs. These examples illustrate a growing interest and commitment by refuge managers to develop new programs and actions, and to enhance existing programs for nongame migratory birds. Examples of refuges conducting various activities specifically for Neotropical migratory birds and other nongame species follow.

Inventory and Survey

A key to successful protection and management of refuge lands is to "know what you have before you do something with what you've got," i.e., a basic ecological inventory. Newly established refuges are initiating programs to inventory and survey ecological resources within their respective boundaries. Older refuges are evaluating their existing programs and modifying management to consider ecosystem management. Over 200 refuges participate in nongame bird surveys such as the annual Christmas Bird Counts and Breeding Bird Surveys. Several refuges also are assisting in collecting data for state breeding bird atlases. Other refuges are beginning to initiate individual efforts to determine distribution and abundance of nongame wildlife, especially Neotropical migratory birds.

For example, at the Bon Secour NWR in Alabama, the University of Southern Mississippi is conducting surveys to determine the importance of coastal habitats to Neotropical migratory birds during their trans-Gulf migration. Refuge staff at the San Andres NWR in New Mexico are establishing an inventory and survey program to determine desert riparian species of Neotropical migrants breeding on the refuge. Biologists at the Laguna Atascosa NWR in southern Texas conduct mist-netting operations during the migration seasons to document spring migration of Neotropical migrants. Ottawa NWR staff are conducting surveys to document passerine and raptor migration on and off the refuge. Located in Ohio along the southwestern shore of Lake Erie, Ottawa serves as a strategic migration staging site for Neotropical migrants.

Staff at other refuges such as Squaw Creek in Missouri, Rice Lake in Minnesota, Seney in Michigan, Bill Williams in Arizona, Balcones Canyonlands in Texas, Malheur in Oregon and the National Bison Range in Montana conduct surveys to document Neotropical migrants and other nongame bird use on their respective refuge. Basic ecological baseline data such as these help refuge staff make better-informed management decisions, which, in turn, yield the maximum benefit to a much wider array of wildlife and other ecological resources.

Habitat Management

In the past, because of emphasis on wetlands and waterfowl management, the ''back forty'' or upland areas of some refuges often received little attention (Clark 1992). In some respects, this lack of attention probably was advantageous to those species requiring protection from disturbance. However, some of these sites may have been severely altered or damaged due to activities prior to refuge acquisition. Restoration or basic land-management techniques may be required to reestablish native ecological communities on these sites. Even though the science of restoration ecology is rather new, refuges are attempting to use such technology, along with successful traditional wildlife management approaches, to restore these sites.

Texas coastal refuges are protecting and restoring important migration staging habitats for trans- and circum-Gulf Neotropical migrants. Along the upper Texas Coast, refuges such as Anahauc, Texas Point and McFaddin are protecting and restoring coastal woodlots that serve as critical resting and feeding sites for Neotropical migrants during spring and autumn migration. Coastal woodlots may be used for a few days or even a few hours; during mild springs, these sites may not be used at all. But in inclement weather, these scattered woodland tracts may become the last safe haven for millions of migrating songbirds. Without the extensive forestlands that once occurred north of the coastal prairie, these woodlots now are recognized as important migration habitats for Neotropical migrants.

Critical to the protection of coastal woodlots is to maintain a vertical diversity within each habitat type on each tract. Protection from grazing and other land uses can quickly restore these woodlots. Vertical diversity may be restored by fencing the site to prevent grazing. Another successful restoration technique is planting native shrubs and trees in tracts that have been damaged or altered.

Refuges can help evaluate the effectiveness of various land-management techniques to maintain or restore nongame bird habitat. At the Great Dismal Swamp NWR in Virginia, researchers from the Smithsonian Institution are studying various management actions to enhance and restore breeding habitat for the Swainson's warbler and other Neotropical migrants. The research project is looking into approaches to replicate optimum breeding habitat for the warbler, which requires large tracts of floodplain woodlands with frequent openings filled with dense undergrowth. At the Tensas NWR in Louisiana, refuge staff are studying the use of artificial nest boxes by prothonotary warblers and other cavity-nesting Neotropical migrants in seasonally flooded woodlands, which formerly were cleared for agriculture.

At the Matagorda Island Unit of the Aransas NWR, refuge staff are studying the effects of various prescribed burns on migration habitats for nongame birds. They are comparing summer prescribed burns and the traditional winter and early spring burns, which are used to enhance habitat for selected game species. Preliminary results show that summer burns, which emulate natural wildfire occurrences, are used immediately by a variety of early migrating shorebird species, such as black-bellied plovers, upland sandpipers and buff-breasted sandpipers. The immediate use of these sites may indicate a strategic management value for summer burns.

Even with primary management directed at wintering waterfowl or endangered species, Texas coastal refuges still can integrate protective and management actions for nongame species. At the Laguna Atascosa NWR located along the southern Texas coast, efforts to restore native brushland communities for the endangered ocelot also enhance breeding and migration habitats for Neotropical migratory birds. This unique ecological community is rapidly disappearing due to agricultural practices and an expanding human population. Less than 5 percent of the native brush remains in southern Texas. Laguna's program to restore native brushland not only benefits the cats and birds, but restores the integrity of a truly rare and exceptional ecosystem.

Each of these examples shows that protecting biological diversity is not just a hands-off approach to land management. Restoring degraded, altered and damaged ecological communities requires, at times, use of restoration techniques and even traditional management approaches. Because many older refuges now are surrounded by residential, commercial and/or agricultural development, some type of land-management activity may be the only avenue to successfully protect and maintain wildlife habitat. A refuge's size, location and outside influences, as well as its goals and objectives, help determine the most appropriate techniques to use (Mazzoni and Clark 1992). Imperative to successful use of land-management tools and techniques is the manager's knowledge of how such efforts will affect the spectrum of ecological resources on the refuge.

Interpretation/Environmental Education

National wildlife refuges offer outstanding opportunities for public outreach and environmental education. From auto tour routes, nature trails and boardwalks, interpretive displays and programs, and environmental education programs for school groups, the System traditionally has offered the public a place to enjoy watching wildlife. With society's rapidly changing attitudes toward wildlife and increasing interest in wildlife observation, refuges will play a greater role in interpreting the importance of protecting biological diversity. As more individuals join the ranks of the birding community, refuges increasingly will be targeted as places to get one more bird on the birder's lifelist.

Refuges are expanding their interpretive, environmental education and public outreach programs to increase the public's awareness about the importance of biological diversity, ecosystem management and nongame wildlife. For example, the Minnesota Valley NWR offers a unique birding experience for visitors. The refuge has developed a songbird trail adjacent to the visitor center. Refuge visitors can sign out a fanny pack containing a pair of binoculars, a bird field guide, and a cassette tape with a narrated tape program. The taped program is keyed to numbered stops along the trail. At each stop the narrator indicates the birds most likely to be seen in the area, including a recording of their songs and a description of their habitat requirements.

In a similar approach, staff at the Buenos Aires NWR in Arizona are developing an interpretive birding trail along one of its more popular riparian hiking trails. At the Anahuac NWR in Texas, Watchable Wildlife funds are being used to develop a boardwalk, complete with interpretive signs, for a coastal woodlot site that is popular with birders. As part of a cooperative effort, staff at the Aransas NWR in Texas are working with a local community to develop an interpretive boardwalk through a tidal marsh located along the outskirts of the community.

Research

Refuges offer excellent opportunities to study the life histories and ecology of nongame wildlife. Research results often can help evaluate existing refuge management programs relative to their effectiveness in protecting nongame wildlife. The same research results may help refuge managers develop new and innovative management approaches to benefit a much wider array of wildlife and ecological resources.

At the Minnesota Valley NWR, researchers are quantifying habitat structure of refuge floodplain forest communities, determining use of these forest communities by forest-nesting birds, and assessing the effects of land uses adjacent to the refuge on floodplain forest bird communities. Researchers from Iowa State University are conducting a study along the Upper Mississippi Fish and Wildlife Refuge to determine diversity and reproductive success of forest-breeding birds in relation to the closed-canopy floodplain forest community. With such knowledge, refuges can make better informed management decisions to ensure these communities are protected and managed for the maximum benefit to all wildlife resources.

Some refuges are directing research efforts at an ecosystem scale, attempting to assess the composition, distribution and abundance of all ecological resources within their respective boundaries. At the Fort Niobrara and Valentine NWRs in Nebraska staff from the U. S. Fish and Wildlife Service's National Ecology Research Center are conducting a biological diversity survey to determine historical and present-day composition, distribution and abundance of all vertebrates, including Neotropical migrants. Results of the study will compare how well the current fauna of the refuge represents the native vertebrate assemblage that was present in the area circa 1850; identify changes in vegetative associations, management actions or other regional phenomena that may have caused extirpation or invasion of species; and suggest actions to restore or enhance native fauna.

In 1988, an agreement was developed among the National Science Foundation, the University of New Mexico, and the U. S. Fish and Wildlife Service to designate the 228,770-acre Sevilleta NWR as a long-term ecological site. Over 250 scientists now conduct a variety of ecological studies at the refuge, including documenting the distribution and abundance of nongame migratory birds.

Individual Neotropical migratory bird species also are subjects of research on various refuges: the Mark Twain NWR in Illinois is studying the habitat requirements for the red-shouldered hawk; at Squaw Creek NWR in Missouri, researchers are surveying populations and habitats of the loggerhead shrike; at Tamarac NWR in Minnesota, the refuge is conducting golden-winged warbler population and habitat surveys; and at the Trempealeau NWR in Wisconsin, researchers are conducting surveys to determine the status of nesting Bell's vireos. Data collected from these studies will help the refuges determine the best techniques for restoring and managing habitat of these species.

Role of the System in Neotropical Migratory Bird Protection and Management

One practical avenue to ensure that Neotropical migratory birds and their habitats are protected is to take an ecosystem approach in wildlife and other land-management programs. Though the refuge system's goals already address protection and management of nongame species, refuges are taking a more active and aggressive approach to ecosystem management. Integrating protection and management of nongame migratory birds into existing programs will place greater emphasis on all ecological resources. In essence, this renewed or increased effort to focus on protecting and conserving biological diversity strengthens and supports refuges' responsibilities to protect and conserve migratory birds and to provide a natural diversity of flora and fauna.

Refuges have played an important role in not only protecting and managing Neotropical migratory birds, but also by taking a proactive role in conserving biological diversity. The refuge system can best conserve Neotropical migratory birds by (1) protecting and managing their habitats on refuges; (2) serving as demonstration sites on how other agencies and private landowners can effectively manage their own properties to benefit these species; and (3) developing and conducting interpretation, environmental education and public outreach programs that inform the public about the values of protecting these birds and the importance of conserving biological diversity.

Successfully developing new programs and integrating such approaches into existing programs will be no easy task. Staffing, funding and outside influences will determine the level of effort each refuge can apply. Essential to incorporating strategies to conserve nongame wildlife and, more specifically, biological diversity are several guidelines suggested by Noss (1992) that a refuge manager or any land manager should consider.

- The manager must consider all levels of biological diversity—genetic, species, community and ecosystem. The manager must think beyond the refuge boundaries and consider how the refuge program can contribute to biodiversity goals at a regional, national and global scale.
- The manager must know what ecological resources occur on the refuge. Simply put, a baseline ecological inventory is essential before developing and implementing land-management action.
- The manager must minimize habitat fragmentation, protect sensitive and rare communities, and restore degraded habitats. Managers must understand the importance of protecting large areas of intact habitat. Similarly, the manager must ensure barriers to movement within and across large tracts are eliminated. Many larger tracts and sensitive areas are best left alone, allowing natural processes to occur unabated. This probably will be the most difficult task for a land manager to undertake, because most have been trained to do something to make the land more "productive." When land-management techniques must be used, the manager should try to use those techniques emulating a historical natural disturbance process.
- The manager must establish a monitoring program to assess the refuge's effectiveness in protecting biological diversity. By evaluating alternative management approaches, the manager can determine which one will best meet the goal for protecting biological diversity.

The public's growing concern for protecting natural systems and its increasing interest in nonconsumptive wildlife-oriented activities present a challenge to public land agencies to improve efforts to conserve biological diversity. The National Wildlife Refuge System is no exception. Refuges have played and will continue to play an important role in conserving Neotropical migratory birds and other nongame species and in protecting our natural heritage.

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Integrating Neotropical Migratory Birds into Forest Service Plans for Ecosystem Management

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The USDA Forest Service is undergoing a major change in focus in response to public interests, growing concern for sustaining natural resources, and new knowledge about wildlife, fisheries, forests and grasslands, and how they interact at the ecosystem level. This shift in direction affects how Forest Service lands are managed, what research is conducted, how resource values are prioritized and how Forest Service employees are trained to meet future management needs. In meeting public concerns over time, Forest Service stewardship has evolved from an emphasis on (1) regulation of uses (avoidance of unfavorable activities) to (2) sustained yield management (managing for a few desired products) to (3) sustainable ecosystem management (focusing on the integrity of the ecosystem, which supplies many goods and services) (Salwasser 1990). ''New Perspectives'' was a Service-wide initiative designed to develop a new ecological and philosophical approach to effectively sustain public lands, biological diversity, landscape integrity and intact ecosystems. In June 1992, New Perspectives culminated in the Chief's decision to create a Forest Service staff group to implement ''Ecosystem Management'' (Overbay 1992). Ecosystem Management, as observed by the Forest Service, is the use of an ecological approach to manage multiple uses of national forests and grasslands, achieved by blending the needs of people and environmental values in such a way that national forests and grasslands represent diverse, resilient, productive and sustainable ecosystems. Goals for Ecosystem Management include: restoring and sustaining the integrity of the land, soils, air, waters, biological diversity and ecological processes; within the sustainable capacity of the land, meeting the resource needs of people and improving the well-being of communities, regions and the nation through environmentally sensitive production, use and conservation of natural resources; seeking balance and harmony between people and the land with equity between interests, across regions and through generations; meeting this generation's resource needs while maintaining opportunities for future generations to also meet their needs; improving the effectiveness of public participation in land and resource decision making; expanding conservation partnerships between Forest Service managers, other organizations and the publics; and strengthening interdisciplinary teamwork between managers and scientists.

During the same time period that its vision and directive for Ecosystem Management emerged, the Forest Service also played a lead role in helping to establish the framework for inter-organizational cooperation in ''Partners in Flight,'' a program to conserve Neotropical migratory birds. Not only has the Forest Service been a Partners in Flight cooperator and contributor since the program's inception at the first national meeting in Atlanta, Georgia, in December 1990 (Finch 1991), it also invested heavily in the organization of the ground-breaking conference, Status and Management of Neotropical Migratory Birds, in Estes Park, Colorado (Finch and Stangel 1993). Attended by over 700 people, this third national meeting of Partners in Flight was designed specifically to bring natural resource managers and scientists together to communicate, synthesize and produce information on Neotropical migratory birds.

To maintain Forest Service momentum in Partners in Flight, we recommend that priorities for Neotropical migratory birds be incorporated into the broader goals and projects of Ecosystem Management. The fit between Ecosystem Management and Partners in Flight is natural because common goals are shared. Both programs emphasize:

- ecology-based, nontraditional management of natural resources;
- partnerships with private and public organizations;
- reliance on research information and teamwork to form management decisions;
- a shift from single interests (e.g., tumber, single species) to a synthesized approach for addressing multiple, diverse needs;
- the need to monitor success of projects and to determine trends in ecosystems and organisms over time and space;
- sustaining natural resources, natural processes and landscape-level interactions; and
- proactive, rather than reactive, management of resources.

Neotropical migratory birds form a complex group of species, ranging across taxonomic, geographical and temporal boundaries, and using the full variety of early and late successional habitats available throughout the Western Hemisphere. What approaches are needed for the Forest Service to manage habitats for such a complex array of species? A holistic view of the natural world must be adopted, with a recognition of complexity, interconnections and dynamics over time and space, and the understanding that collaborative efforts are needed among all those whose activities affect ecosystems. To effectively conserve populations of Neotropical migratory birds breeding on natural forests and grasslands effectively, their needs must be incorporated into Forest Service plans for the management of ecosystems. Teamwork between researchers and managers is needed to develop and apply knowledge for managing multiple species within an interdisciplinary framework of action.

Setting Priorities

Ecosystem Management emphasizes processes rather than endpoints, and as such, should prove to be an effective vehicle for achieving the conservation of Neotropical migratory birds. Interdisciplinary teams in each Forest Service Region are in the process of defining methods and plans for ecosystem management. Within these plans, Neotropical migratory birds can be actively rather than passively accomodated if priorities for their conservation are defined. For ecosystems to be sustained, their weakest links must be identified because these will be the first to break under pressure. Likewise, to sustain the full array of Neotropical migratory bird species, we must have knowledge of which species are most vulnerable to changes in land management. To sustain a dynamic equilibrium of multiple bird species and their habitats, we recommend the following scoping approach:

1. Identify those species that currently need most attention, i.e., those sensitive to

current management practices or rare with declining populations, or already listed as threatened or endangered.

2. Identify those sets of species favored by current patterns of habitats and land use.
3. Identify those species on the second list that are likely to decline if management is changed to favor those on the first list.
4. Define which species are most vulnerable off of List 1 (those species that already are of concern) and List 3 (those that will become a concern if management is altered to favor species on List 1), and then determine the future conditions necessary to sustain both sets of populations.
5. Finally, integrate management of these desired conditions with other resource values. Management should be for a dynamic landscape, adjusting to new knowledge and allowing for critical habitats, old-growth forests, and a full and natural variety of successional habitats.

To prioritize species at the level of ecosystem or higher, their global, national and regional rankings must be taken into account. We recommend that the Partners in Flight prioritization scheme developed by Hunter et al. (1993) be used to select high priority species on national forests and grasslands. Species of concern already have been identified under this scheme for western, midwestern, northeastern and southeastern regions of the United States (*see* Finch and Stangel 1993).

Monitoring Populations Within the Ecosystem Context

An integral part of the Ecosystem Management process is the monitoring of ecosystem diversity, integrity and productivity. An important concept in Ecosystem Management is "adaptive management," the flexibility to adjust management practices in response to new information, e.g., findings from monitoring data. To monitor the ecosystem as a whole, one must monitor its parts and processes, including Neotropical migratory birds. We recommend monitoring populations of Neotropical migratory birds using the methods defined by the Partners in Flight Monitoring Working Group (Butcher 1992), with the goal of achieving dynamic future landscapes that will support Neotropical migratory birds in association with other resource values. To effectively monitor and sustain neotropical migrants in complex ecosystems effectively, it is essential to recognize the multiple scales by which they live. Migratory birds are adapted to daily, seasonal, long-term and evolutionary cycles. The long-term scale encompasses successional changes in habitat and is therefore the appropriate scale for monitoring population responses to land-management patterns. This also is the appropriate scale for monitoring other ecosystem components. Population monitoring during different seasons is important because migratory birds use different habitats during breeding, migration and winter.

To monitor migrants in space, one must recognize that they are adapted to multiple spatial scales: (1) site characteristics (e.g., habitat structure, age classes, nest sites, microhabitats and stand characteristics); (2) watershed or landscape characteristics (e.g., patterns of stand isolation and distance that affect individual habitat use and population patterns and dynamics); and (3) regional, continental and hemispheric characteristics (e.g., migration distances, and kinds and configurations of stopover habitats). Monitoring birds at the landscape level requires intensive sampling at numerous sites across the landscape in coordination with habitat monitoring. While fine-scaled approaches to understanding bird populations still are needed, we recommend that more coarse-filtered mapping and monitoring (e.g., gap analysis) be adopted to assess how Neotropical migrants contribute to regional, national and global biological diversity.

Recommended Steps for Integration

We suggest that the following steps be taken to integrate the conservation of Neotropical migratory birds into Ecosystem Management projects.

1. Identify research needs and transfer research information on Neotropical migratory birds to managers early in the ecosystem management planning process.
2. Include on Ecosystem Management teams a member(s) lnowledgeable about the requirements of Neotropical migratory birds.
3. Identify priorities and monitoring goals for Neotropical migratory birds in Ecosystem Management plans.
4. Have Ecosystem Management plans reviewed by technical experts on Neotropical migratory birds.
5. Define ways to collaborate with Partners in Flight cooperators within the Ecosystem Management strategy.
6. Specify roles of Neotropical migratory birds in Ecosystem Management demonstration projects.

We view demonstration projects as excellent vehicles for stimulating interest in how Neotropical migratory birds can be managed at the ecosystem level and how the principles of adaptive management can be implemented. To illustrate the advantages of establishing demonstration projects, we highlight the Red Rock Canyon Riparian Project on the Coronado National Forest in southeastern Arizona. The Redrock Canyon Watershed includes approximately 17,400 acres along 11 miles, draining into Sonoita Creek near the community of Patagonia, Arizona. The watershed previously was identified as being in less than satisfactory situation when measured against the desired condition for riparian, rangeland and water resources common to similar areas. The Redrock Canyon demonstration project represents a series of goals designed to ultimately will improve the species and age-class diversity of riparian vegetation, an overall indicator of the condition of the entire watershed. This, in turn, will ensure suitable habitat for Neotropical migratory birds and suitable fisheries habitat for the endangered Gila topminnow, improve soil and water resources for the benefit of other desired plant and animal species, retain options for semi-primitive recreation opportunities, and ensure sustainability of suitable herbaceous plants used by livestock.

Of the approximately 180 species of birds that use the canyon, over 70 are neotropical migrants. These include gray hawk (*Buteo nitidus*), zone-tailed hawk (*Buteo albonotatus*), black vulture (*coragyps atratus*), vermilion flycatcher (*Pyrocephalus rubinus*), varied bunting (*Passerina versicolor*), hepatic and western tanagers (*Piranga flava* and *Piranga ludoviciana*, respectively), Cassin's kingbird (*Tyrannus vociferans*), magnificent hummingbird (*Eugenes fulgens*), hooded and Scott's orioles (*Icterus cucullatus* and *Icterus parisorum*, respectively), elf owl (*Micrathene whitneyi*), and yellow-billed cuckoo (*Coccyzus americanus*). Redrock Canyon is less than five miles from the heavily visited Patagonia-Sonoita Preserve managed by The Nature Conservancy. Currently, Redrock Canyon receives less than 50 birdwatchers/per year, but visitation is predicted to increase as habitat conditions improve and word spreads about the project.

This project applies the principles of Ecosystem Management on national forests by stressing:

- *Stewardship.* It endeavors to sustain land health and diversity while providing goods and services. Twenty-five improvement activities were identified during the planning process, including better distribution control of livestock through additional fences and water developments, exclusion of livestock from portions of streams, plantings of trees to speed up recovery, closing of portions of roads, and steps to stabilize channels.
- *Partnerships.* It involves people in resource management decisions. Public concerns were evaluated early in the planning process, and partnerships were established with forest users and interested organizations, such as livestock grazing permittees, the community of Patagonia, and the Arizona Game and Fish Department.
- *Integrated management.* It takes a creative and flexible approach to multiple-use management. This project is innovative in that it charges both the public and agency personnel to evaluate the conditions and needs of an entire ecosystem rather than address individual problems and solutions. The traditional approach would have been to address needs for each range allotment individually, in a process separate from planning for wildlife and recreation resources.
- *Research teamwork.* It involves collaboration with researchers, educators and other natural resource managers. The U. S. Fish and Wildlife Service and the Arizona Game and Fish Department were involved directly in the needs analysis and development of specific proposals. The Nature Conservancy and the University of Arizona Cooperative Extension Service contributed information about the distribution and management of sensitive plant and animal species.

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Integrating the Neotropical Migratory Bird Conservation Program with Traditional Wildlife Management: A State Perspective

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The Neotropical Migratory Bird Conservation Program, also referred to as ''Partners in Flight'' is a relative newcomer on the wildlife conservation scene. It arose out of a need to address the apparent declines in many migratory land bird species, particularly those that winter primarily in the tropics and breed primarily in temperate North America. This need was prompted by the interpretation of long-term data such as the U.S. Fish and Wildlife Service's Breeding Bird Survey, in addition to recent literary catalysts, not the least of which was John Terborgh's *Where Have All the Birds Gone*?.

The Program itself was spawned at a week-long workshop in Atlanta during late 1990, attended by hundreds, and culminated in a Neotropical Migratory Bird Conservation Plan to be co-coordinated by the USDA Forest Service and the U. S. Fish and Wildlife Service. However, even with the federal oversight involved, it always has been understood that, in most states, this program would live or die based on the extent to which it is embraced by state agencies. In the East particularly, the majority of all land is privately owned, with most state wildlife agencies in the best position to foster a rapport with landowners.

Efforts then to implement the Partners in Flight program at the state or regional level typically will be carried out, coordinated or contracted out by the state wildlife resources agency. These agencies serve as a conduit for federal funds, as well as being the recipients of legislative appropriations and even private donations, all of which might be targeted for the Partners in Flight effort. So the degree to which this program is implemented is, to a certain extent, contingent on the wildlife agency's funding base, which in turn largely dictates the expertise of the agency's staff. As a result, wildlife agencies receiving little or no general funding often prioritize their resources toward the management of game animal populations, and fill staff positions with personnel trained to meet the wildlife management needs of the hunting and fishing public. This must be viewed, however, in terms of the origins of state wildlife agencies and their current paying constituency.

To appreciate what will be involved with integrating the Partners in Flight program into traditional wildlife management first requires an understanding of what the differences are. Traditional wildlife management is essentially synonymous with game management and takes its direction from the desire to sustain harvestable populations of game species for the recreational sportsman. Recreational hunting was typically a sport of gentlemen in the late 1800s, and one that depended on the availability of land and an abundance of game. It was largely due to the influence of the hunting public at that time that problems of unregulated harvests and dwindling game populations were brought to the public's attention. The spread of civilization across the landscape had taken with it much of the native wildlife population and habitat. Recognizing the state's responsibility for wildlife, the sportsmen from that era were instrumental in bringing to light the need for state game commissions.

By the early 1900s, most states had these agencies in place and were well underway toward regulating hunting and delving into game management. Unfortunately, game management at that time was predicated on the removal of predators from the natural system thereby ensuring an ample supply of game animals for the hunter. It wasn't until after work by men like Stoddard, Errington, Leopold, and Murie, mostly directed at the role of predation in wildlife populations, that ecology began to creep into game management. With this new foundation of science, game management developed into an academic discipline in the 1930s (Dunlap 1988).

Probably one of the most influential tools in shaping the protocol for game management since the 1930s was the Pittman-Robertson (PR) Act. During another frustrating era for game management in the 1920s poor economic times gave way to rampant habitat destruction and indiscriminate poaching of many game species. Once again, the sportsmen of that day, in conjunction with early naturalists and wildlife managers, were instrumental in helping to influence Congress to pass the Federal Aid in Wildlife Restoration (Pittman-Robertson) Act. Funded by manufacturers' excise tax on sporting firearms, ammunition and archery equipment, monies are apportioned to state wildlife agencies for wildlife restoration projects (Kallman 1987).

At the time that PR funds first became available, white-tailed deer and wild turkey were among the species most in need of attention. However, even though those species are doing quite well in most regions, there is still an allegiance among many state agencies to serve the needs of the PR-paying constituency first. Among state agencies that receive little or no general funding, there is increased loyalty to the hunting public by virtue of the agency's dependency on the sale of hunting and fishing licenses for its income. So the bias of many state agencies is toward the management of a small subset of native species over the majority of native species in an effort to serve the needs of their paying public. As for the management strategies that are used, they remain relatively unchanged over the years. The emphasis is on habitat manipulation to sustain food and cover, and on population censusing and monitoring to ascertain productivity and subsequent response to harvest pressures.

Now, disregarding the comment on harvest pressures, one is left with a potential recipe for Neotropical migratory bird management. So the ability to integrate the Partners in Flight program with traditional wildlife management need not require radical new management techniques, just a broader understanding of the implications of current techniques. It is not just an issue of considering additional species when making management decisions, although it should be that simple. Rather, it is a need to mesh entirely different philosophies of wildlife management, one driven by the need to sustain a harvestable resource, the other by the desire to preserve the natural diversity of the land.

The endpoints are not at all mutually exclusive, but the paths to them often are quite divergent. In the 1890s, the millinery trade rallied the support of hunters and nature lovers alike to help bring about two of the earliest and most effective wildlife conservation laws—the Lacey Act of 1900 and the Migratory Bird Treaty Act of 1918. In this case, the nature lovers were appalled at the act of killing herons and egrets for a few hat feathers, and recreational hunters were in opposition on the grounds that killing these colonial birds offered no sport and therefore should not be tolerated (Dunlap 1988). The issue here was one where all parties shared ownership, despite the differences in their reasoning.

It is only through a sense of shared ownership that the Neotropical Migratory Bird Conservation Program will be well-received and implemented by state wildlife agencies.

By virtue of their long histories with game management, many wildlife managers react to the Partners in Flight program with apprehension and tend to categorize it as the trappings of another environmental special interest group. Perhaps the biggest handicap to the integration of the program has been the lack of precise cookbook-style recommendations for the management of neotropical migrants. Available information has been perceived to be either not applicable across various regions, or conflicting, by virtue of addressing the needs of a number of different species. In many cases it is the sheer volume of species that needs to be addressed that overwhelms many wildlife managers. To counter these concerns, it will be imperative that biologists and managers first exploit the areas of common ground.

At the most basic level, all wildlife species require habitat. So the concerns of a burgeoning human population and its concomitant aftereffects of habitat loss and degradation are relevant to all species. In the case of Neotropical migrants, many of these species are forest dwelling and therefore experience the effects of forest manipulation just as game species do. At the finer scale, simple wildlife management principles can be clouded merely by semantics. Many wildlife managers would not consider promoting understory for songbirds, yet much of their job may involve generating browse for deer—two different objectives with the same end point. Conversely, overbrowsing of understory by deer may signal a deer population problem, while at the same time negatively impacting ground or shrub nesting songbirds. So an increased deer harvest may be sound management advice for deer and songbirds alike. There are many consistencies like this involving game and nongame species management. Unfortunately, it is the inconsistencies that tend to get top billing. The answer is not to give up, but to foster a program of increased awareness and understanding of the relationships between all species and their environments.

One extremely valuable tool that the machinery of the Partners in Flight has manufactured is the species prioritization scheme widely in use in the Southeast. This mechanism for ranking species and their habitats may be the single most influential tool for bestowing ownership in the system across land managers and biologists alike. Everyone has a stake in its development and the system is designed to be implemented at any geographic level, allowing the land manager to both learn from and contribute to the future conservation of neotropical migrants. Given the nature of this system as a dynamic process, there is considerable interest in enlarging the scope of the prioritization scheme to incorporate all bird species, including gamebirds. Although effective as it is now, a comprehensive overview of all birds may be what is necessary to make traditional wildlife managers feel comfortable with implementing a truly holistic management philosophy.

There are other tools as well that have come on line in recent years that are available to assist today's land manager in his efforts to add breadth to his expertise. The USDA Forest Service's Forest Stewardship Program offers private landowners subsidies to manage their forests for natural resource or compatible recreational benefits according to a prescribed stewardship plan. Where wildlife conservation is chosen as the primary management directive, state wildlife biologists are asked to offer assistance in preparing the plan. Where once game animals may have been the only species of landowner interest, now songbirds and wildlife in general tend to come forward as leading interests of many forest owners. This puts today's wildlife managers in the position of having to be better versed in the techniques of full-service wildlife management. It also puts a premium on those biologists who already are skilled enough to assist state and local foresters with a better understanding of the implications of various timber management techniques on all wildlife species.

In conclusion, the Neotropical Migratory Bird Conservation Program is one of the most comprehensive wildlife conservation programs ever to take shape in the western hemisphere. Yet for it to be implemented successfully in the field, it must first find its niche alongside traditional wildlife management philosophy. Integrating the Partners in Flight program into this situation will require a broad-based program of education and support building. The Southeast's species and habitat prioritization scheme offers an educational mechanism for land managers to share ownership in a broad-based wildlife conservation ethic. The Forest Stewardship Program highlights a need for management innovations, and offers a solid foundation for support building with private landowners and sister agencies, all directed at a new management philosophy.

Tools and programs aside, the successful meshing of the Neotropical bird program with traditional management will rest first with the values of the individual land managers and biologists, and will be perpetuated only through the willingness of state wildlife agencies to embrace the need for a new wildlife ethic. Although nongame dedicated funds typically comprise less than 5 percent of most state's wildlife agency budgets (Mackintosh 1989), this ratio cannot be perpetuated in the actions of their personnel. The need for accurate information and a "total wildlife" perspective among wildlife managers has never been greater than with the initiation of the Partners in Flight program. An understanding of the intrinsic value of all species and of the interdependence of those species is paramount to any responsible land-management decision of the future.

Aldo Leopold probably provides the best example of the evolution of thought that must take place for managers to appreciate the need for a new wildlife perspective. As a Forest Service ranger in New Mexico in the early 1900s, Leopold advocated killing all mountain lions and shooting wolves whenever he could find them. Upon discovering a roadrunner with a quail chick in its mouth, Leopold "blacklisted" that species, daring others to prove that it might still be a desirable species (Dunlap 1988). However, as Leopold matured, he gained a better appreciation of game species as more than just a crop, and apparently thought of all species as parts of a larger natural system worthy of protection. This evolution of attitude was probably best witnessed in some of his final writings in *A Sand County Almanac* in which he penned, "A thing is right when it tends to preserve the integrity, the stability, and the beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1949). These were comments from the father of game management.

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Partners in Flight: The Challenge of Cooperation

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Introduction

The threat to Neotropical migratory birds is representative of challenges faced by the conservation community on the verge of the 21st century. When natural habitats were initially degraded, the primary threats were to individual species and local habitats. Remedies were often very specific, like nest box programs (e.g., eastern bluebird, wood duck) or small habitat purchases (e.g., for locally rare plants). As degradation has continued, however, entire ecosystems (e.g., Florida everglades) and suites of species (e.g., Neotropical migratory birds) have been imperiled. Ecosystems and suites of species necessitate a more holistic approach than specialized remedies. For example, Neotropical migratory birds require quality habitats throughout their life cycle, which, for these species, means on an international scale.

The magnitude of current conservation programs demands cooperation and coordination from conservationists at an unprecedented level. For a Neotropical migrant that spends the nonbreeding season in Guatemala, migrates through Mexico and across the United States into Canada to breed, conservation at any single geographic point is not enough. In fact, conservation at all but one or a few critical points, like migration bottlenecks, may lessen long-term viability of populations of Neotropical migrants. The sheer geographic area required by any one species of Neotropical migrant means that no single organization or even country can be an effective conservation agent if acting independently. Conservation on this scale means that people, the stewards of natural resources, must work together in a constructive manner. Notwithstanding the critical need for more information about natural systems and their management, perhaps the most pressing question for conservation at the turn of the century is: "Can government agencies, state agencies, nongovernmental conservation organizations and others work together cooperatively and unselfishly to affect long-term conservation?"

The philosophical and psychological underpinnings of this question are intriguing and in a more general form have stimulated the best minds in history. With a limit of 10 pages of double-spaced text, however, it seems more practical in this paper to focus on a more manageable (slightly) question: "What mechanisms help promote cooperation among a diverse group of conservation organizations working toward the same general goal?"

The mechanism described here is that implemented in the *Partners in Flight—Aves de las Americas* Neotropical Migratory Bird Conservation Program. Launched in 1990 by the National Fish and Wildlife Foundation, *Partners in Flight* promotes proactive conservation of declining but still common species on an international scale and provides a framework for communication and coordination at previously unrealized levels (Stangel and Eno 1992). To provide this framework, the *Partners in Flight* program adopted a system of technical and regional Working Groups, much like that formed for the Interagency Grizzly Bear Committee.

Why Working Groups?

Working Groups were proposed (National Fish and Wildlife Foundation 1990) because they were a viable alternative to accomplish two major goals of *Partners in Flight*—improve coordination and communication among participating groups, and identify priority focal points and projects for conservation of Neotropical migrants and their habitats. Working Groups also offered a partial solution to the leadership question within *Partners in Flight*: decentralizing the decision-making process helped diffuse concerns about who was "in charge" of this multi-agency consortium.

Communication. The framers of *Partners in Flight* (National Fish and Wildlife Foundation 1990) recognized that although many organizations, agencies and individuals are engaged in effective conservation efforts for Neotropical migrants and their habitats, communication and coordination among these groups often is minimal or absent. Although mechanisms for interchange are available and used, for example annual meetings of scientific groups, these opportunities are too infrequent to promote the continual communication necessary to avoid program redundancy and stimulate productive partnerships. Communication and its many benefits could be better facilitated by regular meetings of those involved with the issues. Regular meetings also would nurture development of informal networks, stimulating communication and coordination. Working Groups comprised of resource professionals and activists representing a diversity of organizations fit this need.

Identifying priorities. Working Groups also afforded the opportunity to identify high-priority needs and projects for a multi-organization initiative like *Partners in Flight*. Although the list of factors contributing to the decline of Neotropical migrants is long (Terborgh 1989, Askins et al. 1990), limited financial resources necessitate addressing factors likely to have the greatest impact on conservation. Working Groups, whose membership includes experts in a variety of technical and management areas, provide a forum for the deliberations necessary to identify those factors. The very composition of the Working Groups also provides a way to "fast track" their recommendations. Members within the Working Groups are likely to bring ideas and objectives back to their organizations for discussion and implementation.

Decentralizing decision making. One challenge in organizing *Partners in Flight* was finding a way for each organization to feel "ownership" in the Program, while also maintaining the effort's cooperative nature. This is a delicate balancing act, and may well never be fully achieved. Working Groups come close, however. Meeting as peers, Working Group participants are more likely to concentrate on issues and show less interest in the posturing that is an inevitable feature of cooperative ventures of this scale. Because decisions are made by interactive groups, ownership is available to many and implementation of recommendations is likely to be cooperative because the entire group will benefit from the outcome.

Mechanics

The Working Group structure began to gel at a 1990 conference in Atlanta that launched *Partners in Flight* (Neotropical Migratory Bird Conservation Program 1990).

The 150 conference participants broke into working sessions to discuss monitoring, management, research, education, communication and outreach, and international cooperation. During these breakout sessions key issues were discussed and general focal points for conservation actions were identified. An informal mission statement, or charter, was written, and it was from these break-out sessions that the Working Groups evolved.

The earliest challenge to the Working Groups occurred almost simultaneously with their establishment. Suspicion developed over the respective role of federal agencies and nongovernmental conservation organizations (NGO) to assume leadership of the fledgling Working Groups. This concern was addressed by naming joint chairpersons representing agencies and NGOs. Over time, this tension has greatly diminished as participants began to interact and leaders rose from within Working Group ranks.

The simple logistics of attending Working Group meetings also posed a formidable barrier. NGO representatives were particularly restricted by travel costs, but employees of federal and state agencies also were affected. Proposed solutions included travel subsidies from federal agencies for NGO participants and grant proposals specifically to support travel. Although some travel by NGO and state agency participants has been arranged by federal agencies, this clearly was not a viable long-term solution. Left to their own devices, Working Groups largely overcame this problem by arranging meetings in conjunction with other events, forming subcommittees to focus on specific issues, and developing state, rather than national or regional, Working Groups to address local issues.

Subcommittees were effective because they were small in size and comprised of people with very similar interests. Members were more likely to have opportunities to meet in the course of other business, and because they were concentrating on specific issues, could conduct much business by phone.

Evolution of State Working Groups was a somewhat unexpected but very productive development. As they began to meet, the Regional Working Groups in particular increasingly focused on issues related to specific habitat types and physiographic regions. This more local focus, coupled with travel restrictions, led Colorado, Texas and other states to form their own Working Groups. State Working Groups often mirror the framework of the National and Regional Working Groups, with subcommittees for research, monitoring, and information and education. The tremendous advantage offered by State Working Groups is the convenience of attending meetings and the enthusiasm generated by addressing issues of great local interest. This is particularly important in the West, where large geographic distances make frequent travel difficult. Each of the 12 states in the Western Working Group now have State Working Groups. State Working Group meetings draw up to 100 participants and present unparalleled opportunities for communication and coordination. National and Regional Working Groups will continue to provide oversight and coordination on a large scale, but State Working Groups will maximize information transfer to local biologists, managers and the public.

Development

Working Group development was rapid following the Atlanta meeting. Working Group membership was open to anyone willing to contribute, and mailing lists for some groups quickly blossomed into the hundreds. Although many members were not contributing on a continual basis, communication was vastly improved. As is to be expected, much early effort was devoted to making the groups functional: establishing mailing lists and networks, developing a charter, and identifying goals and objectives. As these tasks were completed, the focus shifted to more programmatic conservation issues. The accomplishments of the Monitoring Working Group and the Southeast Working Group are illustrative of how conservation priorities and objectives were identified and met through the Working Group structure.

Monitoring. Monitoring issues were of great interest from the onset of *Partners in Flight.* Monitoring programs like the Breeding Bird Survey (Robbins et al. 1989) alerted scientists and the public to declines in Neotropical migrants, and monitoring was acknowledged to be an important component of any conservation effort. As attention shifted to declines in Neotropical migrants, monitoring programs came under careful scrutiny. Existing programs were challenged for statistical and design shortcomings, and geographic and taxonomic gaps in coverage were noted. A clear lack of standardization across organizations was evident.

Issues like these were broached by the Monitoring Group in a number of ways. The recently published *Needs Assessment: Monitoring Neotropical Migratory Birds* (1992), a product of the Monitoring Working Group, outlines theory and practice, existing bird and habitat monitoring programs in North America, agency specific programs, and international efforts. Priority species for monitoring also are listed. Input for this volume came from dozens of organizations and individuals. The workshop leading to this publication was hosted by the U. S. Fish and Wildlife Service, and publication costs were covered by the USDA Forest Service. This text now forms the basis for development of new monitoring programs, and has been complemented by other more specific manuals (e.g., Ralph et al. in press *a*, Ralph et al. in press *b*).

Consultation has become an integral role for the Monitoring Working Group. This is particularly true for the federal land management agencies as they refine existing programs and initiate new efforts. The USDA Forest Service (Manley et al. in press) and U. S. Fish and Wildlife Service both have worked extensively with representatives from the Monitoring Working Group to develop "customized" monitoring programs to meet particular agency needs. Consultation with the Monitoring Working Group brings considerable expertise to bear on the issue, and helps ensure that programs for different agencies will be compatible for later analysis.

The Monitoring Working Group also has been instrumental in advancing the need for data centers where results from various monitoring programs can be stored and analyzed. Research efforts are hindered because results from different monitoring programs often are stored in different areas geographically and are not easily accessed for analysis. Data centers also might provide expertise needed to help establish new monitoring programs for any interested organization or agency, with the advantage that these efforts would have the benefit of a standardized approach.

Southeastern Working Group. Regional Working Groups address Neotropical migratory bird and habitat conservation issues primarily from the management perspective, and have led the movement to have physiographic areas as the appropriate unit for conservation action. Physiographic areas are ecologically defined units that are of a logical geographic scale for informed and effective conservation planning. The Southeast Working Group has identified coordinators for each physiographic region in their domain who will organize research, monitoring and management efforts within physiographic areas, regardless of political boundaries. This is a very efficient, if non-traditional, system, in that it allows adjacent political entities to coordinate activities by habitat type. Bird conservation will vary greatly between, for example, the Blue Ridge and the Coastal

Plain within North Carolina, but should be much the same in the mountains of North Carolina and Tennessee. Conservation planning should be based upon ecosystem considerations, where conservation implementation often is best achieved within political boundaries. The focus on physiographic areas should facilitate this process.

The Southeast Working Group, in conjunction with the Western Working Group, also spearheaded the ''Species Prioritization'' scheme (Hunter et al. in press *a*, Hunter et al. in press *b*). Briefly, this scheme makes it possible to rank the vulnerability of species of Neotropical migrants by rating each for a variety of factors, ranging from population size to threats at different points during the life cycle. The objective of this exercise was to provide managers with a list of species most in need of attention. Priorities can be assigned at a number of geographic levels, from a management unit to the hemisphere. The Species Prioritization Scheme still is being refined, but has provided a biologically based platform from which management programs can most effectively be guided.

Identifying Priority Projects

Establishing effective communication networks and enhancing coordination among participants are two major accomplishments of the Working Group system. An even bigger contribution is development of priority projects to promote conservation of Neotropical migrants. After about a year, Working Groups were charged with identifying priority projects within their respective areas. These priorities still are being identified, and will be the catalyst for cooperative actions among participating organizations in *Partners in Flight.* Priorities range from the need for a workshop to stimulate grass-roots participation in conservation projects for migratory birds (Information and Education Working Group) to effects of bottomland hardwood regeneration on Neotropical migrants (Midwest Working Group). Priorities have been developed irrespective of interest groups' biases and represent input from a range of experts within the field of concern.

At a workshop slated for April of 1993 the Working Groups will present their recommendations to Steering Committees representing the federal agencies, state agencies and NGOs, who then will undertake the challenge of building partnerships to implement the Working Group recommendations. The lists of priorities are long, and many require long-term, high-finance commitments. Others can be accomplished in the near future with already available resources. Regardless, the ''table is set'' with a comprehensive list of actions from which conservation organizations can feed for many years to come.

Too Much Bureaucracy?

One criticism of *Partners in Flight* is that emphasis on Working Groups has resulted in an inordinate amount of bureaucracy. To an outsider, the national, regional and state working groups, many with several subcommittees, may seem like an impediment to on-the-ground implementation of conservation projects. To those involved with the Program, particularly those contributing to Working Groups, there seems to be a general feeling of progress and effectiveness. Some feel that progress has been slow, but considering the circumstances—strictly voluntary participation by people that already have full-time jobs, the need to incorporate the input of numerous and diverse organizations, financial limitations to travel—a remarkable amount has been contributed in just over two years.

There also seem to be few alternatives to the Working Group and committee structure. One organization ramrodding a program may produce quick results, but this strategy is unlikely to develop partnerships necessary to sustain commitment over the long term. Consensus, or at least participation, requires input from many voices. Many voices can slow progress; an often inevitable but not wholly undesirable result. *Partners in Flight* has been fortunate in that the vast majority of the Working Group positions have been filled by conservationists—biologists, resource managers, activists and others—committed to implementation and wary of committees for committees' sake.

Progress toward Program goals might have been accelerated if the structure, membership, charter and objectives of the Working Groups had been more rigidly defined at the onset. This also might have weakened the long-term viability of *Partners in Flight.* Each Working Group has unique challenges to confront, both in the conservation arena and from an organizational standpoint. Individual Working Groups may have taken a while to start functioning, and may have spent a lot of time on internal business like charters, but the sense of ownership within Working Groups is high. It is unlikely this result could be obtained simply by commissioning a group of organizational representatives to fulfill the mandate of an outside entity. Having labored over priority lists and the degree of internal organization necessary to reach the stage where priority lists are possible, Working Group members are heavily invested in their own recommendations. This investment will be carried back to the organizations Working Group participants represent, and can only increase the likelihood of implementation and partnerships. Given that *Partners in Flight* Working Groups will be guiding the Program for many years, the maturation process was worth the wait.

Conclusion

Conservation of Neotropical migratory birds and their habitats is an enormous task. In the absence of an omnipotent and very well-funded organization to single-handedly conserve Neotropical migrants, we are left with the challenge of building a coalition of organizations who cooperate to achieve a common goal. The progress within *Partners in Flight* to date suggests that a Working Group structure is an effective approach to this challenge.

Acknowledgments

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The Private Sector and Partners in Flight

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Introduction

The "private sector" encompasses a broad array of landowners and land users. It consists of housing and commercial land developers; private foundations and conservation organizations; oil, gas and mineral interests; homeowners; private recreational facilities and parks; and agricultural landowners. This last category itself includes a mixture of cattle and sheep ranchers, poultry growers, aquaculturists, row-crop farmers, forest landowners, etc. All of these groups have different resource needs and, along with those, different interactions with Neotropical migratory birds and their habitats.

Almost 80 percent of all land in the United States is owned by the "private sector." Families and individuals own about 66 percent, and non-family corporations and partnerships own another 13 percent of all land (Gustafson 1982). The average size of landholding is 40 acres (16 ha) with half of all land in parcels of less than 500 acres (202 ha) and only 20 percent in holdings of more than 5,000 acres (2,023 ha) (Gustafson 1982).

While forest land is not the only habitat type required by the more than 250 species of birds recognized as Neotropical migrants by Partners in Flight (PIF), it is a key community for many. The United States is about 32 percent forested, with the Northeast being most heavily forested (67 percent) and the Great Plains—Rocky Mountain region being least forested (2 percent and 25 percent respectively) (American Forest Council 1991). This paper will address forest lands and landowners, and uses of forest lands.

The potential importance of private forest lands to Neotropical migrants varies by region. Its importance is particularly evident in the eastern United States where private landowners own about 90 percent of all forested lands. Federal ownership is less than 3 percent in the Northeast and less than 9 percent in the South. In contrast, federal ownership approaches 90 percent in the West (Waddell et al. 1989).

The small, private non-industrial forest landowner is the largest holder of forest lands in the United States. Combined, these non-corporate landowners own almost three times more forest than the public owns through the federal government. In contrast, as a group, the forest products industry is the smallest holder of forest lands, owning about 15 percent of all forest land, or roughly three-fourths as much as is owned by the federal government (Waddell et al. 1989).

Yet, to date, most of the effort for conservation of Neotropical migratory birds and their habitat has been focused on federal holdings. It is clear that the private forest landowner, both industrial and non-industrial, must be involved if Neotropical migratory bird conservation efforts are to be successful. Goklany (1992) noted that "Because they own the majority of the U. S., the involvement of millions of private parties and landowners is critical to the overall success of conservation efforts."

Industrial Landowners

The forest products industry is a diverse industry composed of small to large corporations. Some corporations are owned by individuals or families; others by stockholders. Some companies own and operate on their own lands. Others are wholly or partially dependent on purchased timber from public or other private forests. Some operate on short rotations and others longer rotations, or favor hardwoods versus coniferous species.

Despite these differences, there are several common factors within the forest products industry, relevant to this discussion. One is that they hold and manage their forest lands to provide the company's owners/stockholders with a reasonable return on their investment. Second, they harvest their timber to produce a product that is in demand by society; and thirdly, that demand is projected to increase. By the year 2040, annual lumber consumption is expected to increase by 23 percent, consumption of plywood by 50 percent, and consumption of paper and allied products by 100 percent (Schallau 1991). A fourth commonality is that they are in competition with one another. The ability of companies to alter their forest management activities is thus tempered by the competitive nature of American industry, market demands, state and federal anti-trust laws and the need to operate in a fiscally responsible manner.

Companies within the forest products industry have historically worked on their own and through cooperative partnerships with many other organizations and agencies to promote responsible stewardship of forest resources (Owen and Heissenbuttel 1990). The conservation of Neotropical migratory birds is no different. The forest products industry has been a member of Partners in Flight since the program's inception, and continues to be active in all but the International Working Group. A growing list of companies have wildlife biologists, or foresters with wildlife management as one of their land-management responsibilities, actively participating with various Working Groups of PIF. When PIF began, there were only a half-dozen companies involved. Since then, the list has grown significantly and is now triple the original commitment.[1]

Regional Group meetings are one strengh of PIF, and serve to facilitate cooperative partnerships between and within the private and public sectors. At such meetings, particularly state working groups, biologists, foresters and other interested people can meet one another. These meetings provide the setting where one can realize the individual across the table is not really an "eco-freak," or conversely a "timber baron bent on raping the forest." They are real people, with legitimate concerns and needs. However, such group meetings will build cooperation only if the participants are willing to recognize each other's needs and concerns as being legitimate. Cooperation is further assured if each participant contributes something to the partnership. Too often landowners

[1]At this time the companies and associations active in PIF include: the American Forest and Paper Association, Anderson-Tully Company, Bowater (Great Northern Paper Company), Champion International Corporation, International Paper Company, Kaibab Renewable Resources, Mead Corporation, the National Council for Air and Stream Improvement (NCASI), the Packaging Corporation of America, Plum Creek Timber Company, Potlatch Corporation, Scott Paper Company, Stone Forest Industries and Stone Container Corporation, Westvaco Corporation, and Weyerhaeuser Company.

are asked to give something and receive nothing in exchange. Such one-sided offers of "cooperation" usually are perceived as demands.

The forest products industry supports cooperative ventures for three basic pragmatic reasons: (1) cooperation helps limited funds and resources go further and into a more meaningful effort; (2) cooperation with state or federal agencies and universities helps provide credibility to the research ventures or habitat management trials; and (3) cooperation is key to enlightened self interest. If landowners and managers are not involved, it is likely federal and state regulators will not be sensitive to landowner needs and interest.

For example, Bowater (Great Northern Paper Company), Scott Paper Company and Champion International Corporation, with the Manomet Bird Observatory and the National Council for Air and Stream Improvement, Inc. (NCASI), have completed the first year of a research project on Neotropical migrants and forest management in Maine. Also in the Northeast, Pennsylvania State University, in cooperation with International Paper Company and the Pennsylvania Bureau of Forestry, has completed the first year of a study of forest harvesting on breeding bird communities in northern hardwood forests.

In the South, Anderson-Tully Company and Champion International Corporation are cooperating with Memphis State University, the USDA Forest Service and the Tennessee Conservation League on songbird research in the Mississippi Valley. Weyerhaeuser Company, in cooperation with the University of Arkansas and the USDA Forest Service, is finishing a six-year study on breeding and wintering birds in the Ouachita Mountains of Arkansas; and, with NCASI, the U.S. Fish and Wildlife Service and the USDA Forest Service, are initiating a new study on population numbers and breeding success of Neotropical migrants under different silvicultural systems.

In the mid-West, Mead Corporation is cooperating with White Water Associates and NCASI to study biodiversity and Neotropical migrants in red pine plantations. They also are seeking state and federal agency cooperators interested in expanding the study.

In these and other studies, the forest products industry has supported and will continue to support research on forest management and Neotropical migrants by providing funds, professional personnel, data bases, study areas and equipment. In addition, the industry provided a grant to the National Fish and Wildlife Foundation to support additional Neotropical migrant research in 1993. The industry currently is reviewing several possibilities for the development of a cooperative research study in the western United States.

These are just a few examples of cooperative efforts involving the forest products industry and research on or management for Neotropical migrants. But, the forest products industry is one of the smaller holders of forest lands in the "private sector." To date, there has been little to no effort to involve the small, nonindustrial forest landowner in PIF.

Non-industrial Landowners

One vast, as-yet-untapped, resource for PIF is the more than seven million private, non-corporate landowners that hold forest land across the United States (American Forest Council 1991). Few of these non-corporate landowners actively manage their lands to enhance either habitat suitability or timber growth (Alexander 1986, Greene and Blatner 1987). Exceptions include such landowners as The Nature Conservancy, which has been very active in PIF from the beginning, and whose lands are being managed for a variety of habitat and wildlife values. Many other non-corporate landowners express an interest in "multiple use," but their ownership objectives vary considerably as the owners represent a cross section of occupations, interests and reasons for owning land (Shaw 1981). This mix in objectives also is constantly changing because the turnover in ownership of private non-corporate land is relatively high (Shaw 1981).

The challenge for PIF relative to the "private sector" is to reach these landowners and get them involved. We offer four possible approaches. The first would be to make use of the extensive landowner contact network already established by the Agriculture Extension Service. County agents, particularly the state forestry and wildlife specialists, would be sought out by the regional and state Working Groups and encouraged to participate in Partners in Flight. Non-corporate landowners may be more willing to participate in PIF if asked by someone known locally.

The forest stewardship programs created in the 1990 Farm Bill offer another established network to work with. These programs have established a Stewardship Coordinating Committee in each state with both forestry and wildlife expertise. In addition to technical assistance, the programs provide some cost sharing activities that could benefit Neotropical migrants. A third approach would be to contact the non-corporate forest landowners through the Tree Farm Program sponsored by the forest products industry. This program has over 70,000 members and encompasses management on over 95 million acres of private forest lands (Heissenbuttel, personal communication).

A fourth avenue is through the local chapters of the various conservation organizations such as The Nature Conservancy, The Audubon Society, Sierra Club and National Wildlife Federation. Many local chapters of these groups are active in PIF at the state or regional level. Their members could provide another local contact for the small landowners in the area. However, it is important to approach the landowner with a specific project, and one that is sensitive to landowner objectives and private property rights. This should enhance cooperation and help avoid antagonism and conflict. Fear of government intervention and regulation are significant dis-incentives. The bottom line is landowners must be convinced that cooperation is in their own self interest.

Conclusion

Building successful partnerships within the private sector, or between the private sector and the public sector, is predicated upon there being a basic understanding and respect for other partners involved. While it is understandable that such respect should be earned, previously developed personal biases must be "checked at the door" else they present insurmountable obstacles to the successful development of partnerships. To enhance mutual respect, it is important for each partner to provide some resource to the cooperative venture. It is unlikely that each participant will be able to provide an equal level of support, but all should contribute something.

Forest landowners could provide access to land for research or adopt tailored management practices to meet specific regional needs to enhance Neotropical migrant habitat. Industrial landowners also might provide access to land and forest data bases, funds or professionals to assist in research, or equipment for research manipulation of habitats. Local affiliates of conservation groups could help in bird monitoring, education and in some cases with collecting research data. National wildlife conservation organizations, whose primary goal is wildlife conservation, could, if willing, provide significant financial support.

We suggest that new partnerships begin with small projects that have a high probability of successful completion. Then, as understanding and mutual respect grows, larger and more complex projects can be attempted. Starting with too large or complex of a project may result in nothing getting done. Such unsuccessful ventures often leave a bad impression among participants and can breed distrust rather than foster cooperation.

Ultimately it boils down to people. We all must be willing to clearly articulate our position, and listen to the positions of others and accept them as legitimate. Only then will there exist a basis for meaningful discussions and equitable compromise. And compromise is a must in partnerships where there exists a common goal and many divergent objectives. Compromise will be necessary on research topics and priorities; when, where and what types of management trials/demonstrations to conduct; how to implement research results on a variety of ownerships; etc. The respect developed should be carried forward into a commitment by all partners to support the final product of the cooperative venture.

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Birding Economics as a Tool for Conserving Neotropical Migrants

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Introduction

The primary obstacle to the conservation and management of nongame wildlife, including neotropical migrant birds, is the absence of substantial and dependable sources of revenue. Funding for state endangered and nongame species programs has come mostly from voluntary tax checkoffs. Although the tax checkoff has provided a financial foundation for these programs in many states, funding needs have grown more rapidly than contributions through the tax checkoff. To fill this widening gap, other sources of funding must be identified and subsequently tapped.

In consumptive wildlife programs such as hunting and fishing, sportsmen pay a substantial portion of the management bill. Through license fees, harvest stamps and federal excise taxes on hunting and fishing paraphernalia, more than 60 million American sportsmen provide hundreds of millions of dollars each year for state fish and game programs. Unlike these user groups, users of nongame species usually are not identified, classified or characterized. In some ways, nonconsumptive users and user groups also may be more difficult to identify than consumptive users. Surveys by government agencies usually refer to the non-hunting and non-fishing group as "nonconsumptive recreational wildlife users" or "nonconsumptive wildlife users." This group includes photographers, botanists and, above all, birders. Birders are the largest user group of endangered and nongame wildlife species. They also are the only (legal) user group of Neotropical migrant birds. At this time neither fish and game nor endangered and nongame species programs truly recognize birders as a user group, and neither serve birders, although attitudes and policies are changing rapidly. The reason that recognition of birders as a user group has been slow is related to the fact that birders do not support wildlife programs financially, or at least they do not support these programs in ways that are apparent. Recent proposals that suggest birders should be recognized as a user group and be made to pay a portion of the cost of managing nongame and endangered species have triggered several research programs that focus on nonconsumptive wildlife users, particularly birders.

Another reason for the growth in studies of non-consumptive wildlife users is an interest in protecting rare species and sensitive habitats from being degraded by too much visitation. Studies of birders and other wildlife users are part of a new field called "ecotourism" research. This field is similar to traditional wildlife and resource management in that it is multidisciplinary with the focus on both humans and wildlife. Ecotourism studies focus on economic, social and ecological impacts of the various user groups and should dovetail with wildlife management curricula. However, new conservation biology programs within biology departments also are focusing on ecotourism as a means of protecting resources.

The structure of current research on birders as a user group of nongame and endangered species, including Neotropical migrants, is outlined below along with selected highlights from several studies. It should be remembered that much of the research is being conducted by an advocacy group, as is the case with research done by groups that lobby for hunters and fishermen, and by federal and state agencies that manage consumptive species. The studies seek to characterize the demographics of birders, their economic impact at both the national and local level, and identify and characterize birding sites in the United States and abroad.

Who Are Birders? The Need for Demographic Information

To better conserve and manage resources as well as serve a user group, wildlife managers and government policy makers must know their constituency. Basic demographic information includes: age, sex, income, occupation, education, membership in conservation organizations and geographic residence, to name a few. A step beyond the basic demographic information for wildlife users is the user group's knowledge about how wildlife programs are funded and attitudes toward new or proposed funding modes. Luckily, the basic demographic information is available through the U.S. Fish and Wildlife Service's (USFWS) *National Survey of Hunting, Fishing, and Wildlife-Related Recreation* that is conducted every five years. The survey does not address questions about user knowledge about how wildlife programs are funded or user attitude toward alternative funding sources.

Basic demographic information about user groups also is useful to the groups themselves. The results of demographic and economic surveys of a given user group like hunters and fishermen frequently is used as a lobbying tool. Hunters and fishermen have strong lobbies that wield their power to serve their constituencies. This is because fishermen and hunters support an enormous industry. Because so little is known about birders, a strong lobby has never emerged. Instead, dozens of small advocacy groups exist whose voices are nearly mute. As birders learn more about themselves and after they are considered by themselves and governmental agencies as a legitimate user group, their power will grow. Manufacturers and marketers of optics, books and other birding paraphernalia already realize the enormous buying power of birders. Birding is a growth industry.

What do we know about birder demographics? Because wildlife and resource managers have not adopted programmatic research, our knowledge of birder demographics (and economics) is limited to a small set of studies, mostly focusing on active birders or on birders and birding economics at a local scale. Thus, these studies are not random samples of the American birding population, but they do offer some insight as to who birders are and the enormity of their economic impacts.

From studies of birders done at national and site-specific locations we know that the age of birders varies, averaging 44–50 years. We also know that active birders tend more often to be male, have incomes greater than the national average, and that about two-thirds of this group have degrees from four-year colleges. A comparison of the demographics of two groups of active birders is given in Table 1. The two groups were: participants in the 1988–1989 National Audubon Society Christmas Bird Count (CBC) (Wiedner and Kerlinger 1990) and members of the American Birding Association (ABA) (Wauer 1991). ABA members are the more active birders of the two groups and tend to be among the most active of American birders. The results of these studies showed that ABA members were slightly older, more often male, had higher incomes and spent more time in the field.

Perhaps the most basic question about birders as a user group is, How many birders are there in the United States? We simply do not know. Estimates range upwards to 61 million (Hall and O'Leary 1989), although this surely is an overestimate (Kellert 1985, Kerlinger 1993). A reliable estimate will come only after criteria are established for identifying birders in surveys such as the USFWS National Surveys.

How Much do Birders Spend? The Structure of Birder Spending

Like other outdoor recreationists, birders spend large amounts of money on their pastime. One national study revealed that active birders spent an average of $1,852 per year (Wiedner and Kerlinger 1990). That group consisted of the 40,000 plus birders who participated in the CBC in 1988–1989. This undoubtedly is above the national average for all American birders, but is only 54 percent of the amount Wauer (1991) estimated for members of the ABA. Again, a shortcoming of these studies is that they focus on a subset of American birders. It is likely that the annual spending pattern of birders is a decaying function, declining as activity of individuals lessens (Kerlinger 1993). Approximating this function should be a goal of future studies.

Birders spend their money on a wide array of paraphernalia and travel (Wiedner and Kerlinger 1990. Highest on the list of expenditures is travel, with active birders spending more than $1,360 (73 percent) per year on airfare, gasoline, tolls, lodging, food, tour guides and ancillary items such as souvenirs (t-shirts, etc.). Next on the list is optical equipment (binoculars, spotting scopes and tripods). Wiedner and Kerlinger estimated a paltry $90 per year for this category, whereas Wauer (1991) estimated that $232 was spent per year. Other expenditures include books, clothing, magazines, artwork and miscellaneous paraphernalia. A mere 3 percent of the active birder's annual budget goes to contributions to conservation organizations. Thus, when compared to hunters and fishermen, a smaller proportion of birder expenditures goes to wildlife conservation. This comparison is a difficult one to make and my conclusion is based on the fact that hunters and fishermen pay up to 11 percent in excise taxes on paraphernalia and they purchase licenses and stamps. In addition, many of these wildlife users support nongovernment conservation and lobbying organizations. These payments benefit wildlife in different ways. Three percent of the annual recreational budget of active birders went primarily

Table 1. Profile of the active American birder, from two national surveys.

	Wiedner and Kerlinger 1990	Wauer 1991
Average age	44–45 years	50 years
Sex	male = 63 percent, female = 37 percent[a]	male = 74 percent, female = 26 percent
Education	Bachelor's degree = 74 percent	Bachelor's degree = 60 percent
Income	$25,000–35,000	$35,000–50,000
Annual spending	average = $1,800	average = $3,400
Retired	25.7 percent	??[b]
Sample size (response rate)	1,033 (29.5 percent)	1,485 (21 percent)

[a]Kerlinger and Wiedner found an equal sex ratio among birders visiting Cape May during 1988.
[b]Wauer's data (unpublished) revealed that 27 percent of ABA members were 60 or more years old.

to wildlife advocacy and support organizations such as national and state Audubon societies, Nature Conservancy and Sierra Club among others. In both the Wiedner and Kerlinger (1990) and Wauer (1991) studies it was obvious that many birders confuse recreational ''birding'' organizations with conservation organizations.

Calculating the economic impact of birders on a national level is not possible at this time because of the limited nature of previous studies. Estimates as high as $20 billion per year have been reported (U.S. Department of Interior 1982). A reliable estimate of the true economic impact of birders depends on more detailed studies of birders at high, low and intermediate activity levels. The USFWS five-year National Surveys of Hunting, Fishing, and Nonconsumptive Wildlife Associated Recreation are an ideal means of addressing the larger questions related to birding economics and birder demographics.

An entirely different economic impact of birding and birders occurs at the local level. Communities located at birding destinations benefit greatly from this type of tourism. Studies of the economic impact of birders at specific birding sites have been conducted at about a half dozen places in North America. These include: Cape May, New Jersey (Kerlinger and Wiedner 1991); Point Pelee, Ontario (Hvenegaard et al. 1988); Hawk Mountain Sanctuary, Pennsylvania (Kerlinger and Brett in press); the Platte River crane watching area, Nebraska (Lingle 1991); and High Island, Texas (Eubanks et al. in press). With two exceptions, these are year-long studies that will characterize both the annual and seasonal economic impact of birder tourism. Further studies are being conducted at more than a dozen other locales throughout North America and the Neotropics. Each of these studies reveals that economic impact of birders to the communities nearby these sites is in the millions of dollars annually. Furthermore, many birding activities conveniently occur during spring and autumn before or after the normal tourist seasons, which is even more beneficial to the communities because it extends the tourist season by several months. Conservation organizations and government agencies are beginning to use the economic benefits of birding to persuade local officials and businesses that they can make more money be preserving open space than by developing it. These arguments have worked in Cape May where the USFWS recently established a new refuge and is actively acquiring important habitat for Neotropical migrants.

Information from site-specific birding economic studies will be useful to both public and private sectors. Land managers should know how much money birding tourists bring to the communities surrounding their land. If birders are making a significant contribution to an area, local businesses and residents should know how much and who benefits. The argument for developing an area often is that the rateables generated by new homes or other development will provide revenue for a township. In many locations, birding tourists bring more revenue to an area than other forms of development, without generating the cost in governmental services (e.g., schools, police, fire protection, roads, etc.)

Where do Birders Bird? Birding Travel and Biodiversity Hotspots

To understand the structure of birder spending patterns it is necessary to identify the travel patterns and destinations of birders. Inventories of birder travel destinations are nonexistent, although the pages of any birding magazine are replete with advertisements that attract birders to sites throughout the world. In the United States and Canada these sites often are migratory hotspots and usually support a diversity of bird species.

Birding hotspots are synonymous with avian biodiversity or with locations where large numbers of species and/or individuals congregate during migration. These are primary travel destinations of birders. Some examples include: the Rio Grande Valley—southern Texas, the coast of Texas—Galveston eastward, coastal Louisiana, Dauphin Island—coastal Alabama, the Delmarva Peninsula—Maryland and Virginia, the Cape May Peninsula—New Jersey, the Whitefish Peninsula—Michigan, and Appalachian ridges such as Hawk Mountain Sanctuary. Note that a majority of these locations are coastal. These are areas where large number of songbirds, raptors (diurnal and nocturnal), shorebirds and other migrants (many of which are Neotropical) stopover to rest and feed. Consider Cape May, New Jersey as an example of the number of birds that use some of these areas. In autumn, more than 50,000 hawks migrate through the Cape May peninsula, along with thousands of owls, millions of songbirds (both Neotropical and non-Neotropical migrants), hundreds of thousands of shorebirds, thousands of egrets, millions of swallows, and millions of waterfowl and seabirds. This area is one of the major migration focal points in the Western Hemisphere. Despite the importance of coastal habitats to migrating birds, these areas also are experiencing development pressure that threatens the same critical stopover habitat that makes these locales attractive to migrants.

How many birders visit migration sites annually? The numbers vary: Hawk Mountain Sanctuary = 50,000 (Kerlinger and Brett in press); Cape May Peninsula = 100,000 (updated from U. S. Fish and Wildlife Service estimate of 1987); Forsythe National Wildlife Refuge = 175,000 (D. Beall, Refuge Manager, personal communication); Point Pelee National Park = 57,000 (Hvenegaard et al. 1988); and the Platte River crane watching area = 80,000 (Lingle 1991). These sites are some of the most visited birding sites in the world, but there are dozens of others in North America that have similar to slightly less visitation. How many more birding destinations are there and how much protection are they afforded?

Conclusions and Recommendations

The few studies of birder demographics and birding economics that are available reveal that birders are the largest user group of nonconsumptive wildlife. Because they are nonconsumptive and because they contribute little to state and federal wildlife programs, they have not been taken as seriously as their numbers merit. Until better information about birder demographics and birding economics is available, birders will not be considered a user group. Furthermore, without this information there cannot be an enlightened means of turning this user group into a financial (and lobbying) support group for nongame (including Neotropical bird migrant) wildlife programs.

A three-tiered research program will provide information on birding economics and birder demographics to wildlife managers and policy makers who need such information to develop and implement management policy. These three tiers include studies at the (1) national (and state) level, as well as studies at birding destinations in both (2) domestic and (3) Neotropical locales. Basic demographic and economic data should come from the USFWS national surveys done at five-year intervals. The National Surveys must be used so that information about birders can be compared to hunters, fishermen and those people who are not wildlife users. Information at the state level also can come from the national survey, although ancillary studies will be necessary to gain a more complete picture. Because the national survey does not address questions related to wildlife users' knowledge of how wildlife programs are funded and attitudes of users to alternative funding methods, updating of the questionnaires is needed.

Finally, birding (biodiversity) hotspots should be identified and birder use of those sites determined. This is especially critical for Neotropical migrants whose stopover habitats are in jeopardy. Once these sites are identified and use by birds and birders documented, this information can be used to prioritize areas for eventual acquisition or regulatory protection. Perhaps funding for these acquisitions can be provided by birders, the primary user group of nonconsumptive wildlife?

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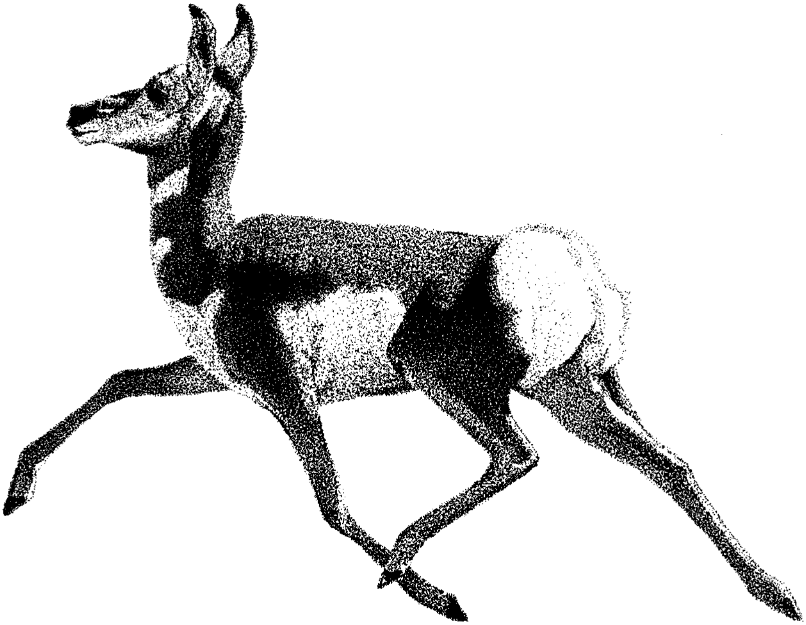

Special Session 8.
Implications of Wildlife Ranching

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Conservation Challenges Concerning Wildlife Farming and Ranching in North America

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Introduction

Recent increases in private ownership and relocation of native and exotic big game related to commercial husbandry have generated controversy throughout North America. This controversy pits the private sector, eager to diversify its agricultural base, against traditional sportsmen and government agencies, worried about impacts of such activities on indigenous free-ranging wildlife, particularly ungulates and their habitat (Demarais et al. 1990, Bunnage and Church 1991, Renecker and Hudson 1991, Benson 1992, Ervin et al. 1992, Geist 1992, Haigh and Hudson 1993). The recent outbreaks of tuberculosis (Rhyan et al. 1992, Thoen et al. 1992) in captive elk (*Cervus elaphus*) have not only "deepened the trenches" on this issue (because of fear of spread of the disease to other ungulates), but have become "we told you so" events for those opposed to game ranching and farming.

Privately owned exotic wildlife and specific commercial uses of native wildlife often fall outside historically regulated wildlife management activities. Because of this, many state and provincial wildlife or agricultural agencies (or both) in charge of regulating wildlife farming or ranching have found themselves without appropriate regulations and policies. A 1989 survey of the 50 U. S. states identified a general lack of knowledge concerning specific policies and regulations affecting this industry among state agencies, which either were or could be directly involved in regulating the exotic deer industry (Ervin et al. 1992). Even when policies and legislation have been reassessed and revised, there has been a general lack of good biological information on which to base policy-making decisions.

In places such as Texas, where privately owned exotic big game and commercial management of native wildlife are well established, the questions is not whether to ranch captive wildlife or not, but how to establish the best possible management guidelines for exotic species (Demarais et al. 1990). In other jurisdictions, particularly in Canada and the West, the question is more basic: should there be privately owned wildlife held behind fences?

Central to any successful free-market system is the need for the private sector to have the freedom and flexibility to extend venture capital to stimulate economic development and return financial dividends to the investor. The currently burgeoning wildlife farming and ranching industries in North America can be looked at as an appropriate effort by financially challenged rural farm and ranch communities to diversify, and thus stabilize, their financial status. However, given the rather unique product involved in these ventures, these efforts should be evaluated and tempered relative to a concern for potential long-term impacts on "The Commons" and on the more traditional livestock industries.

This Special Session is designed to address the major controversy. Separate panels of experts have been developed to address topics within these two realms. Before we venture into these rather detailed areas, first we must bring everyone to a common ground of understanding concerning the nature of the industry with a presentation describing wildlife farming and ranching in North America. The first panel will deal with population-level biological issues which are at the heart of the regulatory and policy controversy. These include:

1. disease-related interactions between commercial livestock and native cervid and the concern that if translocated ungulates have diseases or parasites, these too are translocated;
2. competitive interactions of native and exotic big game, and the concern that exotic species will outcompete native species; and
3. potential consequences of interbreeding between native and exotic big game, and the concern about how genetic make-up of affected populations could be altered.

The second panel will deal with social and biopoltical issues surrounding regulations and policies from several perspectives. Some of the topics to be addressed within these perspectives include the legal classification (or lack thereof) of animals and management systems, the rights of the private landowner and legal mandates to safeguard publicly owned native wildlife in the presence of privately owned animals. Perspectives to be presented include:

1. the private enterprise perspective, with reference to the uniquely different management systems associated with ranching and farming;
2. the perspectives of state and provincial government agencies with either actual or potential regulatory authority over the industry; and
3. the perspective of the Colorado Division of Wildlife, which has been very active in the regulatory and policy-making process in recent years.

The primary goal of this Special Session is to promote the exchange of current knowledge concerning the biological-based controversies and to promote at least acknowledgement, and perhaps understanding, of the social and biopolitical issues. Although some biological information is available concerning potential negative interactions involving disease, genetics and competition, the projection of potential state- and province-wide impacts typically is based on theoretical assumptions and only limited real world experience. However, these limitations should not hinder the pursuit of policy decisions. Where biological information on which to base decisions is limited, we recommend that the appropriate approach is to err on the side of conservatism with regard to our native wildlife resources. We further recognize that the private sector has a valid right to pursue agricultural diversification. This right currently is being infringed by the lack of clear regulatory authority and management framework. We call for an action-oriented policy-making effort which clearly will outline the potential regulatory limitations and eliminate the atmosphere of legal uncertainty currently pervasive in most states and provinces.

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Overview of Wildlife Farming and Ranching in North America

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This symposium covers the major policy issues associated with commercialization of wildlife in general and wildlife farming and ranching specifically. Our introductory paper is confined to outlining the current status and trends in wildlife farming and ranching in Canada and the United States. We limit ourselves to native and introduced wild ungulates, and exclude domestic exotics such as llamas (*Lama peruana*), alpacas (*L. pacos*) and yak (*Bos grunniens*). However, we do include domestic reindeer (*Rangifer tarandus*) because of the extensive nature of husbandry and their interactions with native wild caribou.

There is a growing number of books, conference proceedings and papers on the science and policy issues of game production in commercial and closely husbanded systems (Burger and Teer 1981, Eltringham 1984, White 1986, von Kerkerinck 1987, Valdez 1989, Hudson et al 1989, Renecker and Hudson 1991, Renecker and Kozak 1987, Brown 1992, Haigh and Hudson 1993).

The game industry now is represented by a growing number of producer organizations: Exotic Wildlife Association, American Bison Association, National Buffalo Association, North American Deer Farmers Association, North American Elk Breeders Association, Canadian Bison Association, Canadian Venison Council, and a variety of provincial, regional and state chapters of several organizations. Producer cooperatives also are involved in orderly marketing systems.

It is essential to state the definitions of game farming, game ranching and culling of wild stock. In its simplest form, game farming is intensive husbandry of wild stocks in penned conditions. Game ranching involves free-ranging, managed wildlife usually on private property. Culling is taking of animals from free-ranging wild stocks usually on large blocks of public lands.

Origins of Wildlife Ranching and Farming

Game husbandry has been practiced since ancient times (Hudson 1989), and it has not been limited to the early stages of domestication of conventional farm livestock. In addition to specialized mesolithic economies based on selective hunting and perhaps herding and supplemental feeding, some species were stockaded or tethered in rather intensive production systems.

Some of the most striking menageries were kept in the Old Kingdom of Egypt (2686–2181 BC). Addax (*Addax nasomaculatus*), oryx (*Oryx* spp.) and gazelles (*Gazella* spp.) were kept in the royal courts, and were used in ceremonial and perhaps agricultural roles. From the ancient Roman Empire, full descriptions of enclosures stocked with game for hunting and meat production come from the writings of Varro, Columella and Pliny (Anderson 1985).

Private game reserves persisted from the middle ages to modern times throughout continental Europe and Britain. Although hunting increasingly became the prerogative of the king after Charlemagne consolidated his European empire in the 9th Century, game keeping was franchised to nobility and with time, to landowners. The zenith of wildlife propagation in Britain was in the 17th Century under the House of Stuart (Kirby and Kirby 1931, Kirby 1933).

This system of game husbandry, although effective in maintaining wildlife under heavy landuse pressure, was considered aristocratic by those immigrating to North America and abandoned in favor of public ownership and for awhile, open access (Tober 1981). The current North American centralized system emerged (Geist 1988) from the inevitable destruction that followed.

World Scene

Game cropping and game ranching have continued into modern times with hunting privileges, meat, brood stock and various parts of wild animals used in medicinal concoctions being items of commerce.

Commercialization of wildlife resources in Africa came after European colonization. While endemic peoples depended on wild game for much of their food, its uses were expanded by the advent of safari hunting by Europeans beginning in the early 1900s (Blankenship et al. 1990). Safari hunting was joined by photographic safaris and other forms of wildlife-related tourism after World War II; however, safari hunting has been reduced in the last decade in many countries south of the Sahara. All uses, especially wildlife-related tourism, are economically important to local and national economies (Eltringham 1984).

Organized cropping of wildlife for local consumption and export was started in the 1950s with the pioneer work of Parker (1964) in Kenya and by Dasmann and Mossman (1961) and Dasmann (1964) in southern Rhodesia (Zimbabwe). Most cropping schemes organized on public (crown) land were short-lived or failed entirely (Cumming 1991). Those on private lands have succeeded and are now flourishing in southern Africa. For example, although not all are commercially oriented, more than 8,200 game farms averaging 2,531 hectares are located in the Republic of South Africa (Skinner 1989).

Despite off-and-on criticism of the industry, cropping of kangaroos of three species—the red (*Macropus rufus*) and two grey kangaroos (*M. giganteus* and *M. fuliginosus*)—is well-established in Australia. Kangaroo meat worth $942,000 and skins work $9,672,000 were exported from Australia in 1982–83 (Poole 1984).

Farming and cropping of wild stocks of the green iguana (*Iguana iguana*) (Werner 1991), capybara (*Hydrochoerus hydrochaeris*) (Ojasti 1991), paca or agouti (Smythe 1991), and caiman (*Caiman crocodilus*) (Thorbjarnarson 1991) are widely practiced in

Central and South America. Most production, however, comes from wild stocks, and most is harvested in subsistence hunting. Annual production of dry, salted capybara meat averaged 400,000 kilograms on 53 ranches in Venezuela during 1975–1985 (Ojasti and Rivero-Blanco 1988). However, production from the 53 ranches was less than 2 percent of the total value of capybara meat harvested in the state of Apure (Ojasti 1991). The total value of the caiman harvest in Venezuela in 1987 was $9,017,072 (Thorbjarnarson 1991).

The success of game farming probably is best known from New Zealand (Yerex 1979), where the industry in 1990 contained over a million animals (Drew 1991) on more than 5,000 farms developed since the early 1970s. Sales of antler velvet for Oriental medicines, meat and brood stock have been a powerful stimulus to an economically flat agricultural industry on the island.

While Europe has been the primary market for venison and Asia for antler velvet, it was not until the success of the New Zealand industry became known that intensive game farming began to develop in other regions of the world. Taking the cue from New Zealand, Australia, Europe and now North America are developing game-farming industries which have revolutionized production of venison for a growing market.

Harvests of several ungulates, primarily moose (*Alces alces*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), saiga antelope (*Saiga tatarica*) and wild boar (*Sus scrofa*), totaled 460,000 head in 1988 in the USSR, of which 134,250 were reindeer (Kuzyakin 1991). Except for reindeer, these largely are culling figures from wild stocks.

The saiga antelope is receiving increased attention because of the decrease in its numbers in Kalmykia and Kazakhstan. Cropping or culling of saiga antelope in the Soviet Union for meat, hides and horns used in Oriental medicines is perhaps the best known wildlife cropping scheme in Eastern Europe (Bannikov et al. 1961). Upwards of 600,000 were cropped in some years.

However, the decline of saiga in recent years has greatly curtailed production of the species in the Autonomous Republic of Kalmykia and perhaps also in Kazakhstan. Poaching for the animals' horns, overgrazing of its habitat by sheep and disruptions of its migration routes by roads, telecommunication lines, canals, fences and other contrivances are responsible. The Kalmykian population declined from near 1 million animals as recently as the mid-1970s to less than 150,000 at present. Poaching for its valuable horns has resulted in a greatly distorted sex ratio which further imperils the species' future as an economic resource (Teer et al. in press).

Current Industry in North America: Size and Trends

United States

Approximately 55,813 deer are commercially raised on 291 farms in the United States (Table 1). Most wapiti (*Cervus elaphus*) are farmed in 16 states of which seven jurisdictions permit the farming of the species under a "grandfather" clause. Another five states allow pure wapiti farming but not crosses of wapiti and red deer or pure red deer. The farmed wapiti population has increased at a rate of about 14 percent per year since about 1985 (Renecker 1990). Most wapiti stock located on game farms in the United States originated from surplus animals captured by the federal government during the 1950s and then sold to private individuals. This practice ceased in the 1960s and government agencies shifted their management strategy to killing surplus animals. Presently, agencies choose to provide supplemental feed to free-ranging stock during winter. Only New Mexico made provision for ranchers to fence large tracts of land and then incorporate the animals enclosed by the fences into their commercial hunting operations.

In a mail survey of the 50 states in the United States and 10 provinces and 2 territories of Canada concerning game farming and ranching, respondents reported fallow deer (*Dama dama*), sika deer (*Cervus nippon*) and wapiti were the most numerous on game farms (Teer 1991). Other common species of deer on farms and ranches included axis deer or chital (*Axis axis*), and red deer. While not reported in the survey, it is known that some landowners have sambar (*Cervus unicolor*), barasinga or swamp deer (*Cervus duvauceli*), and musk deer (*Moschus moschiferus*) in penned or husbanded stocks.

Today, the economic value of the commercial deer farm industry in the United States is about $1 million in animals (farm gate value) and another $54.8 million in facilities excluding land (Barbara Fox, North American Deer Farmers Association, personal communication).

Importation of exotic animals is a growing practice. Ninety-eight percent of the average of 700 translocations of wildlife of all species made annually in the world was made in the United States and Canada (Griffith et al 1989). Of all the states, introductions and translocations of exotic large mammals for the purpose of sport hunting are most advanced in Texas (Teer 1991). Ranching of large mammals produces important revenues to the owners. Surveys of exotic large mammals by the Texas Parks and Wildlife Department have been made at intervals of about five years (Traweek 1989). Numbers and kinds have grown from a few hundred animals in 1963 to more than 164,000 individuals of 67 species on 486 ranches in Texas in 1988 (Figure 1).

Alaska's reindeer are non-native, con-specific with caribou and classified as domestic livestock. The herd has had a checkered past. From an introduction of 1,280 individuals in the late 1800s, reindeer numbers grew to over 640,000 by the early 1930s (Dieterich 1991). Numbers declined to about 25,000 in the 1950s because of overgrazing, poaching,

Table 1. Wild ruminants on game farms in the United States.

Species	States farmed in	Number of farms	Number of animals
Farmed			
Fallow deer		252[1]	23,800[2]
Axis deer			350[2]
Red deer			6,300[2]
Sika deer			1,050[2]
White-tailed deer			3,500[2]
Wapiti	16		20,000[3]
Reindeer	20	39	813[4]
Plains bison	47	461	130,000[5]
Extensive herding reindeer	1	19	43,000

[1]Total number of farms for fallow deer, axis deer, sika deer,red deer, white-tailed deer and wapiti.
[2]Source: Barbara Fox, North American Deer Farmers Association.
[3]Source: Wade Hainstock, North American Elk Breeders Association.
[4]Source: Tom Scheib, Reindeer Owners and Breeders Association.
[5]Source: Harold Danz, American Bison Association.
[6]On state and federal agency property owned by Native tribes, Yellowstone National Park.

predation, disease and losses to migrating caribou. Because of the growth of the velvet antler industry and improvement in husbandry methods, numbers of reindeer are increasing. Today, about 43,000 reindeer are located on the Seward Peninsula (15 herds), Nunivak Island, Umnak Island, Hagemeister Island, Kodiak Island and several other islands in the Aleutian Archipelago, and four reindeer farms on the mainland.

Canada

The Canadian Venison Council estimates that the Canadian deer herd in autumn 1992 exceeded 70,000 head with an investment value of $375,000,000 (Table 2) (Hudson and Burton 1993). In Canada, wild ruminants are raised primarily for agricultural purposes except in Quebec where sizable populations of white-tailed deer (*Odocoileus virginianus*) are used for fee hunting.The oldest and best-established industry is based on bison (*Bison bison*)—so well-established that bison are not classified as game—which now approach 20,000 animals, compared with about seven times that number in the United States. Herds are currently compounding at 26 percent per annum.

Most of Canada's reindeer are in one herd in the Mackenzie Delta, Northwest Territories. A small herd has been released on the Belcher Islands where they provide meat for the local community. Some reindeer are farmed in the Peace River area of British Columbia and a few are held under special permit elsewhere.

The most rapid growth has been in fallow deer with British Columbia and Ontario leading. The wapiti industry began in the 1970s and compounded at over 20 percent annually until herds were reduced to control tuberculosis. This segment of the game industry has started its recovery based largely on growth from locally established game farm herds. In eastern Canada, several large companies have imported red deer, mainly

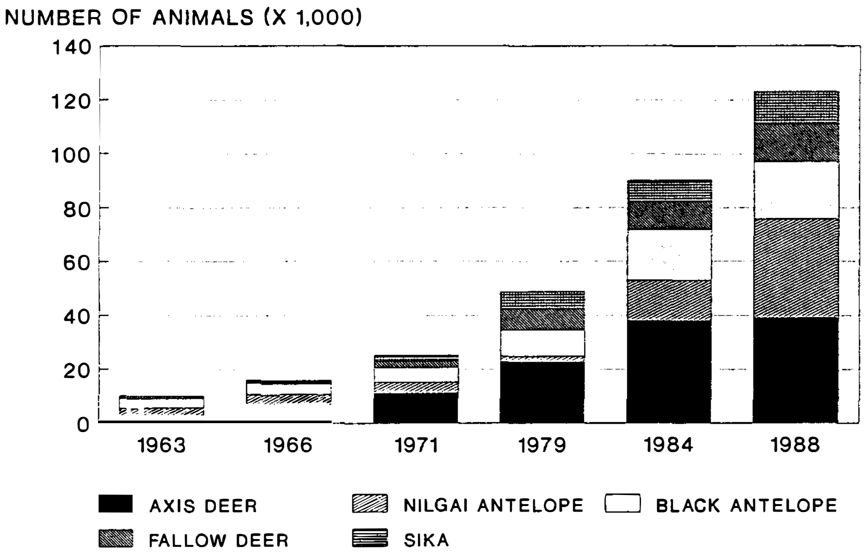

Figure 1. Numbers of the five major species of introduced large mammals in Texas. The five are free-ranging in large areas primarily west of the 100th meridian in Texas. One other, the aoudad or Barbary sheep, also exists in wild stocks. (Data from Traweek 1989.)

from New Zealand. In provinces west of Ontario where wapiti are indigenous, importation of red deer and sika deer is prohibited to prevent hybridization of wild herds.

Products

Sport Hunting

While there is no standard inventory or national registry to assess large mammal populations on a national or regional scale, it is unquestioned that large mammals have been produced through management and used in North America almost exclusively for sport hunting. Further, the harvest of white-tailed deer has far exceeded harvests of other species of large mammals since the demise of the Great Plains bison herds. Moreover, hunting on both private and public lands is trending toward commercial or fee-hunting systems in which those who own or manage the land receive compensation for their efforts (Teer and Forest 1969, Burger and Teer 1981, Teer et al. 1983, Thomas 1984).

Unable to provide statistical information on sport hunting on more than a state level, we have chosen to elaborate on the hunting system in Texas, as it is perhaps the most noteworthy in terms of commercialization and size of the kill, especially in white-tailed deer.

From a population of white-tailed deer estimated at 5,398,874 in the 1991–92 season, 474,047 of both sexes were harvested (Boydston 1992). Leases commonly bring $5 to $8 per acre, and most are made for white-tailed deer hunting. Data are lacking on the total value of leasing to landowners. However, if we accept a modest value of $3 per acre for leased land in only the area west of the 100th meridian where white-tailed deer are most numerous and leasing most prevalent, the sum accruing directly to landowners comes to over $33 million. The 1985 survey of hunting, fishing and wildlife-associated recreation reported that Texas residents spent over $4.8 billion to pursue their interests in wildlife in 1985 (U. S. Department of the Interior 1989). Of the total, $1.07 billion was spent for hunting.

Table 2. Wild ruminants on game farms and ranches in Canada, November 1992.

	Bison	Reindeer	Fallow deer	Wapiti	Red deer	Other cervids[1]
Yukon		70		550		
Northwest Territories		15,000				
British Columbia	3,500	250	17,500			
Alberta	9,000			5,000		825
Saskatchewan	2,240		1,500	4,000		400
Manitoba	1,120			85		15
Ontario	2,500		7,000	1,200	3,500	500
Quebec	4,000		1,200	40	1,800	10,700
New Brunswick	275		60	12	1,000	75
Nova Scotia			7	7	39	
Prince Edward Island	25	20		10		
Newfoundland						
Total	26,660	15,340	27,267	10,904	6,339	12,515

[1]Moose, white-tailed deer and mule deer.

Meat

The term venison usually refers to deer meat, but the word comes from venerie (hunting) which suggests that it appropriately applies to all game meat. Until the late 1980s, international trade in game meats approached 30,000 tons annually, which represented approximately 7 percent of total game production or procurement (Luxmoore 1989). Although these figures still are quoted, the industry has changed markedly in the last several years. Red and fallow deer venison from New Zealand rapidly is approaching the former total game meat supplies which once came predominately from harvests of the brown hare (*Lepus europaeus*) in Argentina. Another change has been a glut of product from eastern Europe. This has had the expected depressing effect on international venison markets.

North America is viewed as a potentially large but complex market because of uneven and constantly changing provincial and state regulations. Most of the demand now is filled by New Zealand. Figures for domestic production are scanty except for established industries such as bison and reindeer. In Canada, an annual slaughter of over 1,000 bison provides 220 tons carcass weight, an amount which is compounding at almost 26 percent per annum (AgriTrends 1991). Production in the United States is about 10 times larger. The annual slaughter of Alaskan reindeer is 187 tons and has a value of $857,000 (Anonymous 1992).

In the lower 48 states of the United States, game-ranched and farm-raised venison production totaled 110 tons in 1990 (25 tons from farm-raised stock), which reflects an increase in production of 177 percent per annum since 1983 (Judy 1992). Average carcass weights of reindeer slaughtered in Alaska are 70, 69 and 47 kilograms for castrates, males and females, respectively, and are sold at about $7 per kilogram for state-inspected carcasses.

Of the farm-raised stock, most of the 25 tons of venison production is from fallow deer. Fallow deer are slaughtered at about 18–24 months of age and yield an average carcass size of about 30 kilograms. The carcass is marketed for about $6.60–8.80 per kilogram, which translates into a carcass return of about $230. Because stags are held currently for velvet production, venison production from wapiti and red deer is small, particularly in light of massive slaughters to control tuberculosis and *Elaphostrongylus cervi*. As this problem is resolved and as velvet prices continue to fall, attention will turn to venison production.

The demand for game meats is reflected in increased sales. In a survey by Judy (1992), multiproduct meat wholesalers that vend venison have increased sales 15–500 percent since 1984. Judy (1992) also reported that venison was the predominant import meat of every exotic/game meat wholesaler, and 76 percent of the businesses believed the game meat industry will double or triple in the next five years. While attention must be placed on consumer education and the development of value-added products, Judy's data show the confidence and potential of this market.

Antlers and Other By-products

There has long been commerce in game hides largely from animals killed by sport hunters. Trophies also have been bought and sold. A central controversy about the emerging game industry relates to velvet antlers (and, of course, bear gall bladders and other bear parts).Much of the world's production of velvet passes through Korea, Hong Kong or Taiwan. However, much is processed and re-exported to ethnic markets in Europe and America. Trade statistics are notoriously unreliable partly because of the different classifications used by custom agencies in each country. An undetermined amount enters as contraband to avoid high import duties and from poached stocks. Korea is the main buyer of large velvet from maral, wapiti and reindeer. Hong Kong absorbs much of the smaller product. New Zealand is one of the largest and best-organized suppliers, but in the last two years, markets have been flooded with velvet from Eastern Europe and Russia. However, the quality of product from these sources has been compromised. Maral velvet from Siberia was once a premium product, and better pieces of wapiti velvet from other origins have been marketed under this label. Spoilage of Russian reindeer velvet in 1992 led to voluntary termination of all reindeer velvet imports by the Korean Pharmaceutical Traders' Association.

Current velvet antler production from wapiti is about 35 tons of raw product in North America. At a current conservative value of $110 per kilogram, velvet antler production is worth about $3.5 million. In comparison, the reindeer industry in the United States produces about 22 tons of velvet antler. At a price of $55–100 per kilogram, the total value was $780,000.

Prices for wapiti velvet have been as high as $230 per kilogram for the green product. With yields of over 8 kilograms per mature stag, annual returns well over $1,600 per stag once were obtained. The current glut has depressed prices for all but the best-quality product.

Brood Stock and Reproductive Products

At this early stage of the industry, sale of breeding stock remains a main source of income for game producers. Except for certain exotic species, some of the strongest prices are for wapiti in the wake of disease-control slaughters and the closure of interjurisdictional movement of stock.

Current estimates of cervid and bison breeding stock remain high as people reinvest their compensation from sacrificing their herds (Table 3). However, new investors have been momentarily deterred and prices have stabilized. Within the United States, breeding

Table 3. Representative stock prices (U.S. dollars) in 1992.

	Breeding males	Bred females	Yearling males	Yearling females	Female calf/fawn	Male calf/fawn
Fallow deer						
Midwest USA	700–800	700–900			680[1]	425[1]
South/northwest	800–1,000	350–400				
Red deer		2,400		1,600		
Wapiti	2,250	8,500			6,000	1,100
Bison—farm/ranch-raised						
Stock sales	1,700–2,125	1,800–3,000	1,800	1,830	1,150–1,355	725
Public sales[2]	1,600	1,030	810	970	750	640
Reindeer						
Open range			1,000–1,500	1,000–1,500	800–1,500[3]	
Farmed			2,000	2,500		

[1]Prices are averages for North America.
[2]Average 1992 sale prices from the National Bison Range, Custer State Park, Blue Mounds State Park and/or Fort Niobrara National Wildlife Refuge.
[3]Price range for male and female calves combined.

stock prices are sensitive to geographic area. Generally, prices have remained stable or increased. For example, the average value of fallow deer has increased 56 percent since 1986 (R. Buckmaster personal communication).

In 1992, total value of breeding stock sales in the United States for farm-raised deer was about $3.2 million (R. Buckmaster personal communication). Price of reindeer stock also has increased with the expansion of the industry from open range to a farm business. Since 1980, prices of bison at the annual American Bison Association gold trophy sales have increased 94 percent. Eventually, prices will stabilize at a level which reflects meat values. Time required for stabilization is difficult to predict. Prices stabilized after 20 years in New Zealand as deer herds approached 1 million head.

Protection of Endangered Species

Game farms as well as zoological parks have played important roles in protecting scarce and endangered species. The Plains bison was protected at the end of the nineteenth century by private owners (Dary 1974); indeed, most bison herds can be traced to several dozen wild-caught calves from Yellowstone placed on private farms and ranches. Game farmers recently played a role in building stocks of wood bison in western Canada as part of reintroduction programs.

Some African and Indian species at risk in their own countries have been brought to the New World for protection and breeding. The scimitar horned oryx (*Oryx tao*) and black rhino (*Dicerus bicornis*) are two cases in point. The blackbuck antelope (*Antilope cervicapra*) from the Indian subcontinent was alleged to have been more numerous in Texas than in its native range. Without doubt, now they are more numerous in their native countries than in Texas even though at one time some were returned by air to Pakistan ostensibly to bolster fading numbers (Mungall 1978). Many species, including sable antelope (*Hippotragus niger*), roan antelope (*Hippotragus equinus*), addax and other species retaining small numbers in indigenous habitats, are present on many game farms in Texas and elsewhere.

While some conservationists disagree with this practice, alleging that they could more easily be protected in specially designed parks in countries where they are indigenous, some species thus have been literally brought from extinction.

Some Factors Affecting the Industry

As others in this session will elaborate on factors influencing game farming and ranching, we will only mention them in this paper. Geist (1990) and Teer (1989) presented overviews of purported detrimental effects of fee hunting and game ranching.

Transfer of pathogens and parasites between domestic and free-ranging wild herbivores has occurred with cattle, bison, wapiti, mule deer and possibly white-tailed deer.

The introduction of diseases and parasites with translocations has been perhaps the most important problem in establishing the industry in North America. Brucellosis, tuberculosis and the meningeal worms (*Parelaphostrongylus tenuis* and *Elaphostrongylus cervi*) have caused serious problems in cervids and bovids in Canada and the United States. The interjurisdictional movements of animals thus has been the topic of keen interest of state, provincial and federal governments.

Escapes of non-native wildlife from game farms and ranches also are important implications. Competition between native and non-native species is the basis for many regulations governing translocations of species. While some species have been deliberately released, as gemsbok (*Oryx gazella*) and ibex (*Capra sp.*) have been in New Mexico, others simply have escaped from husbanded or penned herds. At least six species, three cervids and three bovids, are widely established in wild free-ranging stocks in Texas. Nilgai antelope (*Boselaphus tragocamelus*), aoudad (*Ammotragus lervia*), axis deer, sika deer, fallow deer and blackbuck antelope have escaped and spread from game ranches where they had been stocked primarily for hunting (Teer 1989).Illicit capture and translocations of wild stocks of wapiti and confusion of products of game farms with those of wild stocks are other matters of concern to conservationists and to the industry.

Species such as those of the genus *Cervus* (wapiti, sambar, red deer, sika), sheep and goats readily interbreed and thus are a special problem to the purity of wild stocks.

Humane practices and animal health in keeping animals and in extracting antler velvet are topical with various segments of society. The industry is addressing these problems with the uses of tranquilizers and guidelines for close work (e.g., velveting, castration and penning of captive animals).

Laws and Regulations Governing the Industry

A survey of states of the United States and provinces of Canada concerning uses of non-native large mammals and laws governing their importation and release showed an enormous difference and diversity (Teer 1991).

Most states and provinces are opposed to introduction and release of exotic animals into wild habitat. Some states and provinces freely permit introductions and translocations of both native and non-native species for use in game farms. Game breeder's license and health certificates commonly are required. Others have banned translocations and releases entirely. Washington State's Wildlife Commission recently placed a temporary "emergency" ban on import, transport and propagation of a wide variety of deer, antelope, sheep and goats (Anonymous 1992), and Oregon appears to be following suit.

There simply is no uniformity in laws and regulations guiding the importation, release and husbandry of large mammals. Inter-continental translocations are possible to the United States and interstate translocations are poorly regulated in most states if at all. Because of the surge in interest in game farming, many state and provincial government conservation agencies have been prompted to examine their current laws and regulations with the view to strengthen them (Teer 1991).

In summary, the industry of game farming and ranching and the commercialization of hunting are gaining momentum in North America. States and provinces are dealing with it primarily to protect native wildlife and to provide the agricultural community with another product for diversifying its sources of income. Much remains to be done before the industry is firmly established, or as some might prefer, finally closed.

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Captive Cervids as Potential Sources of Disease for North America's Wild Cervid Populations: Avenues, Implications and Preventive Management

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Introduction

North America's native wild cervids represent a diverse and valuable wildlife resource, and occur in virtually every terrestrial ecosystem on the continent. Several members of the family Cervidae have only recently recovered from declines caused by exploitation in the face of settlement and market hunting more than a century ago. White-tailed deer (*Odocoileus virginianus*), mule and black-tailed deer (*O.hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), and caribou (*Rangifer tarandus*) are once again abundant throughout much of their historic ranges. Today, North America's native cervid resources may conceivably exceed 25,000,000 animals in total.

Wild cervid populations throughout North America are generally healthy and free from significant disease problems. Native cervids are, however, susceptible to a variety of infectious and parasitic diseases (reviewed by Davidson et al. 1981, Dieterich 1981, Forrester 1992, Hibler 1981, Kistner et al. 1982, Thorne et al. 1982). Sporadic infections and occasional disease outbreaks occur in local populations, but these usually are self-limiting and/or have relatively minor impacts on affected populations and their management. Moreover, with one notable and well-described exception—brucellosis in elk in the Greater Yellowstone Ecosystem (Thorne et al. 1979, Thorne et al. 1991a, Thorne and Herriges 1992)—wild cervid populations in North America are apparently free from diseases targeted for eradication under federally sponsored livestock health programs.

Establishment and Transmission of Disease in Captive Cervids

In contrast to free-ranging cervids, native and exotic cervids held in captivity for commercial purposes represent significant potential sources of disease. Activities associated with captive propagation and commercialization of various cervid species have increased exponentially over the last two decades throughout much of North America (Renecker 1991, Anonymous 1992). Unfortunately, much of this growth occurred in the absence of comprehensive or coordinated regulations for identification, sale, transport, records, and disease testing and control of captive wildlife species. This lack of regulation not only fostered an environment favorable for establishing and disseminating various diseases (Clifton-Hadley and Wilesmith 1991), but also increased the difficulty of detecting and subsequently controlling outbreaks that may occur. Early records and documentation of problems associated with wildlife commercialization in North America are incomplete. We believe documented examples probably underrepresent the overall magnitude of such problems, particularly before the early 1980s. Based on experiences in other countries where wild ungulates have been farmed or ranched over longer periods of time (reviewed by Mackintosh 1990, Clifton-Hadley and Wilesmith 1991, Wilson 1991), it is likely that significant disease problems already may have become established in commercial wildlife facilities throughout North America. The magnitude of such problems, the likelihood of their detection and control, and their impacts on free-ranging wildlife are presently unknown.

Several conditions favor the establishment, propagation and dissemination of various disease problems among commercial wildlife facilities in North America. Coordinated disease surveillance programs for captive cervids are generally lacking. Moreover, unregulated movements of captive cervids largely disregard dissemination of diseases as a possible consequence of such transactions and may promote the spread of certain pathogens (e.g., bovine tuberculosis). Various aspects of biology and behavior of captive cervids, including social structures and interspecific variations in susceptibility to parasitic and infectious agents, may lead to establishment of disease problems. Captive cervids are not domesticated, and most are only partially adapted to captivity. In addition, requirements for maintaining healthy captive herds often are either poorly understood or ignored. Consequently, captivity and poor husbandry practices may further increase susceptibility to disease via stress and malnutrition (Griffin 1989, Wilson 1991). Finally, relatively few producers and veterinary practitioners in the United States or Canada are familiar enough with unique aspects of cervid medicine and health management to allow early recognition and control of disease problems.

Potential for Transmission of Diseases from Captive to Wild Cervids

These conditions, combined with the proximity of many captive wildlife facilities to large native cervid populations (Anonymous 1992), foster situations that might lead to transmission of various diseases from captive to free-ranging cervids. Potential transmission routes include fenceline contact, ingress and egress of free-ranging animals, environmental contamination with pathogens, and/or escape of infected individuals; the relative importance of these avenues of transmission varies somewhat by agent and location. In light of observations made in Colorado (Kahn 1993) and elsewhere, however, we believe interactions between escaped captive and free-ranging cervids offer the greatest potential avenue for introducing disease from affected facilities into native wildlife populations.

To date, there has been no documented case where a novel disease has been transmitted from captive to free-ranging cervids in North America — we hope never to have data on such disease introductions. Nonetheless, commercial wildlife facilities represent a significant potential source of novel, uncommon or currently absent diseases that could be introduced into native wildlife and/or domestic livestock populations. We believe two recent experiences in the U. S. and Canada illustrate that the potential for disease introduction from captive cervids to free-ranging wildlife currently exists.

Bovine Tuberculosis in Captive Cervids

Occurrence of a significant disease problem in commercial wildlife facilities and its potential for introduction into free-ranging wildlife is perhaps best illustrated by an ongoing bovine tuberculosis outbreak in captive cervid herds throughout the U. S. and Canada. This outbreak may have started more than a decade ago (Stumpff 1982), but poorly regulated and/or unrecorded animal movements and unreliable testing practices apparently precluded its detection until 1990. By September 1992, *Mycobacterium bovis* infections had been confirmed in captive cervid herds from eight states (Anonymous 1992, Essey and Meyer 1992) and four provinces (Roffe and Smith 1992). In Alberta, whole-herd testing detected bovine tuberculosis in 13 of about 120 game farms; for three of these herds, prevalence ranged from about 18–60 percent (M. J. Pybus and S. V. Tessaro personal communications). About 2,500 captive elk and other susceptible animals were exposed to tuberculosis on infected premises in Alberta and consequently have been slaughtered. Testing in Montana, the proximate source of Alberta's epizootic, also revealed tuberculosis in four of that state's more than 40 elk ranches, but none of the infected herds were depopulated (Essey and Meyer 1992). In Colorado, at lease eight game ranches were investigated and tested based on traced movements of captive cervids to or from other game ranches where tuberculosis infections had been confirmed. In two traceback herds, the animals in question had been "brokered" and could not be located for testing. In another traceback herd near Powderhorn, about 70 percent of captive elk ≥ two years old were diagnosed with tuberculosis at necropsy in 1991 (Miller et al. 1991, Rhyan et al. 1992).

Although investigated extensively, only portions of the epizootiology of this outbreak have been described fully. Where infections of elk were confirmed in Colorado, *M. bovis* was apparently imported in false-negative caudal fold-tested elk that originated from Nebraska by way of Montana (Miller et al. 1991); the latter herd was presumably the source for Alberta's outbreak as well. Bovine tuberculosis spread undetected in the Powderhorn herd for over four years. During that period, fenceline contact with wild elk was likely, and wild mule deer were known to have entered and left the affected facility. Live elk probably had not been sold from this facility, but no records were available for inspection. Only 9 of 30 founder animals were identified at depopulation — the fates of the other 21, all probably exposed to tuberculosis, are still unknown.

The outbreak at Powderhorn had many of the key elements identified by Thorne et al. (1993) as likely to result in introduction of bovine tuberculosis into local wild cervid populations. Similar circumstances have surrounded some affected captive wildlife facilities in Alberta and Montana — in the latter case, the possibility of escape or release of infected elk from one game ranch could ultimately place more than 98,000 elk and 3,500 free-ranging bison in the Greater Yellowstone Area at risk of exposure to tuberculosis. Unfortunately, it will take several years and significant investigative efforts before wildlife managers can reliably determine whether or not tuberculosis was introduced in any of these cases. Although tuberculosis has never become established in wild cervids anywhere in North America (Tessaro 1986, Anonymous 1992), current conditions in some locations may allow this disease to be perpetuated in the wild (Anonymous 1992, Thorne et al. 1993). It follows that precluding circumstances leading to potential introductions seems a far more effective strategy for protecting wild cervid populations from bovine tuberculosis, because it is unlikely that the disease could be eradicated from many free-ranging cervid populations once it has become established (Thorne et al. 1993).

Potential for Spread of Meningeal Worm via Captive Cervids

White-tailed deer are normal hosts for meningeal worm (*Parelaphostrongylus tenuis*). This parasite rarely causes problems to infected white-tailed deer. In other wild ungulates, however, accidental infections with meningeal worm usually result in spinal cord and/or brain damage that is often fatal (reviewed by Anderson and Prestwood 1981, Samuel et al. 1992). The prevalence of parelaphostrongylosis is high in white-tailed deer populations in many eastern and midwestern states and provinces (Anderson and Prestwood 1981, Comer et al. 1991). White-tailed deer also thrive in riparian habitats throughout many western states and provinces, but these populations are free from meningeal worm. However, because suitable intermediate hosts are relatively ubiquitous in distribution, these western white-tailed deer populations represent a large potential reservoir for perpetuating *P. tenuis* should it become established (Samuel 1987). At present, meningeal worm infections cannot be eliminated from white-tailed deer using anthelmintic therapy (Kocan 1985). However, some drugs (e.g., ivermectin) can mask infections by temporarily eliminating fecal larval shedding (Kocan 1985), the diagnostic criterion used to screen for infection in live animals. It follows that translocating white-tailed deer, wild or privately owned, from areas where meningeal worm is enzootic to western states and provinces carries a high risk of extending the distribution of this potentially damaging parasite (Samuel 1987, Samuel et al. 1992).

Recent experiments in elk revealed that white-tailed deer are not the only potential vector for introducing meningeal worm into western ranges (Samuel et al. 1992). Seven of eight elk calves infected with doses of 25 or 75 *P. tenuis* larvae, exposures that might approximate natural rates, developed patent infections and shed viable first-stage larvae in their feces; only two calves died. Although *P. tenuis* infections were fatal in 13 other elk calves given $\geq$ 125 L_3, two of these also shed larvae before dying. Results of these studies clearly demonstrated the potential for translocating meningeal worm into western states and provinces where it does not currently occur by importing infected captive elk, and perhaps other captive cervids, from enzootic areas in eastern North America. Once introduced, meningeal worm could become irretrievably established and dispersed through resident white-tailed deer populations (Samuel 1987, Samuel et al. 1992). In light of these results, and considering the wealth of wildlife resources that may be placed at risk by introducing *P. tenuis* into western North America, we believe it imprudent to allow movements of captive cervids from meningeal worm-enzootic areas to western states and provinces where this parasite could become established until reliable tests are developed to screen all captive cervid species for infected individuals prior to shipping.

Implications for Free-ranging Cervid Populations

Introduced diseases could have a variety of health, management and economic implications for affected free-ranging cervid populations, as well as the agencies responsible for them. Some novel diseases (e.g., rinderpest, some strains of bluetongue or epizootic hemorrhagic disease) would cause direct mortality; losses could be explosive, independent of population densities, and additive to other sources of mortality. Local populations and/or unique gene pools could be diminished or lost, either directly or in the wake of clean-up efforts — Longhurst et al.'s (1952:107–108) account of foot-and-mouth disease eradication in deer in California bears testament to the potential magnitude of the latter. Other more insidious agents might reduce overall health of affected herds, and could alter age structures and reduce recruitment in these populations. Consequently, overall population performance and resilience could be compromised.

Establishing novel pathogens in native cervid populations also could limit options for resource management. Introduction of some diseases would dramatically affect use of sport hunting as the preferred management tool for controlling infected populations. Both public health concerns and perception would impact hunter participation. Establishment of some novel diseases in an area also would affect management of other wildlife (and domestic) species and could preclude translocating animals from or establishing new susceptible species in infected areas. Introducing certain diseases into wild cervids could affect suitability of public lands for livestock grazing. Establishing foci of tuberculosis or other livestock diseases in free-ranging wildlife could fuel conflicts between livestock and wildlife interests and the respective state and federal agencies representing them, not unlike those already associated with brucellosis in the Greater Yellowstone Area (Thorne et al. 1991a, 1991b; Thorne and Herriges 1992).

Big game sport hunting is an economic mainstay of many ''game cash''-funded wildlife management agencies. Reducing these revenues would be detrimental to agencies and their management programs. Big game sport hunting also provides significant income for many state and provincial economies, particularly in the West. For example, in 1991 deer and elk hunting contributed nearly $450 million to Colorado's state economy (Colorado Division of Wildlife 1993). Loss of hunting revenues could be particularly devastating to rural economies. Establishing reservoirs of reportable diseases in wild cervid populations could adversely affect livestock markets and agricultural economics by changing ''disease-free'' status of affected states, provinces and nations. Finally, attempts to control significant disease problems in free-ranging cervids will be costly. Such activities, unless paid for by those responsible for initial disease introductions, could divert funding from other important management activities.

Lack of data limits reliable quantitative assessments of risks to native wildlife populations associated with diseases that could be introduced through captive cervids. Many factors preclude unequivocal predictions regarding the outcomes of such introductions. Knowledge is incomplete for most diseases in native and exotic cervids. Details of epizootiology in and among various species in captivity and/or in the wild are undescribed. Host ranges for many infectious and parasitic agents are undefined. Diagnostic tests for many important pathogens generally are unproven, unreliable and/or unavailable for use in captive cervids. Perhaps most critical, *the long-term consequences of introducing any of these diseases into free-ranging wildlife populations are unknown or, if known, are highly undesirable*. Equally disturbing, based on experiences in North America and elsewhere, is the recognition that *many of these diseases, once introduced, will be virtually impossible to control in free-ranging wildlife populations*. Clearly then, preventing such introductions is the only responsible option available to agencies charged with protecting, preserving and enhancing native wildlife resources.

Strategies for Preventing Disease Introductions by Captive Wildlife

In the absence of reliable knowledge diminishing the potential impacts of diseases introduced by captive cervids on native wildlife resources, we believe responsible resource management agencies are justified in adopting conservative approaches to minimize opportunities for such occurrences. Legal precedent supports our belief. A recent decision[1] in U. S. District Court in Washington upheld that state's "legitimate interest in guarding against imperfectly understood environmental risks, despite the possibility that they might ultimately prove negligible."[2] The court found that the state need not "sit idly by and wait until potentially irreversible environmental damage has occurred, or until the scientific community agrees on what disease organisms are or are not dangerous before it acts to avoid such consequences."[1]

Introduction of tuberculosis, brucellosis, parelaphostrongylosis, the African form of malignant catarrhal fever, foreign animal diseases (e.g., rinderpest, foot-and-mouth disease, etc.) or other significant infectious and parasitic agents into native cervid populations via commercial wildlife facilities could be biologically and/or politically catastrophic. It follows that developing proactive programs and regulations to prevent captive cervids and other captive wildlife from introducing significant diseases into native wildlife populations is the only sound management strategy presently available. For some disease problems in certain species, genera or families of wildlife commercially traded, completely banning their importation and possession is presently the only effective means of preventing introduction of novel pathogens or parasites into native wildlife populations. Cases where importation and possession of species, genera or families for commercial purposes are prohibited have been carefully considered in Colorado (Kahn 1993), Wyoming (Lanka et al. 1990) and elsewhere. With respect to disease problems, we believe this classification generally should be reserved for those diseases with high potential for introduction and/or irreparable damage to native wildlife, livestock resources or public health that cannot be prevented by diagnostic screening and/or treatment of infected individuals of all susceptible captive wildlife species. For many species, genera or families in this category, threats posed by potential for interbreeding and/or competing with native species also may contribute to their classification as prohibited (Lanka 1990, Smallwood and Salmon 1992, Kahn 1993).

In cases where prohibition is unjustified or infeasible, uniformity in regulatory approaches affords the greatest level of protection to native wildlife resources; inconsistencies compromise efficacy of these efforts. Components of a proactive approach to preventing disease introductions while allowing private ownership of captive cervids should include regulations for identification, record keeping, movement, disease testing, quarantine and health inspection of captive cervids and other commercially owned wildlife (*see* Anonymous 1991 for specific recommendations). Additional elements needed to ensure success of programs prohibiting and/or regulating captive cervids to protect native wildlife from disease introductions include support for monitoring compliance and enforcing regulations, prosecution and penalties for violations (including liability for costs of depopulation or eradication programs), and support for improving species-specific diagnostic testing and detection methods for important disease problems. State wildlife management agencies should have the lead role in these regulatory efforts. However, because several diseases of captive cervids represent serious threats to agriculture and public health interest, improved communication and cooperation between wildlife management, agriculture and public health agencies is essential. These entities should work closely together in all jurisdictions to ensure that the fledgling commercial wildlife in-

[1]*Pacific Northwest Venison Producers et al. v. Curt Smitch et al.* USDC WD No. C92–1076WD; September 2, 1992.
[2]*Maine v. Taylor*, 477 U.S. at 148, cited and quoted in *Pacific Northwest Venison Producers et al. v. Curt Smitch et al.*

dustry does not jeopardize viable and vital established interests through introduction or perpetuation of serious disease problems.

Introducing novel pathogens or parasites into North America's wild cervid populations through commercial propagation of captive wildlife poses a clear and present threat to the health and management of our native wildlife resources. Coordinated interagency regulatory efforts are needed to prevent such occurrences and protect valued wildlife resources. Recent attention to problems associated with wildlife commercialization in North America has focused largely on those associated with captive wild ungulates, particularly elk and other cervids. Similar potential problems undoubtedly are associated with captive propagation of other native and exotic fish and wildlife species that, although not addressed here, should neither be ignored nor underestimated in developing proactive management strategies.

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Interspecific Competition Between Four Exotic Species and Native Artiodactyls in the United States

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Introduction

Numerous species of exotic big game occur throughout the United States either confined or free ranging (Lever 1985). Many big game introductions were made in the early 1900s when little attention was paid to wildlife management in general and none to consequences of introductions for habitats or native species. Many of the resulting free-ranging exotic big game populations have been in place 70 years or more. Both negative and positive factors may be associated with any exotic population (Craighead and Dasmann 1966, Demarais et al. 1990, Morrison 1989). Wildlife agencies generally consider exotic big game as potential competitors with native wildlife, and as having no positive qualities (Ervin et al. 1992). Interspecific competitive relationships often are difficult to quantify because of temporal and spatial complexities of study areas, and unique attributes and characteristics of populations involved (Brown 1989, Crawley 1989, Wiens 1977). As such, empirical data on interspecific competitive interactions between free-ranging populations of exotic and native big game are limited. From the applied standpoint of wildlife agencies dealing with habitat degradation and ever-diminishing fiscal resources, free-ranging exotics often are viewed as contrary to the best interests of an overall management program.

We review evidence for interspecific competitive interactions between native artiodactyls in the United States and four species of exotic, sympatric, free-ranging species: sika deer (*Cervus nippon*), axis deer (*Cervus axis*), fallow deer (*Dama dama*) and aoudad or Barbary sheep (*Ammotragus lervia*). These exotic species were selected because they are common in terms of current distribution and/or density. Also, they have been in place for many years and are therefore significant for management considerations, and are species for which at least some empirical data are available. Evidence for interspecific competition is reviewed within the following contexts: (1) the degree of overlap in resource use; (2) changes in resource use caused by the presence of another species; and (3) changes in population characteristics (such as density or age-structure) or individual characteristics (such as fecundity or survival) caused by interaction with the other population(s) (MacNally 1983). We define an exotic as a species not distributed naturally in the Nearctic faunal region (Demarais et al. 1990). We consider interspecific competition as use or defense of a limited resource by a species that reduces the availability of that resource to one or more other species.

Methods

Published information related to interspecific competition was compiled for the four exotic species. State and federal agency personnel currently involved in management of exotics were contacted for current information, policies and programs dealing with exotics. Agency personnel also provided unpublished data and file reports on the four exotic species reviewed.

Results

Sika Deer

Sika deer are native to Japan and the east Asian mainland. In the U. S., free-ranging populations are sympatric with white-tailed deer (*Odocoileus virginianus*) in Maryland, Chincoteague Island in Virginia, and Texas. There also was a small population in south-central Wisconsin. Free-ranging sika deer were introduced in Maryland in 1916. The greatest concentration of sika deer in the state occurs in the southern portion of Dorchester County. The density and local distribution of this population were quite restricted until the 1970s (Feldhamer et al. 1978). From 1973 through 1977, total deer harvest in southern Dorchester County remained stable, but the number of whitetails declined from 75 percent of the harvest to 36 percent. For the last three hunting seasons for which data are available (1989–1991), total harvests have increased an average of 68 percent from the 1970s (to a mean of 1,339 deer per year), although the mean percentage of whitetails (34 percent) has remained constant (Table 1). This is suggestive, although certainly not conclusive, of depressive competition favoring sika deer, if one accepts the implied assumption that harvest trends parallel relative population densities. Several biases may affect the validity of this assumption, however. Sika deer may be preferred by hunters because of their uniqueness or novelty as trophies. Conversely, hunters may prefer whitetails because of their greater body size. Finally, interspecific competition may not be operating at all. Each species may have responded differently to either a habitat change

Table 1. Harvest-revealed relative percentage of free-ranging sika deer (*Cervus nippon*) and white-tailed deer (*Odocoileus virginianus*) from southern Dorchester County, Maryland. Includes data from archery, firearms and muzzleloader seasons.

Year	Total number of deer harvested	Percentage sika deer	Percentage white-tailed deer
1973[a]	973	24.8	75.2
1974	883	33.6	66.4
1975	828	39.6	60.4
1976[b]	921	55.8	44.2
1977	981	64.1	35.9
1989[c]	1530	69.8	30.2
1990	1349	62.9	37.1
1991	1138	65.5	34.5

[a]Two deer of either sex and species.
[b]Firearms allowable bag limit: 1 white-tailed deer and 2 sika deer; or 3 sika deer. Archery allowable bag limit: 1 white-tailed deer and 1 sika deer. No muzzleloader season.
[c]Current allowable bag limits in Dorchester County are: archery—1 white-tailed deer and 1 sika deer; firearms—1 white-tailed deer and 2 sika deer; muzzleloader—1 white-tailed deer and 1 sika deer. An additional deer of either species may be taken with a Bonus Deer Stamp during all three seasons (archery, firearms and muzzleloader).

or disease during the 1970s and maintained a new equilibrium. However, the idea that the Maryland harvest data reflect interspecific competitive replacement is reinforced by trends in other sika deer populations, including the results of experimental enclosure studies on sika deer and white-tailed deer in Texas.

The trend in sika deer numbers in Texas has increased steadily. The latest statewide survey lists about 12,000 sika deer, of which 5,600 are free ranging (Traweek 1989), and these figures are very conservative (J. Baccus personal communication: 1993). Sika deer have increased 49 percent from 1984 to 1988. In an effort to investigate competition between sika deer and whitetails, studies were done in enclosures in the Edwards Plateau region. Six adults of both species were introduced into a 96–acre (30 ha) enclosure in 1971 and monitored through 1979. A similar enclosure, operated since the 1950s, with about 15 adult whitetails, was used as a control (Harmel 1980). While the sika deer population increased from 6 to 62 by the end of the experiment, whitetails increased to 17 the second year and then declined to extinction (Figure 1A). There was a significant inverse relationship in population density between sika and white-tailed deer in the enclosure (Spearman $R = -0.746$; $P = 0.02$). The control population remained stable at 14 individuals by 1979, or about 0.36 deer per hectare. This is about average deer density for the region. The yearly population density of whitetails in the experimental enclosure was independent of the whitetail population density on the control enclosure during the study period ($P > 0.05$). On both enclosures, forage production was poor and was considered to be limiting. Browse and forbs were consumed by both whitetails and sika deer. The exotic deer also ate grass and maintained reproduction as other forage species were consumed. These results again are suggestive of depressive competition. It may be argued however, that a different outcome might have occurred had individuals in each population been allowed to disperse beyond the bounds of the enclosure, had different individual deer with different genetic makeups been introduced into the pens originally, or had different weather prevailed throughout the experiment. Despite inherent assumptions and drawbacks, the Maryland harvest results and Texas enclosure experiments are consistent in their conclusions that sika deer outcompete white-tailed deer.

Additionally, we may consider degree of overlap in resource use noted by Keiper (1990), who reported that the diets of sika deer and white-tailed deer on Assateague Island, Maryland, were positively correlated ($P < 0.02$). He also found the deer population on Assateague Island was composed of 75 percent sika and 25 percent whitetails — similar to the relative percentage of each species in current hunter harvests from southern Dorchester County.

The situation on the southern extension of Assateague Island, specifically Chincoteague National Wildlife Refuge, Chincoteague Island, Virginia, is similar. Chincoteague N.W.R. has sympatric populations of sika deer and white-tailed deer. Sika deer were introduced in the 1930s. Both sika deer and white-tailed deer have been harvested since herd control management was initiated in 1964. During the 10–year period from 1977 through 1986, an average of 100 deer was harvested, of which 84 a year (84 percent) were sika deer. In response to a perceived decline in the density of native deer, there has been no white-tailed deer harvest since 1987. Sika deer harvest has continued at an accelerated pace. In fact, the mean number of sika deer taken during the five-year period from 1987 through 1991 was 271 per year. This is more than three times the mean number harvested per year from 1977–1986. Nonetheless, autumn prehunt spotlight counts since 1989 indicate white-tailed deer comprise only about 20 percent of the total deer, compared to a 10–year average of 16 percent when both species were harvested (I.

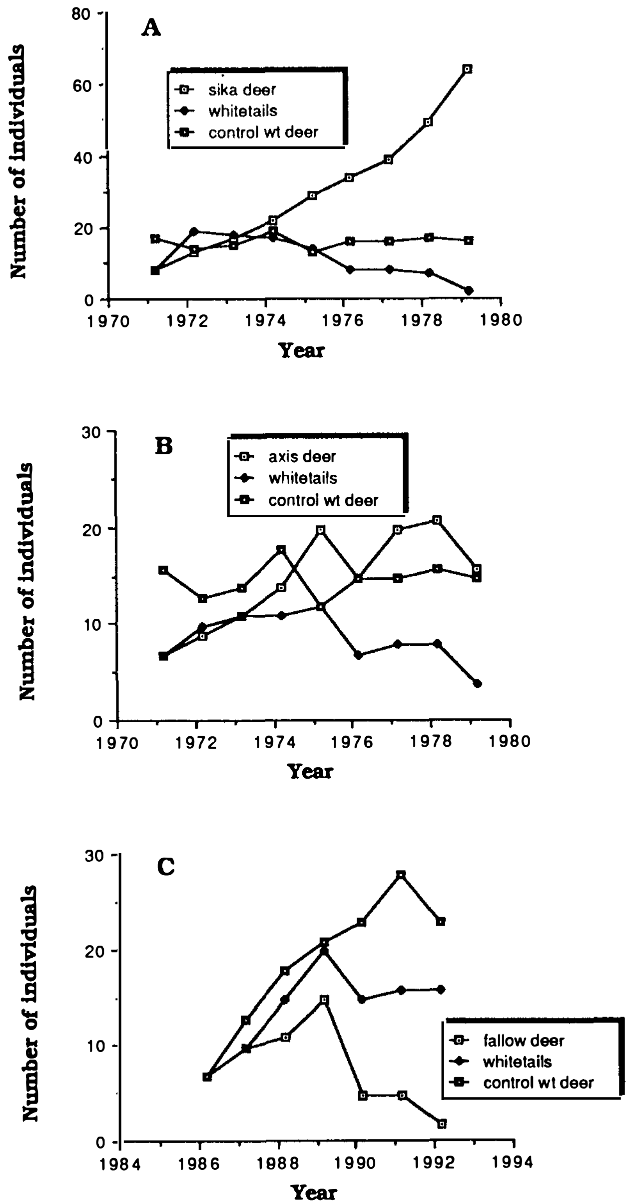

Figure 1. (A) Number of sika deer (*Cervus nippon*) and white-tailed deer (*Odocoileus virginianus*) in a 39–hectare enclosure, and a control population of whitetails in an adjoining 39–hectare enclosure without exotics, between 1971 and 1979 in the Edwards Plateau region of Texas; (B) Number of axis deer (*Cervus axis*) and white-tailed deer in a separate 39–hectare enclosure, and the control population of whitetails, between 1971 and 1979 in the Edwards Plateau region of Texas; (C) Number of fallow deer (*Dama dama*) and white-tailed deer in a 39-hectare enclosure, and a control population in an adjoining 39–hectare enclosure, between 1986 and 1992 in the Edwards Plateau region of Texas (from data in Harmel 1980, 1992).

Ailes unpublished data: 1992). As in Dorchester County and Assateague Island, Maryland; and Texas, the exotic sika deer appear to have effectively displaced native white-tailed deer.

Dietary overlap and competitive advantage of free-ranging sika deer over whitetails on forage-limited habitats in Texas again were noted by Butts et al. (1982), using the animal-bite observation technique, and Kelley (1970) and Henke et al. (1988) based on rumen analyses. These results are consistent with the conclusions of Hofmann (1985), based on comparative rumen anatomy and feeding behavior, that sika deer are more opportunistic, less specialized and more adaptable in forage selection than white-tailed deer. Finally, although there are no behavioral studies on sika deer and white-tailed deer in sympatric U. S. populations, the aggressive nature of sika deer and their ability to physically displace other species of deer has been documented elsewhere (Kiddie 1962).

Axis Deer

The spotted deer, chital or axis deer is native to India, Nepal and Sri Lanka. It is the most numerous exotic in Texas. Current estimates are over 39,000 individuals, of which 17,000 are free-ranging (Tranweek 1989). There are small populations of axis deer of undetermined status in Volusia and Marion Counties, Florida, which apparently have not expanded since their release in the 1930s (F. Montalbano and C. Chappell personal communication: 1992). They also have been introduced onto several Hawaiian islands (Lever 1985). These introductions will not be considered here as there are no native big game species in Hawaii, and thus no interspecific competition. As noted by Coblentz (1978, 1990) however, the biota of island ecosystems are particularly vulnerable to exotic mammalian herbivores. Since the 1940s, axis deer have been free-ranging on Point Reyes National Seashore, California, where they are sympatric with fallow deer and native black-tailed deer (*Odocoileus hemionus columbianus*). There has been no public hunting since 1967. Populations of both exotics on Point Reyes have been culled yearly since 1976 by the National Park Service to maintain about 350 individuals of each species. Culling (a high of 356 exotics in 1981, a low of 35 in 1983; J. Sansing unpublished reports: 1992) is done in response to perceived danger to the natural ecosystem posed by exotics (Wehausen and Elliott 1982), and the belief that "exotic deer are having a significant impact on the native black-tailed deer population" (Fellers personal files: 1983). There are no concurrent estimates on the size of the black-tailed deer population.

Again, enclosure experiments in Texas offer the only direct experimental attempt to determine the extent of competitive interactions. Six adult axis deer and six adult white-tails were studied in a 39–hectare enclosure from 1971 through 1979. The white-tailed population increased to a high of 11 animals in 1975 before declining to 3 nonbreeding individuals by 1979. Axis deer peaked at 20 individuals in 1978 and declined to 15 by the end of the experiment a year later (Harmel 1980, Figure 1B). In this case, yearly whitetail density was not significantly correlated with axis deer density (Spearman $R = 0.04$; $P > 0.9$). Nevertheless, whitetails declined on the experimental plot, as they did on the control plot during a drought from 1975–1976. Whitetails recovered on the control enclosure. They did not recover on the experimental plot with axis deer present, however.

Results of studies to determine resource overlap between axis deer and native species have been conflicting. Based on bite studies with a tame axis doe, and rumen analyses of axis and white-tailed deer, Smith (1977) found little overlap in feeding habits along the Texas Gulf Coast. Axis deer preferred grass while whitetails were predominately browsers. Similar results were reported by Kelley (1970) and Henke et al. (1988). On ranges in poor condition, however, competition was deemed likely, to the detriment of the native species (Ables and Fuchs 1977). Similar results were reported by Elliott and Barrett (1985) for the three species of cervids on Point Reyes N. S. Diets of axis and fallow deer, primarily grazers, overlapped with each other to a greater extent than either did with the native black-tailed deer. The only exception was during summer. In contrast, Butts et al. (1982), using the animal bite technique for axis deer in Kerr County, Texas, found axis deer had a definite preference for browse, but would switch to grass as browse declined. Butts et al. (1982:41) concluded axis deer (as well as fallow deer and sika deer) "...are severe competitors with white-tailed deer in the Edwards Plateau of Texas".

Fallow Deer

Fallow deer are native to Asia Minor and the Mediterranean region. They are the most widely introduced cervid throughout the world (Chapman and Chapman 1980). In the U. S., fallow deer are free-ranging in nine states. Small populations about which little is known exist in Alabama (Wilcox and Dallas counties), Nebraska (Boone and Wheeler counties), the Sacramento Mountains of New Mexico, and Maryland (Talbot County). Larger populations occur in Trigg County, Kentucky, on Land Between the Lakes, Little St. Simon's Island, Georgia, and Point Reyes N.S. in California. In Texas, about one half the 14,000 fallow deer in the state are free-ranging (Traweek 1989). This represents a 35 percent increase over a four-year period in the number of fallow deer in Texas.

Enclosure studies to assess competitive interactions of fallow deer and white-tailed deer were conducted in Texas from January 1986 through February 1992, under the same conditions described previously (Harmel 1992). Unlike the sika deer and axis deer experiments, the white-tailed population increased while the fallow deer population did not remain viable (Figure 1C). Most studies on potential interspecific competition in fallow deer have dealt only with the degree of overlap in feeding habits. On Point Reyes, California, population density of fallow deer apparently has increased more slowly than that of axis deer (Wehausen and Elliott 1982), although it is much more difficult to census fallow deer. As noted, fallow deer preferred grazing although their diet overlapped with black-tailed deer in summer (Elliott and Barrett 1985). In Texas, however, Henke et al. (1988) suggested the ability of fallow deer to use grass would confer a competitive advantage over native deer when forbs and browse are limited. This does not appear to be the case in Kentucky, however, where fallow deer on what is now Land Between the Lakes (LBL) were introduced in 1920. The population peaked at approximately 800–1,000 individuals, but currently numbers only 200–300. Since their introduction over 70 years ago, 90 percent of fallow deer stay within a very limited, overbrowsed area and never disperse—despite no hunting, abundant forage elsewere and no apparent aggressive interactions with sympatric white-tailed deer (S. Bloemer personal communication: 1992). The decline in the fallow deer population on LBL may be due to meningeal worm (*Parelaphostrongylus tenuis*), although this has not been confirmed.

An unknown number of fallow deer were introduced to Little St. Simon's Island, Georgia, around 1920. They apparently displaced the white-tailed deer, as the native species no longer occurred on the island by 1937. The island is about 3,240 hectares (8,000 acres), half of which provides suitable habitat for deer and supports a current population of about 500 fallow deer (K. McIntyre personal communication: 1992). As noted, island biota often are more vulnerable to exotics than are continental communities. This may account in part for the success of fallow deer on Little St. Simon's Island, and sika deer noted previously on Assateague and Chincoteague Islands.

Aoudad Sheep

Native to North Africa, free-ranging populations of aoudad currently occur in Texas and New Mexico. Recent free-ranging populations in California (Barrett 1980, Morrison 1984) have been eliminated through culling, and aoudad now occur only in confinement in the state (B. Clark personal communication: 1992). Aoudad have proven to be highly adaptable in their feeding patterns, disperse rapidly and have relatively high reproductive potential (Barrett 1967). As such, they are considered as potential competitors with mule deer (*Odocoileus hemionus*) and desert bighorn sheep (*Ovis canadensis*) (Simpson et al. 1978, Seegmiller and Simpson 1979).

As of 1988, there were over 20,000 aoudad in Texas, about one-half of which were free-ranging (Traweek 1989). This is exclusive of the harvested, free-ranging population in Palo Duro Canyon, established in the late 1950s (Dvorak 1980). Census estimates of aoudad in Palo Duro Canyon show an increase from 72 animals in 1965 to 775 animals in 1975. Unfortunately, there are no concurrent estimates of mule deer numbers during this period. Aoudad have since spread to surrounding counties outside the census area. Evidence for competitive interaction is again based on observed overlap in feeding habits studies. For the population in Palo Duro Canyon, Krysl et al. (1980) found a dietary overlap index of 74 percent between aoudad and mule deer, with browse providing the greatest component of similarity. They felt there was a strong potential for interspecific competition should populations continue to grow and forage become limited. Browse also was the preferred forage of aoudad on Kerr Wildlife Management Area, although grass made up the largest part of the diet (Butts et al. 1982). They concluded that competition between aoudad and white-tailed deer would occur for forbs, although availability of forbs and extent of habitat partitioning in the region was not addressed.

In Largo Canyon, New Mexico, Bird and Upham (1980) reported an overall dietary overlap of only 48 percent for aoudad and mule deer. The degree of overlap reached 92 percent during the summer, although this may have been an artifact of the sampling method. Low percentages of overlap in winter and spring suggested little potential competition, however. Additionally, they suggested there was relatively little habitat overlap (42 percent) on their study area, with the two species reducing the potential for interspecific competition through habitat partitioning. Current recommendations for aoudad in Largo Canyon, Canadian Canyon, and Hondo Valley, New Mexico, call for populations to be managed "...within levels so competition with other species is minimized and movement from these areas does not occur." Other aoudad populations are to be removed from areas occupied by desert bighorn sheep, and from areas designated for transplants of desert bighorns (D. Weybright personal files: 1992).

Discussion

It is apparent that the four exotic species considered have well-established populations in a variety of different regions and/or habitat types. Sika deer in Maryland, Virginia and Texas, axis deer in Texas, and aoudad in Texas and New Mexico appear to be particularly successful in terms of maintaining population density and distribution. Populations of fallow deer appear to be somewhat less consistently successful in expanding their local distribution. Other introductions of these species have failed. Axis deer have not increased in density or distribution in Florida. Sika deer introductions have failed in Michigan and Nebraska. Fallow deer introductions in Indiana, Louisiana, Michigan, Oklahoma and Colorado all failed to produce viable populations (Lever 1985). These failures no doubt were because of one or more factors—low initial numbers introduced, poor timing, sex and age ratios, health or genetic vigor of individuals, predators, parasites and diseases, and/or condition of habitat. In short, the n-dimensional mosaic of interacting factors, in addition to potential competition with native ungulates, makes the outcome of any big game introduction uncertain. From the standpoint of a resource manager, however, it is not important that a certain introduction may fail. What is critical is that it may succeed, most often to the detriment of native biota.

The same n-dimensional array of factors operate on successful introductions, and preclude the predictability desired by resource managers regarding native/exotic population interactions. This was stated by Brown (1989:104) in the general context of exotic vertebrates: "That particular problems caused by an exotic species in a certain area must always be dealt with on a case-by-case basis does not necessarily reflect on the inadequacy of basic ecological knowledge or the failure to apply general concepts to specific situations. Instead it is a necessity imposed by the historically based uniqueness of both organisms and their environments." Additionally, the relative influence of intraspecific competition within exotic and native populations never has been addressed. It may outweigh interspecific competition in certain situations, such as on overgrazed habitat.

We may expect competition between exotic and native artiodactyls both intuitively, and on the basis of previous field experiments with a variety of animal groups from various trophic levels and habitats (*see* Schoener 1983). Most studies on exotic species considered in this review have been on feeding habits. With the exception of the Texas enclosure studies, there has been no experimental work. Most studies have been primarily descriptive, with competition implied. Alternative explanations, other than interspecific competition, usually can be postulated. In this regard, Arthur (1987:30) noted"...it is necessary to persevere with whatever inadequate data we have at our disposal on natural populations, and attempt to weigh up the alternative merits of competitive and other hypotheses as explanations of species distributions in time or space. As usual in ecology, laboratory experiments give us clear conclusions whose relevance to nature may be debatable, while field studies can hardly fail to be relevant to nature, but are rarely conclusive." Considering the current status of the four exotics reviewed, and the consistent body of evidence suggesting competition, it would seem highly unlikely that interspecific competition was not a major force in these systems.

Competition does not operate in isolation, however. Other factors such as water needs, reproductive potential and dispersal abilities are important determinants in success of exotic populations as well. As noted, aoudad have greater reproductive and dispersal potential than native desert bighorns. On the other hand, the three species of exotic cervids considered generally have single births, while mule deer and white-tailed deer under normal conditions have multiple births (Bunnell 1987). Also, the exotic species generally have a higher age at first reproduction than the native deer (Feldhamer 1980, Feldhamer et al. 1988, although *see* Mullan et al. 1988). Additionally, both sika deer and fallow deer have slow dispersal rates. This is exemplified by the fallow deer population on Land Between The Lakes which, as noted, has not dispersed significantly from a severely overbrowsed area since their introduction over 70 years ago. Expansion of fallow deer and axis deer on Point Reyes also has been limited (Wehausen and Elliott 1982). Regardless, populations of exotic artiodactyls clearly are established and expanding at the expense of native species—again indicative of competition for limited forage resources favoring introduced species. This also may be evident in the generally poor body condition of native species relative to exotics even before population density of the native species declines, as noted by Richardson and Demarais (1992).

Conclusions

Because forage and other resources are variable or unpredictable temporally and spatially (Southwood 1977, Keddy 1989), habitat characteristics necessary to support both exotic and native species rarely are available or constant on a long-term basis. Physiologically and behaviorally (Hofmann 1985), exotic artiodactyls clearly are better able to adapt to increasingly poor habitat conditions. Generally, managers faced with historically secure populations of exotic artiodactyls and sympatric native big game species, and poor habitat conditions, should make every effort to reduce or limit populations of the exotic (Baccus et al. 1985). This is the current management plan for fallow deer and axis deer on Point Reyes N.S., sika deer on Chincoteague N.W.R., aoudad in New Mexico and other areas. New introductions are ill-advised, with fiscal resources and personnel efforts better spent on native species and habitat acquisition or restoration. The guidelines established by Craighead and Dasmann (1966) with respect to introduced big game over a quarter century ago probably are even more relevant, practical and of critical importance today.

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Genetic Tests and Game Ranching: No Simple Solutions

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Introduction

During the last 15 years there has been a rapid growth in the captive rearing of deer species for profit. It is estimated that there are over one million deer on farms in New Zealand, a country with no native members of the family Cervidae. The social deer species, particularly North American elk and European red deer, as well as Asian sika deer and European fallow deer, have proved much more tractable on game ranches than more solitary or territorial deer. Several products of deer have high market value. The low-fat natural meat is sought by restaurants and gourmet shops; the soft leather is made into high-fashion garments; and the antlers and sexual organs are highly valued in Asian markets as medicinal remedies.

In North America, wildlife management and conservation has resulted in the recovery of most native deer species. The North American elk population has grown from less than 100,000 at the turn of the century to over three quarters of a million individuals today. White-tailed deer, which had been reduced to about 300,000 by overhunting, number over 18 million today.

To protect the genetic integrity of native deer populations and distinguish them from farmed deer, biochemical methods have been utilized. These methods were developed and published for the forensic identification of game meats (McClymont 1982) and to better understand the population genetics of native deer species.

Studies of exotic deer that have been intentionally released (Challies 1985) or hybrids that have escaped (Harrington 1985) indicate that they often can compete with or mate with native species.

As mule deer and white-tailed deer do not successfully breed with exotic deer species, they are of concern as vectors of disease rather than hybridization. Elk, however, can hybridize with European red deer and Asian sika deer, as well as other less commonly farmed species. For that reason, developing markers detectable from a blood sample have focused on elk and red deer.

Methods and Results

There presently are two biochemical markers in blood, hemoglobin and post-transferrin, utilized to distinguish elk and red deer (Dratch 1987, Dratch and Pemberton 1992). Two other genetic loci, transferrin and superoxide dismutase, provide secondary markers as they show substantial gene frequency differences between elk and red deer populations but do not distinguish all individuals in those subspecies. Other biochemical markers are under investigation but require testing with a substantial number of elk and red deer standards, i.e., blood samples from elk and red deer in populations where the chances of hybridization are remote.

The testing regime utilized during the last six years to detect hybrids is represented schematically in Figure 1. The differences are detected by electrophoresis, as shown for the markers hemoglobin (Hb) and superoxide dismutase (SOD) in Figure 2. All elk are homozygous for the hemoglobin B allele; red deer are homozygous for the A allele; and hybrids are heterozygous AB. For superoxide dismutase, the differences are not absolute, as shown in samples 8 and 12. Only when animal shows a red deer allele for hemoglobin or post-transferrin, or when one of its parents shows one of these marker alleles, is it classified as not a pure elk.

Because the concern over hybridization has brown in recent years, these tests have been conducted on several thousand animals since 1987. Initial results showed 8–12 percent of those animals tested either in New Zealand or North America were hybrids (Figure 3). This does not reflect the degree of hybridization in the wild, but rather that on games ranches where hybridization had been suspected due to atypical behavioral or morphological characteristics. The percentage of hybrids detected has not changed markedly on North American elk farms tested since 1991, while it has grown to about 30 percent in New Zealand as the focus has shifted from pure stocks to producing fast growing animals.

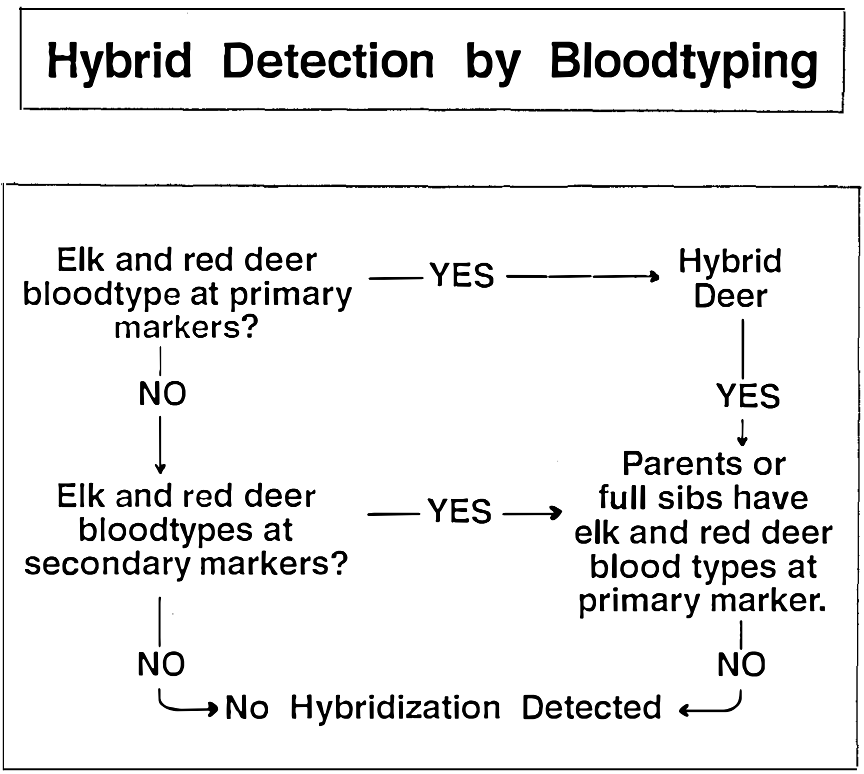

Figure 1.

Gel Electrophoresis of Red Blood Cells at pH 6.1

Samples	1 - 4	European red deer
	5 - 8	Elk - red deer F_1 hybrids
	9 - 12	North American elk

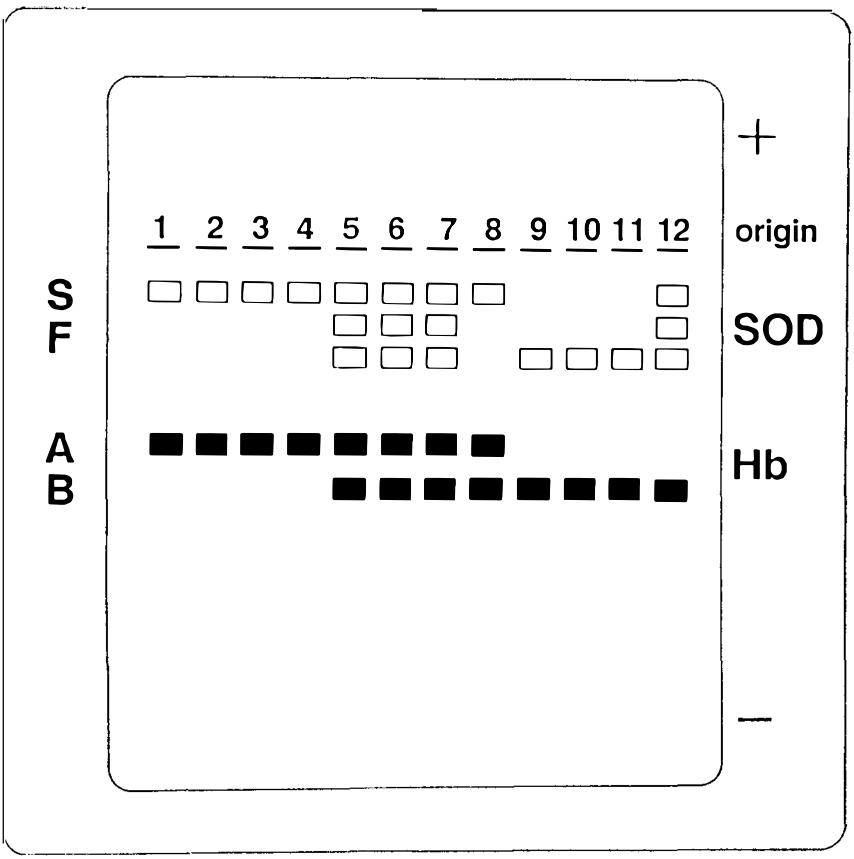

Figure 2.

Discussion

There are several problems in relying on laboratory tests to regulate the growing deer ranching industry. While the species of origin for native deer now can be determined from minute amounts of blood or tissue, there are no genetic tests to ascertain whether an individual animal was born behind a fence or in the wild. Moreover, because the domestication process that produced dogs and hogs took place over thousands of years of selection by man, there is no great likelihood of finding genetic markers after a few generations to ascertain whether a meat sample came from a farmed deer. The only possibility of distinguishing these animals genetically would be collecting blood samples from all animals on game farms so the DNA fingerprinting could be used at a later time to identify them or products from them individually. This is a costly process, in terms of analytical effort, sample storage and record-keeping.

The biochemical methods previously described will identify all pure elk, pure red deer and first generation elk/red deer hybrids. The detection problem lies with subsequent generations of hybridization. Because these markers show simple Mendelian inheritance, for a given marker locus, the offspring of hybrid parents can show the blood type of a pure elk or red deer (Figure 4). Thus, the test loses sensitivity in subsequent generations of hybridization, and particularly is exacerbated when hybrid animals are backcrossed to a pure elk bull (Figure 5). This loss of detection power with generations of hybridization demonstrates the need for many more distinguishing biochemical and molecular markers.

"Elk" Bloodtyping Results Through January 1991

	INVERMAY AGRICULTURAL RESEARCH CENTRE	BOVINE BLOOD TYPING LABORATORY	TOTAL
TOTAL TESTED	1234	2945	4177
HYBRIDS DETECTED	133	395	528
% HYBRIDS	10.8%	13.4%	12.6%

Figure 3.

If secondary markers are utilized to increase the sensitivity of hybridization tests, this is done at the expense of specificity. In other words, if these markers are utilized some pure elk will be called hybrids. The trade-off between sensitivity and specificity is a problem well recognized in disease testing, and recently has been seen in the tuberculosis testing of elk. From a management standpoint, it also is important to recognize that as more primary markers are discovered, animals that previously have been classified as pure elk will be identified actually as hybrids.

Most of the recent research on hybridization detection in the Cervidae has focused on elk and red deer. North American elk can breed with many other non-native deer species (Figure 6) and the genetic markers which would identify those hybrids remain to be found or verified with population genetic studies of known standards. Both the necessary genetic research and subsequent testing are costly, and a source of funds for that analytical effort has yet to be identified.

Conclusions

1. There are no genetic tests to determine whether an elk or any species of the deer family was raised on a game farm or came from the wild. The obstacles to developing such tests are as much biological as technical.
2. There are powerful forensic tests available to determine the species of origin for all

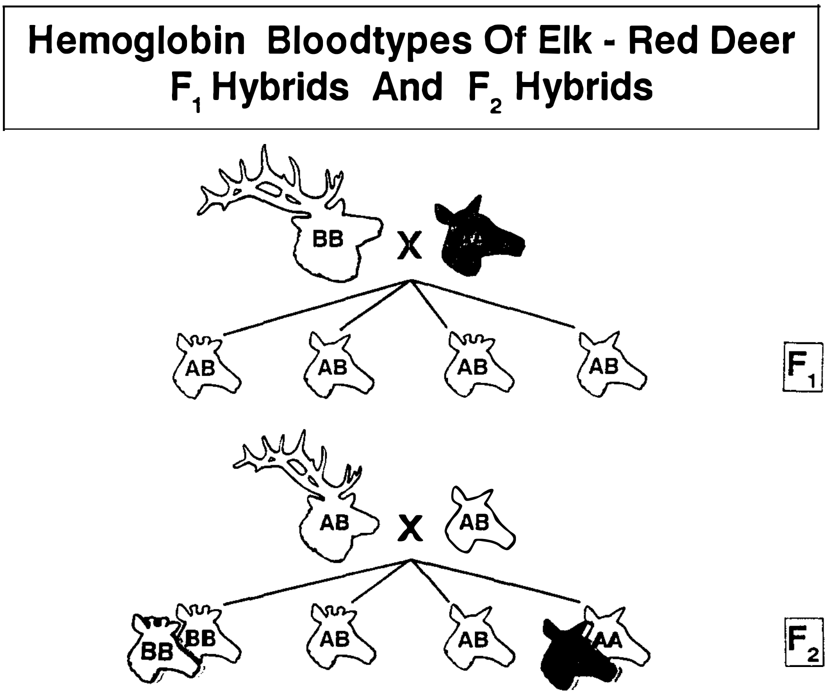

Figure 4.

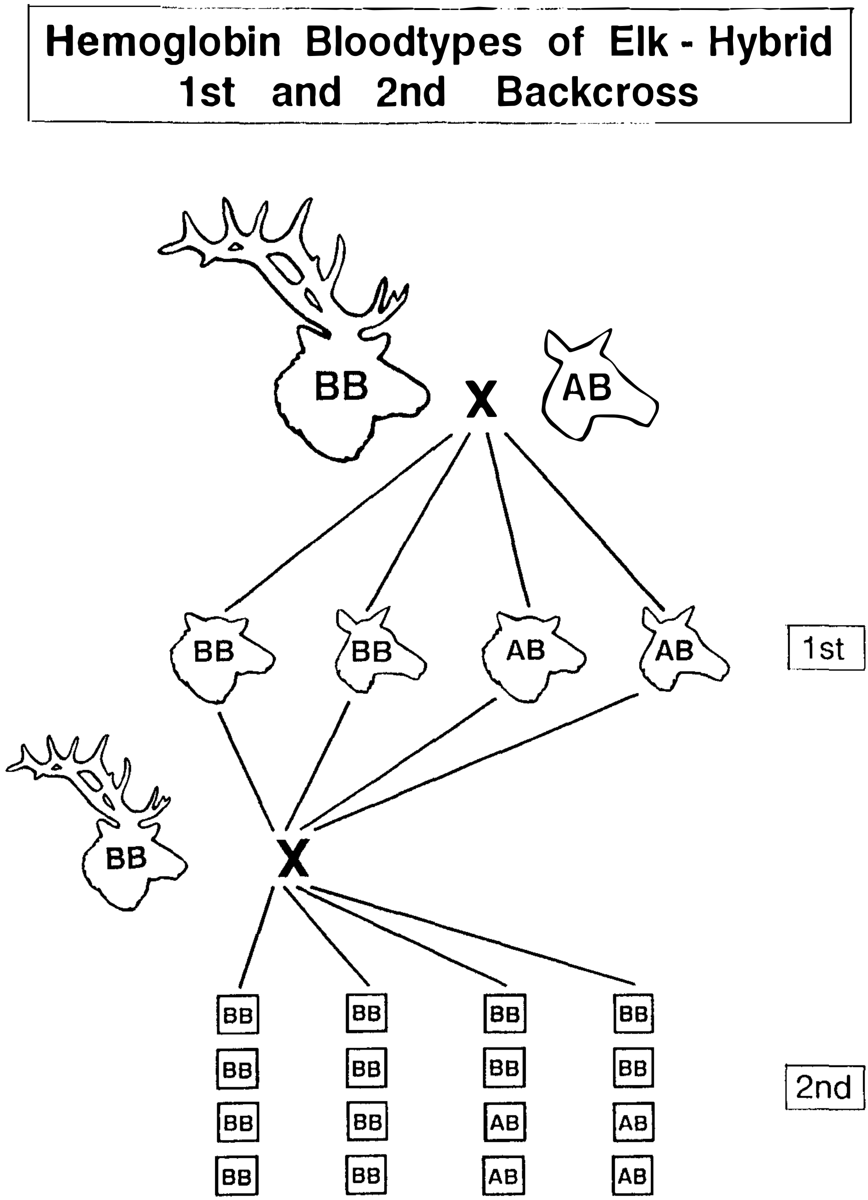
Hemoglobin Bloodtypes of Elk - Hybrid
1st and 2nd Backcross
BB
X
AB
BB
BB
AB
AB
1st
BB
X
BB
BB
BB
BB
BB
BB
BB
BB
BB
BB
BB
AB
AB
BB
BB
AB
AB
2nd

Figure 5.

Branches of the Family Cervidae That Can Hybridize

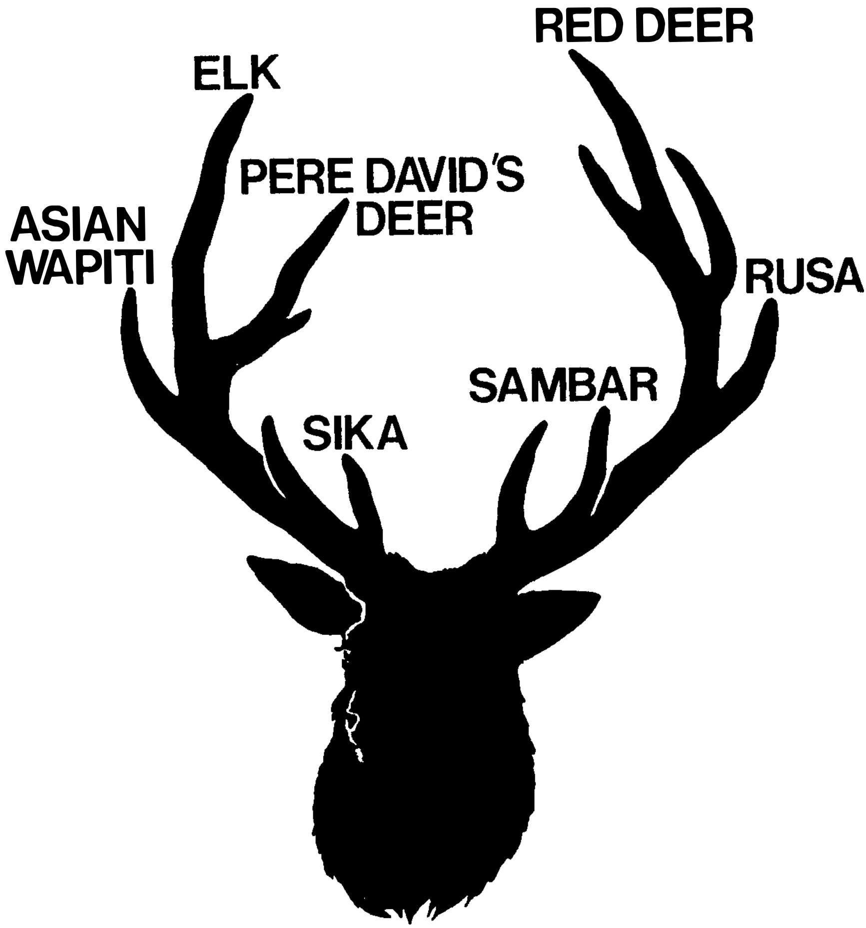

Figure 6.

deer species native to North America. These tests also identify hybrids, but loose detection power with generations of hybridization.

3. As more genetic markers are developed, some animals originally classified as pure elk will be subsequently be identified as hybrids.
4. Laboratory tests have identified as hybrids between native elk and introduced red deer. These powerful tests will not provide a substitute for a consensus wildlife management policy with regard to game ranching.

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Agency Perspectives on Private Ownership of Wildlife in the United States and Canada

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Introduction

The private ownership of wildlife in general, and the development of an industry involving the farming of cervid species in particular, has been the subject of intense discussion and controversy in recent years. While this discussion has occurred throughout North America, it has been particularly acute in the western states and provinces where large and diverse populations of native big game mammals exist, often on public lands.

Methods

Information in this paper was gained during two separate surveys. In developing a "white paper" on the private holding of cervids, the Oregon Fish and Wildlife Department contacted most fish and wildlife agencies in the United States. A series of informal questions regarding the legal status of private ownership, regulatory authority, funding and costs of regulation, disease, and any additional issues or problems associated with private big game holding were asked. Based largely on the responses, a more formal questionnaire was developed and distributed to personnel in the fish and wildlife agencies of the 50 states and 12 Canadian provinces or territories.

Of the 50 surveys sent to state wildlife agencies, 45 usable responses were obtained, for a 90–percent response rate. In Canada, 9 of 12 jurisdictions (75 percent) responded. Not all respondents completed every question in the survey.

Results and Discussion

Most state and provincial wildlife law was enacted when the private holding of wildlife was a minor issue. The establishing legislation for many wildlife agencies either does not clearly define "wildlife" or does not make clear distinction between native species and introduced exotics. Of those authorities in the U. S. and Canada responding to the question "What is the legal definition of wildlife in your jurisdiction?", 11 of 42 (26 percent) and 3 of 9 (33 percent), respectively, indicated clear, defined authority over all species which might be broadly considered wildlife in some or all of their historic range.

Fifty-seven percent of agencies in the U. S. and 67 percent in Canada indicated a narrow definition which spoke generally to only native species or referred to wild nature, wild character, or other characteristics subject to interpretation when dealing with privately held animals. Six of 34 states (18 percent) indicated no definition of wildlife of any kind.

The definition of "wild" and "wildlife" may vary widely from jurisdiction to jurisdiction, leading to confusion and legal challenges to agency authority. It therefore is necessary in many jurisdictions to interpret the intent of the enabling legislation of the wildlife agency. This interpretation can then be challenged legally, with state by state and province by province case law establishing jurisdictional authority. There is no uniform interpretation of the definition of wildlife, for regulatory purposes, among agencies in North America.

When U. S. agencies were asked whether animals held on game farms or ranches were considered wildlife, 32 percent did not feel such animals were so classified and 68 percent felt they were. In Canada, eight of nine jurisdictions (89 percent) considered game farm animals as wildlife. Several jurisdictions reported that animals were not considered wildlife within the facility, but were immediately classified as wildlife upon escape or release.

The regulation of privately held wildlife generally has not been a priority for state or provincial wildlife agencies. Authorities have tended to deal primarily with issues associated more directly with wild populations. Increased interest in privately held wildlife has led to higher levels of involvement in this matter. Fifty-four percent of responding states reported recent legislative or rule-making changes regarding this issue. This indicates an increase in regulatory activity in recent years. Ervin et al. (1992) reported 15 of 50 states had either recent or pending legislation affecting exotics in a survey conducted in 1989. Of the 45 states responding to a question in our survey on policies towards game farming and game ranching, 11 percent indicated no agency policy and 64 percent permitted some level of activity with regulation. Seven percent of respondents indicated that other agencies were responsible, and 9 percent indicated opposition to the activity, at least for native species. In Canada, game farming generally is viewed as a legitimate diversification of traditional agricultural practices, but all responding jurisdictions recognized a concern for the potential impacts on free-ranging wildlife. Throughout Canada, restrictive regulations already are in place, or are actively being developed. Manitoba and Newfoundland do not allow game farming.

Current license and fee revenue generally has not paid for increased levels of regulation, indicating some diversion of sportsmen's dollars or public funds into this program. Fee levels in states or provinces with established game farming have shown that fees collected do not begin to cover the expenses of the program. Sportsman's dollars fund the majority of regulation costs in the United States. In Canada, public funds (i.e., agency budgets) must cover most or all of the program costs. If responsibility for an existing or expanded industry remains with wildlife agencies, either fees from the industry must be increased, sportsman's dollars must subsidize regulation, or both. In lieu of fee increases, other wildlife programs will be sacrificed. Of states contacted in our survey, 93 percent reported that the wildlife agency was fully or partially responsible for the enforcement and costs of game-ranching regulation. Seven percent reported that another agency was responsible. The state department of agriculture was the primary alternate enforcement and regulatory agency. Some degree of agricultural agency involvement in regulation was indicated by 11 of 45 states reporting, or 25 percent. In Canada three of nine jurisdictions have shared responsibilities between wildlife and agricultural agencies. However, in five responding jurisdictions, agriculture is the lead agency in Canadian regulation.

There has been concern over delegation of authority over game farming to agricultural agencies in some areas. These agencies generally do not have the statutory authority to protect wildlife populations, nor the expertise to recognize the legitimate concerns for wildlife. Instead, they often are charged with developing agricultural industries for commercial purposes. Agricultural agencies are more likely to recognize the positive aspects of game farming than are wildlife agencies (Ervin et al. 1992).

Jurisdictions define "game farming" differently. When asked to define the term, 16 percent (U. S.) and 22 percent (Canada) had no definition, 16 percent (U. S.) and 33 percent (Canada) equated the term to simple possession of live animals for regulation, and 46 percent (U. S.) and 44 percent (Canada) equated the term for regulatory purposes as connected to propagation, sale or other commercial use. When asked about regulations concerning current operations, 61 percent of U. S. wildlife agencies reported fencing standards, 80 percent required some form of animal inventory and 55 percent mandated some form of individual animal identification marking. In Canada, of the seven jurisdictions with regulations already in place, six had fencing standards, six had at least minimal facility requirements, six required annual inventory of all animals and all transactions involving game farm animals, six required individual permanent animal identification, and all had relatively detailed regulations for disease testing.

There is little consistency in what species are allowed on game farms. The three Canadian prairie provinces span the full range: Alberta allows only native species, British Columbia allows only non-native species and Saskatchewan allows a mix of native and non-native. Similar inconsistences occur throughout the U. S. There has been considerable discussion throughout North America on the pros and cons of each position, and each jurisdiction makes its own decision based on a combination of social, economic, biologic and political concerns.

There often is no clear legal authority to control escaped animals, even though they may pose an immediate threat to wildlife or an eventual threat to human safety. Escaped animals in some jurisdictions may take on the aspect of a protected wildlife species by default, since there is no clear legal authority for hunting seasons or other means of take. This may protect escaped animals at a higher level than native wildlife, potentially leading to a competitive advantage. At least two states (Colorado and Oregon) and three provinces (Alberta, British Columbia and Quebec) have rules which clearly define agency authority to control escaped big game animals. Of additional concern is the potential civil liabilities impacting legal hunters who kill escaped privately held wildlife, which may be at least superficially identical to their legal quarry.

The jurisdiction and regulation over privately held wildlife is complex and confusing. In addition to the questions of definition mentioned earlier, the current regulatory structure has several state, provincial and federal agencies responsible for different aspects of control. The U. S. Fish and Wildlife Service, Agriculture Canada and the Canadian Wildlife Service have jurisdiction over international import, migratory birds and endangered species. They have regulations and a permitting process concerning the possession of these animals. Beyond this level, jurisdiction over wildlife in captivity becomes complex, with different agencies, branches, divisions and sections responsible for the licensing of traffic in wildlife for commercial markets, exhibitions, disease control, and in food and fiber production.

In many states and provinces, different agencies have responsibilities for regulating the holding and health of wildlife. Generally these tend to be the departments of wildlife and agriculture. The release of domestically raised wildlife or imported wildlife often is illegal, but there are questions concerning the legal definition of "release." Agencies generally consider release as any introduction which allows the animals to range freely. Some members of the public have questioned this interpretation and consider any stocking of private land to be a private property issue. Of particular concern is the stocking of large private holdings, with or without "game-proof" fencing, in the range of the same or similar species. Only a few jurisdictions (Oregon, Alberta and Utah) report restrictions on visibility within holding areas or on area size. The ownership and disposition of native wildlife within private land designated for the raising of privately held wildlife also is of concern to many agencies.

A fundamental issue underlying all aspects of private ownership is the change in philosophy inherent in the development of a widespread industry involving private ownership of endemic wildlife. The inception of modern wildlife management included the concept that endemic wildlife belongs to the people of the state or province, and responsibility for managing that wildlife is entrusted to the governmental regulatory agency. Development of a widespread industry involving the private ownership and sale for profit of native species would involve a change in this philosophy.

Private holding of wildlife in North America generally has not been permitted; however, there have been numerous exceptions to this policy. Zoos, private organizations, landowners and other have obtained wild animals legally, often with the assistance of government agencies interested in removing surplus wildlife or encouraging the distribution of certain species. As an example, for many years elk (*Cervus elaphus*) were trapped by the U. S. government in the Yellowstone area and shipped to other states and countries (Thomas and Toweill 1982). There was little apparent concern over the eventual "ownership" of these elk, and animals were shipped to government agencies, local Elks Clubs and private individuals.

The extent of privately held wildlife still is quite minimal for most species. In Oregon, there are an estimated 110,000 wild elk, while the number of captively held elk is numbered in the hundreds at the present time. Other states and provinces report similar ratios, with a few significant exceptions. Alberta currently has approximately 5,000 elk held in captivity, and only 17,000 free-ranging elk. In Texas, there has been an increase in populations of privately-owned big game species in recent years. The Texas Parks and Wildlife Department estimated 12,000 exotic big game animals in the state in 1963, 168,000 in 1986, and currently estimates over 500,000 individual exotic animals in the state (W. Armstrong personal communication: 1993). This still is significantly less than the estimated populations of native large mammals, but the ratio of exotics to native wildlife is increasing markedly.

The introduction of viable exotic wildlife species into new ecosystems is considered a risk to wildlife and wildlife habitats. Of the states and provinces responding to the survey, 84 percent and 100 percent, respectively, reported some policy or regulation on introductions. While most biologists might agree that the preservation of species integrity in wildlife/habitat assemblages is a desirable goal, there are few standardized policies on the introduction of exotic species. The survival, behavior and effect of many introduced species is unpredictable, and thus, introductions of exotic species into native habitats are considered detrimental by most ecologists. While examples of harmful introductions are abundant, there also are active, ongoing programs to introduce species for public benefit in many jurisdictions. Such introductions include many species of upland game birds and fish thought beneficial by constituent groups. These introductions often are made into environments that have been extensively modified by human activities. The introduction of non-native mammals, particularly large game animals, generally is not conducted, but even here, often no formal policy is in place.

Diseases and parasites in game farm animals are a significant component of the issues facing wildlife management agencies in Canada and the United States. Outbreaks of bluetongue (in Manitoba) and bovine tuberculosis (widespread in Canada and the U. S.) in game farm animals have moved these concerns from the theoretical realm to one of reality. Such outbreaks pose tremendous problems to wildlife and agricultural agencies at all levels in dealing with the political, regulatory, administrative, enforcement, media and public interest issues associated with an outbreak. This diversion of staff time and budgets occurs at the expense of traditional wildlife programs.

There is considerable discussion over the degree of risk, if any, that diseases in privately held wildlife pose to wild cervid populations in North America. From a management perspective, the risks of these diseases to free-ranging wildlife, agriculture and human health are significant even if only the perception of a risk is present. The intense public scrutiny and media attention associated with a reported disease outbreak often includes misinformation, confusion and vastly increased work loads for wildlife agencies. The lack of regulations, ease of transportation of game farm wildlife, and the absence of proven diagnostic tests and therapeutic treatments act in conjunction to increase the risk of spreading disease from captive to free-ranging wildlife. Although the extent of transmission risk cannot be specifically identified, it is clear that the risk of new introductions, from any source, should remain a serious concern for wildlife managers.

The lack of an indemnification program in the United States has led to problems when disease is identified in a privately held herd, especially when diseased stock may be identified, but not destroyed. Legal jurisdiction over captively held cervids also needs to be clarified among state agricultural and wildlife agencies and the U. S. Department of Agriculture. In contrast, Canada has a federal indemnification program to control and eradicate a series of "reportable diseases." Following confirmation of any such disease, Agriculture Canada has the authority to immediately quarantine, slaughter and compensate for any species in any jurisdiction. The scope of this authority allows swift and effective action to control these diseases.

Some progress in disease control has been made in the deer farming industry, particularly with bovine TB. Experience with conventional livestock indicates that cooperation between agricultural operators and government agencies can lead to effective control of disease in farmed animals. For example, Agriculture Canada recently declared that the outbreak of bovine TB in elk is under control, at least in Alberta, following the slaughter of 2,588 elk and payment of $ 16.2 million. However, lack of a U. S. indemnification program, misapplication of testing procedures from domestic to exotic species, unknown diseases and disease implication in farmed wildlife, and the presence of widespread and abundant wild cervids in the vicinity of some ranching operations all indicate that a continuing precautionary approach is warranted.

The current value of many wildlife species creates a financial incentive for unscrupulous individuals to illegally remove animals or products derived from animals (meat, antler velvet, trophies) from the wild for sale. This value also creates a legitimate economic growth impetus which may create wealth and provide jobs and associated benefits to many areas, particularly important in depressed rural communities. Of the states surveyed, 63 percent of respondents reported incidents of illegal activity associated with game farming or ranching. Fifty percent of the respondents to a question on the prevalence of the illegal activity felt it was moderate, high or increasing, and 50 percent felt the prevalence was low. Forty-eight percent of respondents felt that illegal activities associated with game farming or ranching posed a significant threat to wildlife; 52 percent did not. When asked if the legal, permitted activities associated with private holding of big game animals posed a significant threat to wildlife, 70 percent of U. S. agencies did perceive such a threat, while 30 percent did not. In Canada, Alberta and Saskatchewan (two provinces where game farming is well established) reported evidence of illegal activities. These consisted primarily of poaching of live animals from the wild, unpermitted import and falsified records. Three jurisdictions indicated no evidence of illegal activities to date. Ontario, currently without regulations, could not differentiate legal and illegal activities. Most respondents indicated that legal and illegal activities at the current level were not a significant concern, but, as game farming increased, so would the opportunity for negative impact on wildlife. The most common threats cited specifically were disease, hybridization and the commercialization of wildlife.

The sale of antler velvet is legal in 78 percent of the 37 states responding to a question on allowable sale items in our survey. Ninety-two percent of respondents allow the sale of meat, 81 percent permit the sale of live animals and 68 percent the sale of hides. In Canada, all responding jurisdictions with game farming allowed the sale of live animals, six of seven allowed meat sales of one or more game species and five of seven allowed the sale of hides. Sixty-five percent of the states responding allow some form of hunting of privately held animals, but only one Canadian province (Quebec) allows this activity.

There are many operations in the U. S. which hunt game-farmed deer species on a fee basis. Legal questions exist concerning the required licenses, open seasons, disposition of product and other aspects of the hunting of privately held big game animals. Creating a venue for harvest of such animals, such as elk, outside of the current season and license structure creates the potential for illegal harvest of native wildlife. Regulation of this activity adds to the enforcement burden of an often shrinking or static enforcement staff. While some operators express little interest in this aspect of game ranching, it is a significant portion of the business in many states. Only 12 percent of states responding reported different regulations for game ranching, as opposed to game farming. The states reporting differences were primarily in the West. Game farming, for the purposes of this paper, was defined as the raising of traditional wildlife species primarily for sale as food, fiber or livestock. Game ranching was defined as the propagation of these species for purposes other than food, fiber or live sale, such as hunting.

Since elk and deer range widely in areas with game-farming industries, many current or potential deer and elk ranches are in big game habitat. Existing hunting seasons create the potential for conflict between hunters and operators. Incidents may involve hunters with valid tags taking game-farm animals during existing seasons, without known trespass. Escape of privately held animals or comingling of privately held and wild animals during hunting seasons pose potential liability problems to hunters, risk of financial loss to animal owners, and increased complexity in hunting regulations and enforcement.

Certain introduced species of wildlife can interbreed with native species, potentially producing fertile offspring. If such interbreeding occurs, the genetic make-up of affected populations may be permanently altered. Reductions in the genetic integrity of different species reduce the overall diversity of the entire ecosystem, therefore reducing stability. Hybridization between elk and red deer (*Cervus elaphus*) is a concern to wildlife agencies. Although they are the same species, they represent extremes in the species continuum and, as such, exhibit markedly different behavioral and morphological characteristics. Elk and red deer have hybridized in free-ranging situations in New Zealand, and such animals commonly are encountered in auctions and markets throughout North America. In addition, at least three states (Colorado, Montana and Wyoming) have reported hybrid red deer/elk taken by hunters during authorized elk seasons. These animals were taken on public lands, and were either in herds of native elk or in close proximity to such herds. Hybridization readily occurs between other members of the genus *Cervus*. Red deer and sika deer (*Cervus nippon*) have hybridized in Scotland to the point where no true individuals of either species may exist. Tests for detecting hybridization have been developed, but are not 100 percent accurate.

The development of the relatively new industry of cervid farming has several potential positive impacts. The meat of most deer species is relatively low in fat and cholesterol. Wildlife can be raised in pastures which are not particularly high quality for some domestic species. The sale of hides, antler velvet and other potential products may add substantially to the potential income of producers.

Deer meat is in high demand in many communities. While total demand is unknown, it probably is much higher than the current, readily available supply. Substantial potential export markets also exist. Export of new agricultural products would benefit both local and national economies; however, the extent that the demand for these products, particularly meat, occurs at the expense of more traditional meat sources is unknown.

Jobs could be created by a new industry. Positions could exist in production, slaughter, marketing, export, restaurant trade and other areas. Deer farming itself requires substantial capital investment (primarily fencing and broodstock expenses), creating demand for these products. The industry is at an early stage of development, with most operators selling foundation stock to those entering the industry. Prices for breeding animals currently are quite high, but the eventual levels of these prices are unknown.

In addition to potential economic benefits, one known positive effect of privately held wildlife is the captive breeding of threatened or endangered species. However, the species raised in such operations generally hold little commercial potential and to date are a minor part of game-farm activities in Canada and the U. S.

It is clear that numerous conflicts and questions exist in the relationship between private big game ownership and traditional wildlife agency functions. Most agencies are not well equipped to address these questions, and often scarce resources must be diverted from traditional programs to attend to private ownership matters. It also is clear that, in the absence of a uniform policy on private ownership and native wildlife, fish and wildlife agencies must confront the issues concerning this situation in order to safeguard the resource consigned to their protection.

There often are profound philosophical differences between those interested in establishing an industry based on private ownership and sale of wildlife and the agencies charged with protection and enhancement of those species in the wild. The future course of this industry's development and our current perception of wildlife agency roles in wildlife management may be subject to dramatic change in the near future.

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Wildlife Management Agency Concerns about Captive Wildlife: The Colorado Experience

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Introduction

Private possession and subsequent commercial use of captive wildlife have increased dramatically in Colorado and throughout North America during the past 10 years. This increase has caused resource management agencies to reexamine policies, legislation and regulations that govern such uses of wildlife. In most instances, existing policies and laws have been inadequate to protect native wildlife populations from real and perceived threats of captive wildlife (Geist 1985, Lanka and Guenzel 1991). At the same time, however, the captive wildlife industry has tried to portray itself as a benign form of alternative agriculture and has attempted to divert control and regulation of this industry from wildlife to agriculture agencies. These two trends have been in direct opposition in many states and provinces during the past five years. The resulting conflicts have been highly emotional and confrontational. Consequently, in many instances, game-farming decisions have been determined by legislative and judicial bodies rather than by wildlife and agricultural commissions.

Current Status in Colorado

Private possession of wildlife was legalized in Colorado in 1968 by legislative action. Early regulations were concerned with commercial hunting facilities and required record keeping and some form of tagging animals. From 1968 to 1980, facilities licensed to hold captive ungulates grew from 2 to 10. Over the next 12 years the number of operations increased to 97; during that same period, the total number of captive elk in Colorado increased from 250 to over 3,200. Concurrently, the number of individuals interested in possessing exotic wildlife also showed a similar increase.

During the 1980s, the Colorado Division of Wildlife (CDOW) also first detected problems associated with wildlife commercialization. Five populations of exotic wildlife occurring in the wild were documented — these populations were all the results of escapes from private facilities. After examining existing law, it became evident that neither the CDOW nor the Colorado Department of Agriculture (CDA) had clear authority to regulate these expanding populations of captive wildlife.

In 1987, a working group consisting of personnel from CDOW, CDA and the Colorado Department of Health was convened to make recommendations on statutory and regulatory changes needed to manage Colorado's existing commercial wildlife industry and to protect native wildlife. This working group also interacted with the newly formed Colorado Elk and Game Breeders Association to insure industry involvement. In developing and defending recommendations and regulations, it quickly became evident that little published data on the impacts of game ranching on native wildlife existed, particularly in the western United States.

Domestic Livestock or Captive Wildlife?

Industry representatives expressed desires to be regulated by the CDA and have their animals classified as alternative livestock. Wildlife officials argued that captive wildlife are not domestic and still maintained all genetic characteristics of free-ranging conspecifics, the only difference being the constraint of movement caused by game-proof fencing. This conflict still is unresolved five years later and, in fact, is one of the primary points of contention between wildlife agencies and the commercial wildlife industry on an international basis. Various definitions of domestication have been used by the industry (Prescott-Allen and Prescott-Allen 1986, Hudson 1989). These definitions all conclude that when any animal is under some degree of human management, that animal can be classified as domestic or domesticated. In contrast, CDOW defines domestic animals as ''those animals which through long association with humans have been bred to a degree which has resulted in genetic changes affecting color, temperament and confirmation, or other attributes of the species to an extent that makes them unique and distinguishable from wild individuals of their species'' (CDOW Regulation #1100a).

Perhaps a more important criterion for policy makers should be how the public perceives an animal. An informal survey of resident licensed hunters conducted by CDOW suggested that the public in Colorado identified elk (*Cervus elaphus nelsoni*) as wildlife even when particular animals are privately owned and behind fence (Kahn unpublished data). Formal surveys concerning such public attitudes regarding captive wildlife are lacking. However, wildlife agencies need this information to more clearly define their role in regulating the industry.

Regulation

The process for adopting regulations for the commercial wildlife industry was developed by the Colorado Legislature. By statue, the Wildlife Commission and CDOW are the primary rule-making and regulating authorities, respectively. However, the Agriculture Commission must approve all regulations that involve captive wild ungulates raised as ''agricultural products'' (those animals raised for hunting are regulated exclusively by CDOW). CDA and CDOW jointly regulate health monitoring and disease control. This dual responsibility makes each agency and commission sensitive to the other's mission and goals. This sensitivity is particularly important to the industry, which tends to view wildlife agencies as being unsupportive and law-enforcement oriented. Experiences in Colorado show this type of authority can work, provided each agency takes the necessary time to justify its respective recommendations and consider alternative perspectives in decision-making processes.

Through the foregoing process, a series of compromise regulations were developed by CDOW, CDA and representatives from Colorado's commercial wildlife industry. These regulations on facilities, record keeping, animal marking, escape and other aspects of wildlife commercialization were designed to minimize the impacts of game ranching on Colorado's native wildlife populations without unduly hampering growth of the game-ranching industry in Colorado. Although an improvement over previous regulations, the relative efficacy of these new regulations, with respect to protecting Colorado's wildlife resources and providing a stable environment for the industry, has yet to be determined:

Facilities and Record Keeping

CDOW instituted new minimum facility requirements in 1990. These requirements were developed jointly by CDOW and industry representatives. Captive ungulate facilities require 8–foot fences, locked or double gates, animal handling facilities and a separate quarantine facility. Record-keeping standards require owners of captive wildlife to report all animal movements and transactions to CDOW within 10 days and provide CDOW with a detailed year-end inventory of all captive wildlife. Records on animal movements are essential in regulating health testing to prevent or tract disease problems (Miller and Thorne 1993), as well as for law enforcement purposes.

Animal Marking

All captive wildlife in Colorado must be marked with a tamper-proof eartag issued by either CDOW or the United States Department of Agriculture; both tags are unique alphanumeric coding systems. Eartags are the primary differentiation between captive and free-ranging individuals of native ungulate species and, as such, are essential in related law enforcement cases. Moreover, permanent marking is an integral component of health testing programs for captive wildlife (Miller and Thorne 1993).

Escape and Recovery of Captive Wildlife

Any risk assessment of game farming must take into consideration the likelihood that captive wildlife will escape and interact with native wildlife. Intuitively, most wildlife professionals and commercial wildlife operators know that fences are not escape-proof. Law requires owners to notify CDOW immediately of any captive wildlife escape. In addition, the owner has 72 hours to recapture escaped animals. Thereafter, CDOW can initiate recovery efforts and may bill the owner for all costs of such efforts.

Incidence of escapes from game farms or ranches rarely are documented and data are limited (Massey 1986, Rennie 1986). However, CDOW has documented 33 incidents of captive wildlife escaping or being released from wildlife parks since 1988 (Table 1). Over 75 percent of documented escapes have occurred since adoption of uniform fencing regulations in 1990. Among these cases, the number of individual animals escaping has ranged from 1 to 100, and total numbers are conservatively estimated at 400.

Success of efforts to recapture escaped captive wild ungulates has varied widely — from all to none. Escaped captive elk and elk/red deer hybrids have been recovered (both alive and dead) in 60 percent of these incidents. However, in only 33 percent of these cases have *all* escaped individuals been recaptured. A minimum of seven escaped captive elk were harvested by licensed hunters during the 1989–1992 hunting seasons. These harvests have occurred as far as 90 miles (144 km) from the facility of origin.

Recovery efforts have been even less successful for other species — in 67 percent of

Table 1. Escape and recovery of captive wildlife in Colorado 1988–1992.

Species	Number escaped	Number recaptured
Elk	173 (18 incidents)	154
Red deer	40 (3 incidents)	8
Barbary sheep	115 (4 incidents)	0
Ibex	65 (3 incidents)	15
Mouflon sheep	125 (5 incidents)	75

documented cases, owners of escaped exotic wildlife species have failed, and in some cases have not even attempted to recover the animals at large. CDOW has spent in excess of $150,000 during 1989–1992 in efforts to control and eliminate escaped populations of exotic ungulates. Despite extraordinary efforts, escaped exotics remain at large in several Colorado locations. Moreover, breeding populations of exotic ungulates have been established in the wild in at least six sites. These populations include aoudad (*Ammotragus lervia*), ibex (*Capra ibex*), red deer (*C. elaphus elaphus*), fallow deer (*Dama dama*) and wild boar (*Sus scrofa*).

CDOW also has documented incidents of native wildlife entering licensed facilities (Table 2). In many instances, ingress problems with mule deer (*Odocoileus hemionus*) are recurrent and cannot be rectified without double fencing. Mule deer in Colorado can readily gain access into facilities either by crawling over or going underneath fences (J. W. Seidel personal communication).

Prohibited Species

When CDOW managers originally began to rewrite the captive wildlife regulations in 1989, they decided that certain species of wildlife or groups of species had such significant potential for negative impacts on native species that the only recourse was a total ban on their possession and importation (Table 3). Documented problems with escapes and subsequent failures to recapture captive wildlife in Colorado, both before and after this list of prohibited species was formulated, demonstrate the need for such regulations.

Species were placed on the prohibited list for a variety of reasons. Exotic member os the subfamily Caprinae posed threats to Colorado's native bighorn sheep (*Ovis canadensis*) and introduced populations of Rocky Mountain goats (*Oreamnus americanus*). Specifically, mouflon sheep (*Ovis musimon*) readily hybridize with bighorn sheep and pro-

Table 2. Ingress of native wildlife into licensed captive wildlife facilities in Colorado 1989–1992.

Species	Number entering	Number of individual incidents
Mule deer	185	22
Elk	123	6
Pronghorn antelope	7	3
Bighorn sheep	2	1

Table 3. Colorado's prohibited species list.

Species	Reasons for prohibition
All members of the subfamily Caprinae not native to North America	Disease introduction Habitat competition Hybridization
Oryx and addax	Habitat competition and degradation
Subfamily Alcelaphinae (wildebeest, hartebeest)	Introduction of malignant Catarhaal fever
White-tailed deer	Introduction of meningeal worm
All members of the family Suidae not native to North America	Habitat degradation
Red deer and any hybrid of red deer	Hybridization with elk

duce fertile offspring. Experiences in New Mexico with aoudad revealed that they compete successfully in western habitats and pose threats to desert bighorn sheep (*O. canadensis nelsoni*) and potentially all other wild ungulates (Morrison 1989). Colorado's experiences with several of these species (ibex, aoudad, mouflon sheep) already suggested that eliminating them from the wild once they were established was both difficult and expensive. The value of these species was quite low from an agricultural standpoint, but they were desirable, and in some cases essential, to operators of commercial shooting preserves.

Members of the subfamily Alcelaphinae, including wildebeest (*Connachetes* spp.) and Hartebeest (*Alcelaphus* spp.), were prohibited at the request of the Colorado State Veterinarian. These species are carriers of the African form of malignant catarrhal fever, a herpes virus that is potentially fatal to numerous livestock and wildlife species. Adequate testing procedures are not available to screen for subclinical carriers of this virus.

Possession and importation of white-tailed deer (*O. virginianus*) were prohibited because of concerns about meningeal worm (*Parelaphostrongylus tenuis*). White-tailed deer carry this parasite, which poses a potential significant threat to mule deer, elk, moose (*Alces alces*), pronghorn antelope (*Antilocapra americana*) and domestic llamas (*Lama glama*) in Colorado. Lanka and Guenzel (1991) suggested that all factors needed to introduce this parasite into western North America are presently there, except for the parasite itself. White-tailed deer are common in eastern Colorado and their range is expanding westward; secondary host terrestrial snails are found throughout the Rocky Mountain region (Pilsbry 1939, 1940, Beetle 1989). It follows that because there were no definitive tests for detecting the presence of meningeal worm (Samuel 1987), banning importation and possession of white-tailed deer was deemed necessary to prevent the introduction of this parasite.

Recent work in Alberta suggests that elk can be infected with meningeal worm and pass larvae (Samuel et al. 1992). These discoveries have promoted further concerns that elk and other captive cervids may serve as alternate vectors for introduction of this parasite (Samuel et al. 1992, Miller and Thorne 1993). Currently, Alberta has a moratorium on the importation of all ungulates because of this possibility (Stevenson 1988). At present, however, white-tailed deer are the only species whose importation is prohibited by CDOW to prevent introduction of meningeal worm into Colorado.

All species of wild hogs (*Sus* spp.), including the European boar, were prohibited because of their potential impact on ground-nesting birds and native vegetation. In addition, wild swine carry several diseases of concern to domestic swine producers. One escaped population of wild boar survived at an elevation of up to about 8,700 feet (2,650 m) in south-central Colorado for four years before it was controlled. Another problem with these species is the high degree of hybridization that has occurred between domestic pigs (*S. scrofa domestica*) and wild species — hybridization makes enforcement of these particular regulations somewhat difficult.

Prohibiting possession of red deer was by far the most contentious of these issues. Two primary concerns formed the foundation for prohibition: (1) red deer or elk/red deer hybrids escaping and subsequently interbreeding with native elk could effectively alter the gene pool of Colorado's native elk herd and (2) imminent problems were likely because there were thought to be considerable numbers of red deer and red deer/elk hybrids on game ranches throughout Colorado. Statewide, native elk populations number about 225,000 head in total. Wild elk are highly valued by the people of Colorado. In 1990, elk hunting contributed over $250,000,000 to the economy of Colorado.

There are no reports of red deer and elk interacting in the wild in North America. However, studies in New Zealand (where both species were introduced) revealed that in the area surrounding Fiordland National Park free-ranging red deer and elk readily hybridized to such an extent that the number of pure elk found after approximately 80 years was minimal (Harrington 1985, Challies 1985, Nuggent et al. 1987). To examine probable consequences of red deer introductions into native elk herds, CDOW developed a simulation model designed to examine possible changes in genetic composition that could occur in elk herds after the introduction of red deer or red deer/elk hybrids (Hobbs 1990). This model showed serious potential consequences of such occurrences: 60 years after an introduction of ten red deer (or red deer/elk hybrids) into a population of 500 elk, 65 percent of the simulated herd had some degree of hybridization. Moreover, simulation results were consistent with field data from New Zealand (Nuggent 1989). In light of these results, regulations were adopted prohibiting possession of red deer and their hybrids to minimize this threat.

In modifying statutes governing regulation of captive ungulates, the Colorado legislature had previously mandated that if CDOW banned possession of red deer then owners of existing red deer and their hybrids would be compensated for their financial losses. Consequently, as part of the prohibition regulations, CDOW instituted a voluntary testing and compensation program. Methods developed by Dratch and Gyllensten (1985) and others were used to test captive elk in Colorado. A total of 1,645 captive elk were tested from 1990–1993; this represented about 90 percent of the state's captive elk population at that time. During three years of testing, 239 (15 percent) hybrids were found on game ranches throughout Colorado, and subsequently were sold out-of-state. The testing and compensation program ended in January 1993. CDOW spent about $810,000 on this program; most of that money went directly to captive wildlife producers to compensate for costs associated with replacing red deer hybrids with pure elk.

Environmental Concerns

Wildlife managers have focused on concerns such as disease (Miller and Thorne 1993), hybridization (Dratch 1993) and competition from exotic species (Feldhamer and Armstrong 1993) when addressing threats to native wildlife posed by game ranching. Although these are serious problems, the impact of extensive game-proof fences on wildlife habitat and migration should not be overlooked. By design, these fences restrict wildlife movement and access to and through specific pieces of property. In Colorado, these restrictions are exacerbated by necessary seasonal movements of wild ungulates from summer range to winter range. In specific situations, fencing has altered migration routes and increased mortality to migrating mule deer.

CDOW regulations now provide for denial or modification of planned or existing facilities that have the potential to disrupt migration, breeding or critical habitat for native wildlife. To date, this regulation only has been used to modify facilities rather than to prohibit them outright. This fencing issue is contentious because, on one hand, it directly affects landowners' private property rights, while on the other, there is a legitimate and growing concern that loss of habitat from game ranching could become significant as the industry expands. Potential impacts of this form of habitat loss are no less severe than those caused by road, housing or ski-area developments. In some ways they may be more severe because such habitats are totally lost to native ungulate uses. Colorado's law requires that all native wildlife be removed from commercial wildlife facilities prior to licensing. Because "wildlife" still are seen behind the fences in these facilities, however, the public (and to some extent wildlife managers) may continue to view them as "habitat." Others argue that because the animals are captive and privately owned, these lands can no longer be counted as wildlife habitat. Wildlife managers need to be aware of this dichotomy of opinions and be careful not to overlook habitat concerns. Policies and regulations should be developed more fully to address the issue of habitat loss and impacts on free-ranging populations brought about by game farming.

Public Perceptions

Wildlife agencies know little about public perceptions on the issue of holding wildlife in private ownership for commercial gain. Geist (1985, 1988, 1989) contended introduction of markets and paid hunting jeopardize the North American system of public ownership of wildlife. Alternatively, Rasker et al. (1992) asserted that some current wildlife management problems can be solved by applying profit-motivated incentives offered by commercial markets. Most positive examples of this latter approach occur in Africa, where wildlife populations and habitat have declined dramatically over the past 50 years. Opponents of game ranching in North America argue that on this continent populations and habitat are much more stable and therefore these radical programs are not necessary.

For wildlife managers to decide whether to allow (or to attempt to ban) game ranching they must understand public perceptions within their particular geopolitical area. People in Wyoming seem to oppose unequivocally the concept of private ownership of native wildlife; this attitude is reflected in statutes and regulations of the Wyoming Game and Fish Department banning such activities. In Colorado, the public does not seem to share that same perception. It clearly wants CDOW to manage the industry and minimize risks to native wildlife, but there has been little support for or even discussion of a total ban on game ranching. These attitudes are reflected in the policies and regulations of the CDOW which acknowledges private ownership of wildlife as a legitimate enterprise. Such disparate public attitudes arising in adjacent states with similar cultures and resources demonstrate the need for wildlife managers and agriculture officials to design and use survey instruments in measuring public perception towards captive wildlife before making policy and regulatory changes.

Public support for wildlife programs and agencies is the key to their success. Does private ownership of wildlife jeopardize that support? Some argue yes. One attraction of wildlife is the wild and elusive nature of free-ranging animals, particularly when compared to domestic livestock that are easily accessed and viewed. Wildlife, from this standpoint, is different because it is not mundane or common. This public perception is very strong. Wildlife should remain wild and "different" from domestic animals.

If people in Colorado routinely see captive elk on elk farms behind fence, will they lose interest in elk? Will they be able to differentiate between captive elk and wild elk? Will they still support programs to manage and protect wild elk? Posewitz (1993) contended commercial ownership of wildlife will erode support and lead to trivialization. These concerns are heightened by a game-ranching industry that refers to its animals as domestic livestock. Whether today's captive elk are domestic or not is a matter of which definition is used. There is little doubt, however, that, as a species, the Rocky Mountain elk has started down the road towards domestication in Colorado. Two key issues for wildlife managers, agriculture officials and the captive wildlife industry are when the public will perceive this change to occur and what the outcome will be for free-ranging elk populations? These issues must be considered by all of the entities involved in wildlife commercialization and its management. There are real biological concerns that must be addressed. Perhaps more importantly, though, fundamental changes in public perceptions and values of wildlife must be recognized as a potential concern of all those involved with the captive wildlife industry.

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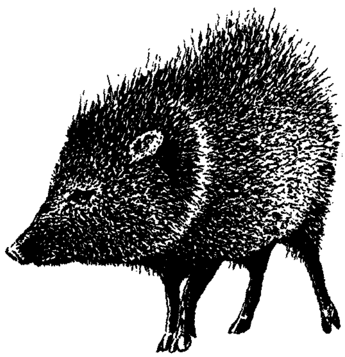

Special Session 9. *Adaptive Resource Management: Policy as Hypothesis, Management by Experiment*

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Opening Comments: Slaying Slippery Shibboleths

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Macnab (1985:403) introduced "slippery shibboleth" to the wildlife literature with the expression of concern for the overuse of carrying capacity and other concepts that are loosely defined and remain "largely hypotheses in search of critical field tests." To deal with this issue, Romesburg (1981) and Macnab (1983, 1985) emphasized the need for better hypothetico-deductive science and an experimental approach to management. We contend that "Adaptive Resource Management" (ARM) (Walters 1986) is one approach to management and research that may help to slay wildlife shibboleths. We also recognize the potential for ARM itself to become a shibboleth, and part of our purpose in arranging this Special Session and writing this introduction is to attempt to dispel that contingency before it begins.

In the broadest sense, ARM is done whenever the dual goals of achieving management objectives and gaining reliable knowledge are accomplished simultaneously. With ARM, we acknowledge the uncertainty about biology that underpins our prescriptions for management, so the prescriptions are treated as predictions that should be verified or refuted. If refuted, the knowledge gained in the process provides new and better prescriptions. This adaptive process mandates articulation of underlying assumptions and implementation of management by designs that allow predictions to be tested with adequate statistical power. Thus, ARM treats every management action as a potential learning opportunity that can feed back more reliable information in a process of continuous quality improvement (Imai 1986).

Perhaps some of us will be uncomfortable with the notion that we should admit to the uncertainty in our understanding of how ecosystems will respond to intended or unintended perturbations. After all, is not our credibility as a profession jeopardized if we, as experts, reveal a lack of understanding? No. We always will be vulnerable to weak links (uncertain facts and unproven principles) that underlie our management plans (Murphy and Noon 1991). If we acknowledge these weaknesses, but do management in a way that strengthens our understanding, then we ought to be able to successfully defend our actions, whether in public or judicial arenas.

ARM also provides opportunity to test explanatory hypotheses (Gavin 1989, 1991, Keppie 1990) with hypothetico-deductive (H-D) methods, rather than simply being satisfied with retroductive explanations (Romesburg 1981). In other words, we should be seeking a better basic understanding of the structure and function of ecosystems which will permit us to be better managers (National Research Council Committee on Forestry Research 1990, Lubchenco et al. 1991). Thus, our profession should foster greater synthesis between the so called "basic" and "applied" sciences. We concur with Romesburg (1991, 1993) that a substantially better understanding of the processes of nature is possible, that this understanding will lead to better management, and that educators should be devising academic programs in natural resources that will educate students who are interested in and capable of conjecture and theory testing.

Thus, adaptive management offers something of value to managers, administrators and researchers alike. It allows managers to manage and provides the potential to resolve confrontational gridlock. In many cases, management can proceed by a design in which opposing perspectives can be tested and resolved, thereby possibly limiting the opportunity to resurrect the same issues repeatedly in the future.

However, managers might have to admit to less certainty about whether their intuitions are correct and can provide a sound basis for management interventions. At best, when their intuitions are correct, they will gain more reliable knowledge. At worst, when their intuitions are incorrect, they are afforded the opportunity to make adjustments to programs before it is perhaps too late to do so, thereby preserving their credibility.

Furthermore, ARM is attractive to administrators and policy makers because they can hedge their bets, i.e., be flexible with regard to one particular policy, and simultaneously test among several. Thus, policies are subjected to the same skepticism that competing alternate hypotheses undergo during scientific studies (Clark 1992, Loucks 1992, Walters et al. 1992). For example, the assumptions that underlie a harvest policy like density-dependent population growth can be examined with management programs that also are field experiments.

Finally, ARM also allows researchers to do large-scale, manipulative experiments which were called for decades ago by Anderson and Burnham (1976) and Macnab (1983), and recently reiterated by the Ecological Society of America (Lubchenco et al. 1991:

395). Managers and researchers still should strive for sound experimental designs that include a priori power analyses, randomization and replication. Often times, replication and randomization will be constrained (Nichols 1991), and some "experiments" might not be planned at all, but rather could take advantage of serendipitous manipulations performed by others. Regardless, what is most important is the attempt to falsify hypotheses about how and why wildlife systems behave as they do, to erect better ones (e.g., Sinclair 1991), and to test among competing ideas about the effect of management (Macnab 1983).

Can ARM be done? We organized this special session to show not only that it *can*, but also that it *is* being done. In the first two papers, Mike Conroy and Mark Boyce point out that building conceptual and quantitative models and using them properly to synthesize our understanding and to develop predictions that can be tested are essential parts of the ARM process. These papers are followed by Kevin Gutzwiller's proposal for an adaptive approach to study the impacts of recreation on wildlife—an approach that has great potential utility, in that human recreational activity can, perhaps, be regulated more readily than can wildlife behavior. Brad Semel and Paul Sherman stress the need for understanding fundamental animal behavior to better manage wood duck recruitment and the placement of nest boxes. The next two papers—Bob Clark and Tony Diamond's paper on opportunities for designed management in restoring duck breeding habitat in the Canadian prairies, and Fred Johnson et al.'s paper on adaptive management for determining harvest strategies of waterfowl—are calls for applying ARM to two currently critical concerns in wildlife management. Calls for ARM are answered in the last three articles, which relate sound case histories of ARM. Fiona Schmeigelow and Susan Hannon's, and Eric Kurzejeski et al.'s articles are examples of land management where habitat manipulations are designed into a forest management plan, so as to better understand the effects of timber harvests on wildlife. In the final paper, Mike Gratson describes an ARM strategy that is being used in Idaho to study the demographics of compensatory and additive mortality, concepts that are the underpinnings of harvest strategies in Idaho elk populations across the state.

Natural resource policy makers, administrators, managers and researchers are at a watershed in how business is done. We can continue with our linear style of management, implicitly assuming we know everything and therefore do not need to check whether what we are doing is right (*see* Bailey 1982), or we can strive for wider application of adaptive resource management wherever it is warranted. The future of wildlife management resides in this working partnership between research and management.

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The Use of Models in Natural Resource Management: Prediction, Not Prescription

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Athens

Along with most other professionals, natural resource managers have become technologically sophisticated. We frequently use models, ranging from forest growth and yield models, to sustainable yield curves, population viability analyses and habitat suitability indices. Projections from these models are routinely incorporated into decisions ranging from whether and how to cut a particular forest stand, to state and federal agency policies and regulations. Models have been used as part of expert testimony in court cases for such species as the American black duck (*Anas rubripes*) (Blandin 1982) and more recently the northern spotted owl (*Strix occidentalis borealis*) (Murphy and Noon 1991).

Throughout the recent proliferation of modeling in resource management, I have felt a discomfort which I think is shared by many of my colleagues, both in management and research. I fear that models are frequently, perhaps commonly, used without adequate appreciation of their limitations. Many users of models appear to treat model predictions as virtually synonymous with knowledge. Particular models and even parameter values have become ingrained as part of agency guidelines and protocols. If my fears are justified, our profession will suffer from at least two consequences. First, inevitably many of these modeling efforts will fail, to the discredit of the agencies or other entities who have uncritically depended on them. Those with adversarial political or philosophical agendas will waste no time in exploiting these discredited efforts as part of their attempts to roll back policies, regulations and laws that have taken conservationists decades to establish. Second, modeling failures will exacerbate what is, in my opinion, an already serious rift between management and research. Models, then modelers, and ultimately research and development programs, will be blamed for model failures, and part of that blame will be deserved. Short of outright disastrous failure of models, I think we will observe a continuation of what has already happened: the use of model predictions when they "seem to make sense"; the "tweaking" of model parameters to make them fit observations; and the discarding of model output that makes no sense at all.

I think that there is a better way. I propose that models can best be viewed as generators of predictions under management alternatives, which then need to be evaluated, rather than as prescriptions for any particular management action. This approach explicitly admits that current knowledge, including models, is incomplete, and that "prediction is difficult, particularly about the future" (Chinese proverb quoted in North and Jeffers 1990). I review general approaches for model building and use, as well as some misconceptions and fallacies about models. I then suggest several criteria for predicting the utility of models in decision making and review selected types of models in terms of these criteria. Finally, I recommend ways in which models can help resource managers and researchers to cooperatively design programs of adaptive resource management (Holling 1978, Walters 1986).

General Approaches to Modeling

For those readers unfamiliar with modeling, following are some of the approaches used by modelers. Those wishing a more thorough treatment are referred to discussions by Walters (1971, 1986), Tipton (1983), and Starfield and Bleloch (1986), among others. First, I wish to make clear that by "models" I am not referring to purely empirical models used in statistical estimation and hypothesis testing (e.g., multiple regression analysis), although these often will be useful in the preliminary development of models or in the estimation of model parameters. Rather, I am referring to models that have at least two common themes: (1) they are based on some at least provisional understanding of a system (e.g., an animal population, a forest ecosystem) and (2) modeling is being used to assist with further understanding, management or both.

Models are abstractions of the system of interest, just as a road map is an abstraction of a highway network. There are typically three goals to modeling and they involve mutual tradeoffs (Levins 1966). *Realism* is the correspondence of the model to biological reality. *Precision* is the ability of the model to mimic and predict real world events. *Generality* is the ability of the model to apply to a broad array of situations. None of these is necessarily implied by the others; a "realistic" model may not be "precise," and vice-versa.

Myths About Modeling and Understanding

A frequently stated goal of modeling is to assist in organizing existing knowledge about a system and to focus further research. For example, I agree with Johnson et al. (1985b) that a simple model of the annual life cycle of mallard (*Anus platyrhynchos*) has been useful in summarizing existing knowledge on the population dynamics of the species. I think it is less clear that research into critical aspects of mallard population ecology occurred because of insights provided by the model, and that we have advanced knowledge as a consequence of modeling, but perhaps that judgment is premature.

However, it is a fallacy that predictions or other output from models can be used to affirm an underlying theory upon which the model is based; that is, to "prove" that the model is "correct." If a model is very complex, the connection of model predictions to particular model assumptions might be unclear and confounded by complex interactions among model components. Even in simple models, it is fallacious to use correspondence of model predictions to data to unequivocally affirm model assumptions for two reasons. First, a model prediction is a deduction from a general premise (model assumptions) to a particular case (a prediction). Under the rules of logic, "correctness" of the model is a sufficient, but not a necessary condition for agreement of the prediction and the observation. In fact, two different and themselves "incorrect" sets of theory and assumptions might correctly predict an observed event, resulting in what Levins (1966) calls "intersecting lies"; "truth" may or may not lie at this intersection. Second, both data (e.g., observations from an experiment) and model predictions usually contain uncertainty, in the form sampling error for the former, or parameter bias and imprecision in the latter. Attempts to reject statistical null hypotheses of no difference between model predictions and observations are thus frequently burdened with very low statistical power, rendering already weak (on logical grounds) inference about model validity even weaker. For example, a habitat model might predict that a particular species should occur in habitats A and B 75 percent and 25 percent of the time, respectively. Leaving aside the fact that complete empirical agreement with this prediction would *not* corroborate the underlying hypothesis, the result, based on one sample of 10 animals, that 8 animals are in A and 2 are in B would not be convincing evidence in support of the model.

Finally, in my opinion, it is a myth that formal, mathematical models are *needed* for understanding natural systems and for solving natural resource problems. Modeling is not the only, and sometimes not the best, way of gaining this knowledge. Modeling is neither necessary, nor sufficient, for gaining understanding in ecology and resource management and is not a substitute for clear thinking. I will go further and suggest that modeling exercises can actually *inhibit* the gaining of *reliable* knowledge (Romesburg 1981).

Model Reliability

Modelers often seem infatuated with the acts of building a model and producing numerical output. Of course, any model is capable of producing output, no matter how course or qualitative the input and assumptions. Somehow, the production of numerical output feeds the modern desire to appear more ''quantitative'' or ''objective,'' even when numerical differences in model output might be meaningless. The danger, of course, is that output and showy graphics can distract attention from the unreliability of the model whence it came and appear ''reliable.''

A variety of techniques has been used by modelers to provide some assurance of reliability. *Sensitivity analysis* involves the controlled variation of parameter values in various combinations, and the observed response of model output. For example, changing adult survival rates by 10 percent in a population growth model might result in a 5 percent change in population growth rates, given that other model parameters are held constant. Sensitivity analyses can provide some idea of the relative importance of errors in parameter values, but because they rely on model structural assumptions they cannot be used to ''validate'' a model. *Validation* is the testing of model predictions by means of independent observations; i.e., data not used in the construction of the model or the estimation of model parameters. However, validation usually is conducted under conditions similar to those under which the model was constructed, and there is no guarantee that a ''validated'' model will perform well (i.e., be more *general*) under some quite different set of conditions, as might occur under alternative management. Managers usually will be more interested in how well the model *forecasts* or predicts the future under a selected scenario, rather than how it explains existing conditions. Henceforth, except when I am discussing model validation, when I refer to ''prediction'' it will be in this forecasting sense.

Much effort has focused on obtaining values for model parameters and in ''calibrating'' models to data. However, relatively little attention has been paid to the evaluation of critical structural assumptions of models, including the form of functional relationships such as density-dependence and other feedback mechanisms. For example, the assumed degree of density-dependence in mortality or birth rates in models used to simulate the effects of harvest on popoulations will have dramatic effects on projections from these models, often completely overwhelming any potential uncertainty in other parameter values and inputs. Yet, I have seen only a few harvest management models (e.g., Anderson 1975) in which this assumption is both dealt with explicitly and recognized as being critical.

Criteria for Successful Models

The preceding discussion leads me to offer several criteria which I think may be useful in predicting whether a particular modeling effort is likely to be useful. Again, I am assuming that modeling has the twin purposes of (1) assisting managers in making better decisions; and (2) helping with better understanding of how the system works. I believe that these goals are inextricably linked and of equal importance. Clearly, managers will be served by having understanding of both how and *why* particular management approaches work or do not work (c.f., Gavin 1991). This understanding is itself dependent on the managers taking action.

In my view, modeling can facilitate this process by providing a means of formally defining our current understanding of the system under management and of generating predictions under alternative future management scenarios. To do so, a model must have *realism*, i.e., (*Criterion 1*) *be closely connected to a biological theory or hypothesis* that represents that provisional understanding. The details of the model itself are the formal mathematical statement of this provisional understanding, and model output represents deduced conclusions: *if* the model structure and parameter values are true, *and* one takes as given a particular set of initial conditions and input, *then* certain model output will follow (or, for stochastic models, on the average will follow). A related aspect of realism is that, to the extent possible, parameters, model states and other model components should have biological meaning, i.e., be related to real biological phenomena and mechanisms. Many readers will recognize here elements of the hypothetico-deductive (H-D) method (e.g., Romesburg 1981): a logically deduced conclusion or prediction based from a set of premises—the hypothesized model structure and parameter values, plus initial conditions and exogenous variables).

Because part of both management and learning through the H-D method involve prediction, management models should have a degree of *precision*; that is, be able to explain and predict real-world phenomena. Thus, to be useful, a model should have been shown to (*Criterion 2*) *be valid, or at least have in place a means for validation*. Related to this, model parameters, besides having theoretical meaning (Criterion 1), should at least potentially be observable.

Management in natural resources often has been called an art, rather than a science, implying a degree of uncertainty and trial-and-error in the results of any given management action. However, uncertainty about the consequences of management action is not an excuse for managing in a non-scientific manner. The scientific method is helpful here: models can be used to formalize current understanding about the system, and then to make testable predictions about outcomes under different management scenarios. Presumably, a choice often can be made among management alternatives, including the establishment of "controls" for comparison. Models should therefore (*Criterion 3*) *enable testable predictions* about the consequences of these alternatives. Thus, management itself becomes the "experiment" used to evaluate the predictive ability of the model, and hopefully, the tenability of the underlying provisional knowledge.

Finally, in order to be useful, falsification of model predictions in the course of the management "experiments" must somehow be incorporated into future management decisions and used to modify the original model. Thus, (*Criterion 4*) *a formal mechanism is needed for providing "feedback" to modify both our understanding (the model) and selection of future management options.*

These four steps constitute the essential elements of adaptive resource management (ARM).

Review of Modeling Efforts

Below, I consider how well models used in natural resource management have fulfilled these criteria. My review was limited to terrestrial wildlife in North America, and I considered two major types of models: (1) population dynamics models, especially those incorporating harvest or other population manipulation; and (2) habitat assessment models, e.g., in particular Habitat Evaluation Procedures (HEP; Schamberger and Krohn 1982). My review focussed on articles on terrestrial wildlife modeling published between 1975 and 1992, especially in *Transactions of the North American Wildlife and Natural Resources Conference, The Journal of Wildlife Management, Wildlife Monographs* and *The Wildlife Society Bulletin.* I also reviewed several recent volumes of *Econogy, Ecological Modelling, Conservation Biology,* numerous government (e.g., U. S. Fish and Wildlife Service) publications, and workshop proceedings. I eliminated models that were purely empirical unless their primary purpose was prediction relevant to management and models that made no reference to management, or those that dealt primarily with economics or human behavior. The remaining articles, while not an exhaustive review of the literature on modeling in natural resource management, are, in my opinion, a reasonably accurate profile of the approaches and methods used in wildlife management. I cited individual articles when these serve to illustrate a point, but will supply the complete list of reviewed articles upon request.

Connection of Model to Theory

All population models at least implicitly incorporate assumptions about the relationships among demographic parameters, population size, and other variables and parameters, and thus an implied understanding about the way in which these relationships work. Unfortunately, there was great variability in the manner in which authors communicated these assumptions to readers, or in some cases, in their apparent awareness that assumptions had been made. Anderson (1975) began with a clear statement of underlying theory for his model of optimal exploitation, based on years of previous ecological work, and generated alternative testable hypotheses for the specific case of mallards. By contrast, Alexander and Taylor (1983) modelled sex-specific survival rates of canvasbacks (*Aythya valisineria*) as being density-dependent, but gave little mention to their model's assumptions that survival rates do not very with age, despite abundant theoretical and empirical evidence to the contrary (Johnson et al 1985a).

Compared to population dynamic models, the connection of habitat-assessment models to theory appears generally weak. Many habitat suitability models (e.g., Clawson et al. 1984, Irwin and Cook 1985, Dubuc et al. 1990) examined empirical relationships between habitat variables and animal abundance without *a priori* reference to theory. Because the statistical models used have no biological structure, interpretation of parameter estimates are inferred post-hoc, if at all, and often at considerable risk of misinterpretation (e.g., Williams 1983, Rexstad et al. 1988). Habitat assessment models sometimes invoked niche theory and other ecological concepts to link population density and habitat variables (e.g., Short 1982, Flather and Hoekstra 1985), but neglected other, important ecological factors. In particular, HEP models fail to make any direct connection between "habitat factors" and fitness, settling instead for crude (and admittedly easier to obtain) measures such as presence/absence or relative abundance, or vague concepts such as "potential density." However, density or abundance can be misleading indicators about the functional relationship of habitat to populations (Van Horne 1983, Pulliam 1988, Hobbs and

Hanley 1990, Pulliam et al. 1992). Further, the mathematical form and parameter values of many HEP models appear arbitrary, with little biological content; even if empirical validation of these models were possible which, as discussed below, is problematic, I am not convinced that much would be gained in the way of understanding. Finally, without denying the importance of site-specific approaches, I concur with Van Horne and Wiens (1991) that "any attempts to model wildlife-habitat interrelationships ... must also consider the importance of the spatial and temporal scales of resolution used and must treat habitat units as part of a larger landscape mosaic"—an approach only recently taken by Pulliam et al. (1992) and others.

Model Validation

In my review, I found few examples of adequate model validation. In some cases (e.g., Brown et al. 1976, Pojar 1979, Williams 1981, Gruver et al. 1984, Nelson et al. 1988, Taylor et al. 1987, Lenarz 1991) validation either was not attempted or the method of validation, if any, was not described. In others (e.g., Bobek 1980, Crête et al. 1981, Johnson et al. 1986), validation was attempted but the scope (e.g., range in input/output, number of independent predictions tested) was severely limited. Often "validation" consisted of broad statements about the model predictions being "comparable" or "reasonable" (e.g., Kurzejski and Lewis 1985). In several cases, authors conducted validations in which independent data were compared to model predictions (e.g., McDonnell et al. 1985, Straw et al. 1986, Frederick et al. 1987, Diefenbach and Owen 1988, Hobbs 1989, Livingston et al. 1990), but I found no cases in which predictions were tested under conditions very different than those under which the model was constructed. Nonetheless, there frequently was little hesitation in using the model to predict (i.e., forecast) the results of particular management actions (e.g., Alexander and Taylor 1983, Gruver et al. 1984, Kurzejeski and Lewis 1985).

Validation appears to be particularly problematic for habitat assessment models. In some cases, models were considered "valid" if they generated the same qualitative statements about "suitability" as those provided by "experts" not acquainted with the model (e.g., O'Neil et al. 1988). More frequently, it was claimed that animal use of "suitable" habitats was *prima facie* corroboration of their suitability (e.g., Straw et al. 1986). There are at least two difficulties with the logic behind this latter "validation." First, it is *not* necessarily true that suitability of habitats can be inferred based on the usage by or abundance of animals in them (e.g., Lidicker 1975, Van Horne 1983, Pulliam 1988, Pulliam et al. 1992). Second, the absence of animals from a habitat cannot be used to infer lack of suitability; a habitat may be "suitable," but dispersal to it from other suitable and occupied areas has not yet occurred (e.g., Lancia et al. 1982). Thus, it is difficult to see how predictions from most habitat models *could* be tested: absence of animals in a habitat predicted as suitable could always be explained on demographic grounds, whereas presence, even at high densities, might not imply that the habitat is contributing positively to life requisites. In practice, however, most authors treated animal presence as confirmatory of habitat suitability, and absence as evidence of lack of suitabilility, perhaps explaining the relatively poor predictive ability of many habitat models (e.g., Mauerer 1986, Morrison et al. 1987).

Finally, in fairness, I must note that the conceptual sophistication and procedures for validation of habitat models has markedly improved in recent years (e.g., Morrison et al. 1992, Pulliam et al. 1992); I think the jury is still out on whether and how fast these improvements will be translated to useful predictive modeling in this area.

Means for Testing Hypotheses about Management

Models were sometimes presented as "planning tools," in which agencies could sift through various management scenarios to see which combination would result in some "optimal plan" (e.g., Matulich et al. 1982, Short 1982, Rhodes et al. 1983, Nelson and Wishart 1988). Implicitly, this approach treats the model predictions as a stopping point: the only step left is to sift through the various plans and determine which plan or combinations gives the desired "result." An alternative is to view models as stepping-off points, suggesting an array of management actions and their predicted impacts. For example, Schmitz (1990) used a model based on optimal foraging theory to predict diets of white-tailed deer (*Odocoileus virginianus*) under different hypothetical feeding strategies, then tested these predictions with a manipulative experiment involving supplemental feeding. Similarly, Crête et al. (1981) and McCullough et al. (1990) each made a series of testable predictions and corresponding recommendations for the harvest management of moose (*Alces alces*) and white-tailed deer, respectively. By contrast, Alexander and Taylor (1983) did not suggest hypothesis tests, but instead over-extrapolated model predictions and selected an extreme harvest rate as the "optimum" management strategy (Johnson et al. 1985a).

Unfortunately, even some of the best modeling efforts occasionally treated model output as if they were actual data, for example, terming manipulation of inputs under various management scenarios as "experiments" used to "test hypotheses" (e.g., Frederick et al. 1987, Hobbs 1989) when the only system being "experimented" upon was the system of equations and parameter values assumed by the modeler. I do not suggest that these or other authors actually believed that such modeling games constituted real-world experimentation, but would prefer that they had used some other term such as "gaming," and reserved "experiment" for its more usual, empirical meaning. On the other hand, some modelers have acted as though they really *do* believe that model predictions are better than empirical observations: advocates of "data alignment" (e.g., Pojar 1979, Williams 1981) adjust empirical estimates of demographic and other parameters to correspond to model predictions, in the apparent belief that if the data do not agree with the model, it is the former and not the latter that must be incorrect. In these instances, one is tempted to apply to modeling the old saw about statistics: that it is used like a drunk uses a lamppost, more for support than illumination.

Means for Updating Model and Management Decisions

I could find very few examples of modeling efforts that were part of a process directed both toward the iterative updating of model reliability, and the provision of feedback for modifying management decisions. Perhaps there are several of these efforts underway that I am unaware of, or that have yet to generate reportable results. Of the modeling approaches I reviewed, I believe four are illustrative—the aforementioned efforts by Crête et al. (1981), Schmitz (1990), McCullough et al. (1990), and the long-standing model used by the U. S. Fish and Wildlife Service for the forecasting of autumn flights of mallards (Pospahala et al. 1974). This last model, although largely empirical, is based on simple theory of population dynamics and habitat characteristics, and has been repeatedly validated and updated. It provides a short-term forecast of duck populations that is used by managers to assist in the setting of harvest regulations. Once these regulations are in place, the implementation of the regulations results in collection of data that are used to update the model and, presumably, to evaluate the "success" of the management decision. The model is based, however, on views about the effects of harvest that have not been thoroughly tested (e.g., Nichols et al. 1984, Conroy and Krementz 1990) and management experiments (e.g., Anderson et al. 1987) are needed. Although of limited scope, it is an example of the use of models in an adaptive management context that has become institutionalized.

Discussion

My review suggests that, although most models appear to have at least some theoretical foundation or realism (Criterion 1), relatively few models have been subjected to adequate validation (Criterion 2). Further, some types of modeling efforts, in particular those purporting to predict habitat suitability, appear to be generally weak, on both theoretical and empirical grounds. More disappointing still is that modeling seldom is part of a process where model predictions could be tested and used to enhance knowledge and improve management (Criteria 3 and 4).

I do not suggest that because all four criteria may not have been met a model is of no potential value to managers. I do suggest that Criteria 1 and 2 (realism and validity) are minimal standards for a model useful to management; those models that fail to meet these criteria are unlikely to be useful to managers. Further, whereas modeling can be a useful heuristic device, and can help to organize and focus research efforts, I suggest that to be useful to management modeling cannot stop here, but *must* be part of a part of a *process* that leads to improved understanding and management (Criterion 4). It is therefore difficult for me to see even the eventual utility of models that are incapable of producing testable prediction (Criterion 3). I make no predictions about models that meet the last but not the first two criteria, simply because I do not believe such models exist: models that are neither theoretically motivated nor possible to validate cannot be used to make testable predictions.

I leave it to others to falsify my predictions about model utility or my assertions about various modeling efforts failing to meet Criteria 1–4. Perhaps the best ''experiment'' would be for managers to implement new, or continue existing programs that incorporate modeling as part of an iterative *process* of ''learning while doing'' (Walters 1986), and to compare the ''results'' five years hence to modeling efforts or management that are not part of such a process.

Why Do We Use Unreliable Models?

If I am correct, and models are commonly used in natural resource management that are unreliable and do little to advance either management or understanding, then we as natural resource professionals should be asking why this is occurring. First, I think there has been a certain amount of relegating of ''modeling problems'' to specialists (sometimes entire ''shops'') who are quantitatively inclined, but who are not necessarily very familiar with actual management problems, or in some cases, with the scientific issues involved. In addition, there has been a tendency to isolate resource management problems and treat them as separate from a general, underlying body of knowledge (Gavin 1989, 1991). These results in the development of models with little generality beyond a narrowly prescribed set of conditions, and little capability of enhancing understanding of how managed systems work. Finally, there is an apparent disconnection between model development, which often is done by researchers, and the subsequent application of models by managers. As long as models are viewed by researchers as ''done'' when coded and, perhaps, validated, and by managers as "off the shelf and ready to use" (North and Jeffers 1990), little progress will be made. Rather than being viewed as separate operations, model development and use should be inextricably linked, and the relationship between the model developer and user continuous and symbiotic.

Conclusion

Modeling as part of management recognizes that all management has (or should have) an underlying conceptual basis. However, explicitly recognizing that our current understanding of resource systems is always "wrong," and that no model is ever "correct" leads to adaptive management—improving knowledge while doing management. Modeling in isolation from management, or as a simple prescription for management, is not useful. Viewed as generating predictions, and not prescriptions, models can be an integral part of an adaptive approach to managing natural resources (Holling 1978, Walters 1986) and gaining reliable knowledge (Romesburg 1981).

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Population Viability Analysis: Adaptive Management for Threatened and Endangered Species

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Introduction

Population viability analysis (PVA) is the process of estimating the probability of persistence of a population for some arbitrary time into the future (Soulé 1987, Boyce 1992). PVA has its origins in the conservation biology movement; indeed, it is one of the keystone ideas of conservation biology (Wagner 1989). Performing a PVA entails compiling available biological data on a species and using these data as the basis for a simulation model for the population. The model then can be used to project future population trajectories from which one may estimate the probability that it will persist, for say 100 years, or other related estimates such as the probability of extinction or expected time extinction (Dennis et al. 1991).

The probability of extinction emerging from PVA would appear fundamental to establishing priorities for conservation based on guidelines that have been proposed for the categorization of species by International Union for Conservation of Nature and Natural Resources (IUCN) (Mace and Lande 1991). In other applications, attempts are made to determine the minimum viable population (MVP) necessary to meet conservation objectives. Unfortunately, such applications are premature because we cannot reliably estimate the extinction probability for any species (Lebreton and Clobert 1991, Boyce 1992).

Yet, I believe that PVA can be enormously valuable if viewed in the context of adaptive management. The process of pulling together all available data and building a simulation model constitutes a synthesis of our current understanding of the population. Simulation models can be used to generate hypotheses of how we expect the system to respond to perturbations or management manipulations (Boyce 1991b). If this is followed by monitoring the consequence of management actions, PVA clearly is within the framework of adaptive management (Walters 1986).

Limitations

We do not know how many individuals are necessary to prevent population extinction, and there is insufficient empirical and theoretical basis on which to make such extrapolations. Small populations may remain viable over quite long periods of time. For example, the Socorro Island red-tailed hawk (*Buteo jamaicensis socorroensis*) has persisted for well over 40 years with a population of only 20 ± 5 (Walter 1990). Although small populations gradually lose genetic variability due to drift, these populations may be important because geographic isolates often are genetically distinct (Lesica and Allendorf 1992). Small populations clearly are much more prone to extinction due to chance events, inbreeding depression, or an Allee effect (Soulé 1987, Dennis 1989). But we do not have sufficient knowledge of any of these processes to make defensible proclamations of a minimum viable population for any species.

Lack of Genetic Basis for Assigning MVP

It is common to place a target of an effective population size (N_e) of 50 for a short-term MVP, presumably based on the assumption that a 1 percent loss of heterozygosity is acceptable (Frankling 1980, Lacava and Hughes 1984). Then what often follows are calculations to estimate N_e based on data on sex ratio and mating system (Harris and Allendorf 1989).

Although N_e may give insight into the consequences of drift to loss of genetic diversity, there are numerous measures of effective population size depending upon the mechanisms affecting drift. Ewens (1990) reviews calculation of N_{ei} relative to inbreeding, N_{ev} for the variance in gene frequencies among subpopulations, $N_{e\alpha}$ targeting the rate of loss of genetic variation and N_{em} for mutation effective population size. Yet another measure, $N_e^{(meta)}$, defines the effective population size in a metapopulation experiencing repeated extinction-recolonization events (Gilpin and Hanski 1991). Each of these basic measures of N_e then is subject to adjustment for unequal sex ratio, age structure and variable population size (Harris and Allendorf 1989). There is no sound basis for selecting one of these basic measures of N_e over another, yet, as Ewens (1990) shows, they can lead to radically different estimates of MVP.

Likewise, there is no solid basis for the often-cited rule of thumb that 500 individuals may be sufficient to maintain long-term viability of a species. Unfortunately, the 50/500 rule does not have a sound genetic or demographic basis (Lande and Barrowclough 1987, Ewens 1990). And there is no theoretical or empirical justification for basing MVP on an estimate of N_e.

Yet, the 50/500 rule is very popular. Clearly such simple guidelines would be very useful as we confront the global extinction crisis. It simply is not feasible to postpone conservation programs while we conduct a detailed PVA for each population of concern. Happily, there is some evidence that we may be able to come up with empirical justification for such rules of thumb. For example, studies of bighorn sheep (*Ovis canadensis*) (Berger 1990) and birds on oceanic or habitat islands (Jones and Diamond 1976, Pimm et al. 1988, Soulé et al. 1988) consistently show that populations less than 50 are insufficient, and the probability of extinction is high for such small populations. Persistence of populations between 50 and 200 is highly variable, whereas populations over 200 are unlikely to go extinct over the time frames of these studies.

Inferences from these few studies should be restricted to particular taxa, and we may require larger numbers for populations that vary more, for example, insect and small mammal populations (Thomas 1990, Tscharntke 1992). Also wise is Soulé's (1987) rule of thumb that one should always attempt to maintain three or more replicate populations. Further empirical evidence urgently is needed to justify the use of rules of thumb for MVP. But until such evidence becomes available, reliance on rules of thumb, such as the 50/500 rule, is arbitrary and capricious.

PVA Lacks Statistical Reliability

Performing a PVA almost always is severely constrained by the availability of data. Securing precise population estimates usually is difficult at best (Seber 1982, Richter and Söndgerath 1990), and for some populations it may not be possible to obtain estimates for many demographic parameters. Furthermore, any realistic population projection model requires knowledge of the population-regulating mechanism (Sinclair 1989) thus requiring estimates of a density-dependent function (McCullough 1990). But absolutely essential is that the model structure be defensible (Grant 1986, *contra* Ginzberg et al. 1990).

Assigning a hard number to a MVP is not possible (Thomas 1990). If the model is sufficiently complex to be realistic, we typically do not have enough data to do a conscientious job of estimating all of the population parameters. When these sampling errors are propagated by stochastic population projection, the confidence intervals surrounding some future probability of extinction are so large that the entire process becomes questionable (Lebreton and Clobert 1991). These problems are particularly severe for threatened and endangered species where the entire living population may be insufficient to yield acceptable levels of precision in estimates of demographic parameters such as survival.

Simulation Approaches

Problems with parameter estimation are indeed serious. But to my mind, the greatest value in PVA is not in the numbers generated by the models but in the identification of a model that formalizes our current understanding of the ecology of a particular population or species. Results from this model constitute testable hypotheses about the behavior of the system.

Software packages for PVA should be used cautiously because each case must be modeled uniquely. Models should be developed that capture the essential ecology of the system, but yet are as simple as possible to reduce the number of parameters that must be estimated. To illustrate the diversity of approaches that may be taken, I will review examples that use a variety of structures and modeling approaches.

The first PVA was Shaffer's (1983) model for grizzly bears (*Ursus arctos horribilis*) in the greater Yellowstone ecosystem. This was a stochastic simulation model that emphasized demographic structure. One approach is to explore the sensitivity of various variables in the model. By so doing, it became clear that adult survival was among the most sensitive elements in the model. PVA thereby offered valuable insight into the management of grizzly bears and contributed to the development of programs to enhance adult bear survival by minimizing conflicts with humans.

In contrast to the demographic approach used for grizzly bears, Foin and Brenchley-Jackson (1991) modeled critical habitat for the endangered light-footed clapper rail (*Rallus longirostris*) in southern California. Reliable demographic details for the rail were unavailable, and the only well-documented connection between the bird and its habitat was a linear relationship between the biomass of Pacific cordgrass (*Spartina foliosa*) and the number of rails. But the salinity, transpiration and soil moisture of salt marshes are essential to the development and maintenance of cordgrass stands used by rails.

For many species, focus on habitat in a PVA model is the correct focus, and I have chosen the light-footed clapper rail example because it does not dwell on the demographic structure of the population. Indeed, such details often are not known and may be best left out of the models. Eberhardt (1987) reviewed data from a number of large mammal populations to show that simple models without age structure could offer quite sufficient descriptions of population dynamics. For many threatened and endangered species, the most fundamental management programs will entail habitat management. Details of demographic structure for these species may be of little value.

The most extensive PVA program has been on the northern spotted owl (*Strix occidentalis caurina*), stimulated by the severe economic consequences of habitat protection for the subspecies (Boyce and Irwin 1990). The first effort included simple Leslie matrix projections with random elements (USDA Forest Service 1986, Marcot and Holthausen 1987). Use of an exponential growth model clearly was inadequate, and the prognosis for the owls was grim irrespective of future habitat management. A more realistic model by Lande (1988) included density dependence via dispersal of young owls. This was subsequently expanded into a dynamic model (Lamberson et al. 1992) and then interfaced with explicit landscapes imported on a geographic information system (McKelvey et al. 1992). Lande's hypothesis regarding population regulation via juvenile dispersal remains untested, but it forms the basis for many of the Interagency Scientific Committee's management recommendations for the northern spotted owl (Thomas et al. 1990).

Adaptive Management

PVA models by themselves usually are weak and cannot be counted on to provide reliable population projections. But when combined with an iterative process of model improvement and validation, the model can provide a progressively more robust understanding of the dynamics of a species and its habitat; and a model developed in such a way can be a powerful tool for management.

How can PVA be incorporated into adaptive management protocols? Adaptive management proposes application of different management tactics in time and space, essentially as experiments, to develop a better understanding of the behavior of the system (Walters 1986). For endangered species applications, it may be possible to implement various management strategies in spatially separated subpopulations. Active management must be part of such a program, and may encompass a variety of activities such as habitat manipulation, predator or disease control, manipulation of potential competitors, winter provisioning of food, transplanting individuals from other subpopulations to sustain genetic variation, and supplementation of population with releases of captive stock. Monitoring of the genetic and population consequences of such manipulations then provides data to validate and/or refine the PVA model.

Management of grizzly bears in the greater Yellowstone ecosystem has proceeded according to an adaptive management protocol. High sensitivity of population growth rate to adult survival suggested the importance of minimizing adult mortality factors. Aggressive programs to eliminate bear/human conflicts focused on areas identified as mortality sinks (i.e., localities where repeated bear mortalities had been documented). As prescribed by an adaptive management program, after the recovery program had been implemented and additional data were obtained, Shaffer's model was updated (Suchy et al. 1985). Preliminary evidence suggests that the program was highly successful. Indeed, federal officials recently have entertained the possibility of delisting grizzly bears and reverting management to respective state and federal agencies (Boyce 1991a). However, extensive wildfires during the summer of 1988 altered habitat for the bears, and further updates to the bear model will need to be incorporated once the demographic response to the fires has been documented.

Another adaptive management program has been proposed for the management of endangered populations of *Banksia cumeata* in Western Australia. Based upon their PVA modeling, Burgman and Lamont (1992) recommended watering seedlings in several subpopulations to enhance seedling survival. Such programs require careful monitoring because watering or other forms of "enrichment" can have community-level effects that could be counter productive (Rosenzweig 1971). For example, it is conceivable that competing species or herbivores might respond more vigorously to watering than the target species.

For the northern spotted owl, the Interagency Scientific Committee (ISC) explicitly acknowledged the importance of adaptive management approaches for evaluating and updating their conservation strategy, posed as an Appendix in the ISC report (Thomas et al. 1990). Adaptive management would require implementation of various timber harvest programs and associated landscape manipulations and then documentation of the consequences for spotted owl populations. Thus far, no such programs have been implemented because litigation has interfered with the ability of management agencies to develop timber harvests.

For several years, the Captive Breeding Specialists Group (CBSG) of the IUCN has been organizing "Population and Habitat Viability Analysis" (PHVA) workshops for various threatened and endangered species. These have been enormously successful at bringing together available data on a species, identifying possible structures for a PVA model and stimulating agency coordination for conservation programs. One cannot place much stock in MVP estimates that emerge from these exercises, but if they help provide structure that will encourage adaptive management approaches, they perform an exceedingly valuable function.

"Adaptive management is learning by doing" (Lee and Lawrence 1986). But agency restrictions may severely limit our ability to actually do management with threatened and endangered species. Naturally, any programs that might pose a risk to a threatened or endangered species will meet strong resistance from agencies charged with protecting the species. Yet, creative manipulations may be allowed if they could only be viewed as enhancing conditions for the species of concern.

In a legal context, PVA probably will face many challenges because of omnipresent biological uncertainty. Given the statistical weakness of population parameter estimates and our inability to generate robust population projections, any PVA will be open to question even though the PVA constitutes our best statement of the expected behavior of a population. Such uncertainty recently was used in court to challenge the proposed adoption of the Interagency Scientific Committee's conservation strategy for the northern spotted owl by the USDA Forest Service. Although Lee and Lawrence (1986) suggest that biological uncertainty may often frustrate attempts to manage by adaptive management, it is through adaptive management that we can hope to resolve some of the uncertainty associated with PVA. It is the best we can do, and we know of no better way to gain "reliable knowledge" about managing our natural resources (Romesburg 1981).

Conclusion

Population viability analysis (PVA) entails evaluation of data and models for a population to anticipate the likelihood that a population will persist for some arbitrarily chosen time into the future. Models vary depending upon the availability of data and the particular ecology and life history of the organism. Unfortunately, we have insufficient data to validate PVA models for most endangered species. Seldom, if ever, do replications exist, and small sample sizes typically result in projections bearing large confidence intervals. A great danger exists that resource managers may lend too much credence to a model when they may not fully understand its limitations.

There is too much more to be gained by developing a stronger understanding of the system by modeling, than is lost by shirking modeling for fear of its being misinterpreted. PVA as a process can be an indispensable tool in conservation, and it involves much more than attempts to calculate statistically feeble estimates of minimum viable populations or probabilities of extinction. PVA entails the process of synthesizing information about a species or population and developing the best possible model for the species given the information available. When done properly, this involves working closely with natural resource managers to develop a long-term iterative process of modeling and research that can reveal more about how best to manage a species. Done properly, PVA is a variation on Holling and Walter's notion of adaptive management.

Adaptive management proposes application of different management tactics in time and space to develop a better understanding of the behavior of the system. For application to endangered species problems, implementation of various management strategies may be attempted in spatially separated subpopulations. Active manipulation must be part of such a program. Monitoring of the genetic and population consequences of such manipulations then provides data to validate and/or refine the PVA model.

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Serial Management Experiments: An Adaptive Approach to Reduce Recreational Impacts on Wildlife

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Introduction

Although many forms of wildland recreation—including hiking, fishing and nature viewing—seem innocuous, such activities can cause displacement, detrimental changes in behavior and reproductive declines in wildlife (Boyle and Samson 1985). Some activities, like shore recreation (Pfister et al. 1992), boating (Kahl 1991) and the use of off-road vehicles (ORVs) (Webb and Wilshire 1983), can be blatantly intrusive. As these types of recreation and the related industry of ecotourism expand (Purdy et al. 1987, Whelan 1991, Holecek 1993), impacts on wildlife will mount. In the face of long-term and widespread recreational impacts, agencies with charges to preserve wildlife populations and communities are finding it difficult to meet their goals (Purdy et al. 1987). Even when habitat is set aside for conservation purposes, recreationists can severely degrade its value to wildlife. Indeed, many types of recreation directly affect habitat quality for certain species (e.g., Garton et al. 1977, Madsen 1985, Hammitt and Cole 1987, Blakesley and Reese 1988). An important impediment to reducing recreational impacts is the lack of a clear understanding of cause-and-effect relations. Management experiments offer an efficient and realistic means of generating reliable information about causal relations (*see* Macnab 1983, Anderson et al. 1987, McCullough et al. 1990, Nudds and Morrison 1991). Of course, such experiments are not always feasible (Gutzwiller 1991), so simulations and observational studies, which can provide valuable information about associations, will have to suffice in some situations.

Serial experimentation, an adaptive approach in which the results from each new experiment are used to update existing knowledge and refine current management plans, holds promise for reducing recreational impacts on wildlife. Although management experiments are not widely used to determine how to minimize the effects of recreationists on wildlife (cf. Fraser et al. 1985, Götmark et al. 1989, Melvin et al. 1991), whenever feasible they should be the primary and standard approach for solving such problems. The opportunities are abundant because in many situations managers have the ability to manipulate the duration, daily and seasonal timing, frequency, periodicity, and spatial scale of recreational activities. How these variables influence recreational impacts on wildlife is what needs to be understood. Just as one often must apply the scientific method repeatedly to clarify facts about a phenomenon, managers should anticipate the need to conduct a series of related management experiments (i.e., repeat the scientific method in a management context) to resolve a particular recreational-wildlife conflict. Because of the large potential for interaction effects and confounding influences in recreational impact studies (Gutzwiller 1991), serial management experiments are likely to advance our knowledge about the causes of and solutions to recreational impacts better than any other management or research strategy. In many situations, serial management experiments constitute the most credible and defensible approach for determining management actions and policies. In the present paper, I (1) offer advice about how to design initial and follow-up management experiments, (2) provide examples of how such experiments might be implemented, and (3) identify major knowledge gaps about the effects of recreationists on wildlife that management experiments could help fill.

Design of Serial Management Experiments

Basic Principles

To obtain useful information, managers will need to adhere to the principles of experimental design. When necessary, advice about these and other technical issues can be secured from research biologists. All of the statistical and biological considerations pertinent to field experiments in general are relevant for recreational management experiments (*see* Gutzwiller 1991 and statistical references therein). Vertebrate populations can exhibit highly complex dynamics over time (Turchin and Taylor 1992) and space, so it will be essential to recognize this and design and interpret experiments accordingly. Some of these dynamics—especially cyclic changes—will be impossible to detect unless data are collected repeatedly and consistently, as for a time series. The appropriate time interval between sampling events will be species-specific and depend on life span and how rapidly populations can be expected to change with recreational impacts or treatments from associated management experiments. Conceivably, the interval could be days, weeks, months or years. Turchin and Taylor (1992) used a minimum of 18 periods (years in their examples) to maintain statistical power, which is the ability of a statistical test to detect a significant effect or relation when one actually exists. Longer series, however, may be necessary to detect complex dynamics driven by recreationists because of variation due to lags in responses by wildlife, wildlife learning and habituation, and the context-dependent nature of vertebrate responses to recreational activities. Critical values for one-tailed tests are smaller than those for two-tailed tests, so the statistical power of management experiments also may be maintained by testing one-tailed hypotheses whenever possible.

Because of constraints on resources (equipment, time, personnel, study areas), the quality and interpretability of management experiments may suffer from inadequate replication, for which there are no easy remedies. Stewart-Oaten et al. (1992) provided practical guidelines for surmounting replication problems, including advice about checking assumptions for conventional statistical techniques, using the Welch t test, and relying more on biological effect sizes (e.g., magnitudes of changes in reproduction and survival) than on attained significance levels of test statistics to determine the importance of perturbations. The availability of true replicates and controls often will be limited, but if treatments are randomly assigned to experimental units and relevant covariates are measured on each unit, differences among replicates can be accounted for analytically via analysis of covariance (Gutzwiller 1991). In some situations, experiments simply will not be possible because the spatial scale of analyses or the level of biological organization (individual, population, community) under study may severely limit available replicates. Observational and simulation studies may be alternatives in such cases.

Eberhardt and Thomas (1991) clarified differences between experimental and nonexperimental approaches, and they supplied criteria to help researchers decide how to design environmental studies and interpret the results. Temporary closure of areas to recreationists or the banning of certain activities may be necessary to obtain experimental units that are true controls. Opposition from recreationists to such actions may occur, but having true controls (and known treatment levels) will improve the manager's chance of establishing actual causal relations and effective management plans. When feasible, managers will find it valuable to sample responses to experiments at various temporal and spatial scales and levels of biological organization (individuals, populations, communities) because experiments applied to one combination of scales and levels may influence patterns and processes for that combination, other combinations, or both (*see* Emlen et al. 1992, Gascon and Travis 1992). Being aware of such relations will help managers detect the full effects of management experiments, which may produce planned or unforeseen results and desirable or undesirable consequences.

Principles for Recreation Management Experiments

Managers should expect the effects of recreationists on wildlife to be context-dependent (*see* Hammitt and Cole 1987). That is, the impacts of a given recreation activity on a species during one set of circumstances may not be the same as those for the same species during another set of conditions. Differences between two areas in community composition, the species' regional abundance, food and habitat availability, and the history of recreational disturbance, for example, may contribute to disparate responses by wildlife to the same type of recreational disturbance. Response differences within a single area over time may be attributable to shifts in population age structure as older individuals (perhaps habituated to or tolerant of recreationists) die and younger individuals (having little or no experience with recreational disturbance) enter the population. Response differences among individuals of the same species to human intrusion are not unusual (e.g., Knight et al. 1987, Götmark et al. 1989, Kenny and Knight 1992) and are thought to originate from disparate experiences with people (Fraser et al. 1985, Knight and Temple 1986).

Context-dependent responses will require managers to use experiments that involve at least several factors (variables) because the actual cause of a detrimental effect otherwise may be overlooked. As the number of factors considered increases, however, so will the number of replicates necessary to maintain statistical power. Because of the context-dependent nature of many recreational impacts, the literature may be of limited help in narrowing the search for which facets of a recreational activity to manipulate. On-site, direct observations will most likely prove more useful than the literature in this regard. One may be tempted to initiate management experiments in which single presumed causes of impacts are manipulated. But if presumed causes turn out not to be actual causes and a lengthy series of single-factor experiments ensues, progress toward solving a recreation problem would be retarded. Given the numerous factors that can influence wildlife responses to recreationists (Gutzwiller 1991), it seems unrealistic to expect single-factor experiments to reveal completely how recreational activities should be managed. Although a management scheme based on a single-factor experiment could be successful initially, it may become ineffective when conditions change from those of the original experiment. Thus, even for successful single-factor experiments, follow-up experiments to test the validity of the plan under various conditions would be essential.

One way to involve several factors and still achieve adequate replication would be to begin with a multifactor, coarse-level experiment and use it as an initial screening device. Constraints on resources will preclude initial use of numerous fine levels of multiple factors. Instead, managers could first experiment with a few broad levels of each factor—

a minimum, intermediate and maximum level for example. Extrapolation of responses at one level of a factor to another level may not be justified, so coarse levels should be chosen to cover the entire range of observed values for a factor, otherwise the relevance of certain levels will not be clear. For instance, suppose deer are not alarmed by low densities of visitors, they are displaced by intermediate visitor densities and they learn to tolerate or habituate to people (and thus are not displaced) at high visitor densities; experiments that involved only low or high (extreme) visitor densities would not detect the displacement effects of intermediate visitor numbers. The objectives of this initial screening step are to avoid missing pertinent effects, identify which of several potential factors actually are important and determine roughly what ranges of those factors are influential.

The next logical step would be to confirm initial results by repeating the experiment several times. This could be accomplished efficiently simply by leaving in place during several more relevant time periods (e.g., months, breeding seasons, staging periods) the management policy used for the initial experiment. If the outcomes are desirable and consistent, then the next phase of the experiment series—fine tuning the management plan to maximize the satisfaction of recreationists and minimize impacts on wildlife—is warranted. Experiments involving several fine levels of pertinent factors (significant main or interaction effects) could be used to identify which levels within an intermediate or maximum range, for example, are important. Despite resource constraints, it may be somewhat easier to obtain adequate replication at the refining stage because, compared to the number of factors studied initially, fewer factors would be important to examine at this point. Experiments employing fine levels of factors will help identify more accurately the factor levels at which recreational impacts on wildlife occur. Suppose, for instance, that in an initial management experiment (screening analysis) high numbers of hikers, but not low or intermediate numbers, were found to reduce habitat use by neotropical migratory landbirds. A subsequent (refining) experiment that involved several narrow levels of high numbers of hikers would enable managers to determine more accurately how many hikers could be accommodated in habitats before hikers displaced neotropical migrants. In this way, management plans can be refined to meet both the demands of recreationists, whose continued support and cooperation are essential, and the needs of wildlife. In short, a more sustainable coexistence of wildlife and recreationists would be promoted by fine-level management experiments.

Examples of Serial Management Experiments

The two scenarios that follow illustrate some of the possible problems and decision processes involved in serial management experiments for minimizing recreational impacts on wildlife.

Aircraft Overflights

Flights of fixed- and rotary-winged aircraft are becoming increasingly popular as a means to view large natural areas and their wildlife, and managers are trying to find ways to minimize aircraft impacts on wildlife (e.g., MacArthur et al. 1982, Hamr 1988, Stockwell et al. 1991). Aircraft altitude, speed, and noise, whether the craft is a plane or helicopter, and the frequency and timing of flights are among the factors that may influence wildlife responses.

Suppose a manager, based on some initial observations, suspected that helicopters operated by ecotourism companies reduced ungulate use of excellent autumn feeding areas. Little information was available in the literature about aircraft impacts on wildlife in this landscape during the autumn, so the manager, in consultation with a research biologist, devised a management experiment that included as many potentially important factors as available replicates (separate autumn feeding areas in flight paths) allowed. By explaining to tour operators that it was in their financial interest to minimize impacts on ungulates that are popular with tourists, the manager was able to set up, with the cooperation of the companies' pilots, an experiment that manipulated flight altitude, speed, frequency, and daily and seasonal timing. Based on previous operations, low, intermediate and high levels of flight altitude, speed and frequency were identified. Coarse levels of daily flight times (morning, afternoon) and seasonal flight times (early and late autumn) were defined and scheduled. The experiment was conducted, use of each feeding area (dependent variable) was measured and the effects of the treatments were assessed.

After the first autumn, flight altitude and frequency emerged as significant factors that reduced (but did not eliminate) habitat use. No other main or interaction effects were evident, and covariates such as weather and hunter density accounted for little of the variation in use of feeding areas. Low altitudes (but not intermediate or high altitudes) and high flight frequencies (but not low or intermediate frequencies) displaced some individuals from the feeding areas. The same experiment during the next two autumns confirmed the initial patterns, so the manager and tour operators divided the low-altitude and high-frequency categories into finer levels and resumed experimentation with just these two factors. Experiments with four levels of low altitude and four levels of high frequency were conducted.

No significant differences in the use of feeding areas were detected among the finer levels of high frequency, implying that none of the levels permitted satisfactory use of feeding areas and that high flight frequency should be curtailed. Of the four new altitudes, the lower three had more influence on use of feeding areas than did the highest altitude. After the second year of the refined experiment, use actually began to improve somewhat in feeding areas exposed to the highest of the new flight altitudes. But during the second year of the refined experiment, temperatures were lower, snowfall occurred earlier and snow depth was greater, compared to conditions during the previous four years of experimentation. The manager surmised that these more extreme conditions stressed the animals energetically, which promoted their tolerance to flights over the feeding areas at the new highest altitude. Use of feeding areas exposed to such flights was not as low during the second year of the refined experiment as it had been during previous autumns, so the tour operators argued that flights within the new highest level of altitude should be allowed. The manager reminded them that ungulates had been displaced by low flights of roughly the same altitude during the original experiment and that the most recent experimental results might not apply under typical autumn weather conditions. Even if part of the improved use of feeding areas was due to habituation, the manager continued, animals not yet used to low-altitude flights would be displaced. Experiments during the next two autumns corroborated these ideas, so low-altitude and high-frequency flights, as defined in the original experiment, were not permitted over feeding areas.

In this scenario, the adaptive management decision was based on evidence that was gathered during several years. Separate single-factor experiments involving flight speed, or daily and seasonal timing—factors that did not affect use of feeding areas—would have delayed development of a management plan. In addition, potential interaction effects could not have been examined in single-factor experiments.

Four-wheel-drive Vehicles

Impacts of ORVs, including four-wheel-drive vehicles (FWDs), have been documented for various species (e.g., Bury et al. 1977). Because of vocal and organized objections by ORV enthusiasts (*see* Melvin et al. 1991), it could be difficult in some areas to implement a policy that restricts FWD use. Experimental evidence relating FWD use and wildlife variables would be invaluable for developing a defensible management policy that would permit area use by both FWD recreationists and wildlife.

Consider a situation in which FWDs were implicated in the decline of amphibians by observations of direct mortality and wetland habitat destruction, increased erosion, increased sedimentation, and increased water turbidity. Suppose it was not clear whether the number of vehicles, the locations of FWD operation, or associated interactions were responsible. Total elimination of FWDs was unacceptable to the agency managing the regional wetland system because FWD recreationists had strongly objected to this option. After reaching an agreement with FWD users, the manager and local research biologist set up a management experiment to determine whether suspected FWD factors were actually causing the amphibian decline. Separate wetland sections (experimental units) were randomly selected and treatment combinations were randomly assigned to sections. To enable the manager to assess both main and interaction effects, a completely crossed design was implemented involving coarse levels of FWD use that spanned the range of recently recorded activity: 0–10, 11–20 and 21–30 FWDs per section per month (FWD density); FWD operation within 0–50 feet (0–15.2 m), 51–100 feet (15.5–30.5 m) and 101–150 feet (30.8–45.7 m) of standing water (distance to water). The experiment was implemented during the spring, when reproducing amphibians seemed most susceptible and FWD activities were at their peak. For each wetland section, rainfall was recorded as a covariate, and amphibian abundance (dependent variable) was estimated from surveys of vocalizing adults and samples of tadpoles.

The analysis revealed an interaction between vehicle density and distance to water, indicating that the impact of FWD density on amphibian abundance depended on distance to water. The manager found that as FWD density increased, its effect on amphibian abundance became increasingly more severe as distance to water decreased. Further, for wetland sections subjected to 21–30 vehicles per section per month and FWD use within 0–50 feet (0–15.2 m) of standing water, mean amphibian abundance was significantly lower than that for all of the other treatment combinations, whose means did not differ significantly from one another. The same results were obtained for the second spring, but not for the third spring. For each year's analysis, rainfall on wetland sections had been used as a covariate to reduce variation in amphibian abundance so that the treatment effects could be assessed more clearly; nevertheless, variation in amphibian numbers was somewhat higher during the third spring than during previous springs.

Recalling events that had occurred during the third spring, the manager remembered that a fire had swept through a portion of the wetland system during early spring and altered the vegetation on several experimental sections. Evidently, this produced enough variation in amphibian numbers to obscure the actual effects of the treatments during the third spring because, when the percentage of burned area in each section was later measured (via aerial photographs) and controlled for in the statistical analyses, the third spring's results were the same as those for the first two springs. Judging this to be sufficient evidence that operating approximately 21–30 FWDs per section per month within 0–50 feet (0–15.2 m) of water was detrimental, a more refined experiment was initiated to determine whether specific threshold levels of FWD density and distance to water could be identified. Wetland sections were subjected to combinations of FWD density (in the range 21–30 vehicles) and distance to water (in the range 0–50 feet [0–15.2 m]) and, after repeating these more refined experiments, it was clear that more than 23 vehicles per section per month used within 40 feet (12.2 m) of standing water led to high amphibian losses. Based on these results, the agency devised a policy for wetland use that precluded these problems and still enabled the FWD enthusiasts to continue their activities. A monitoring program also was established to assess the long-term effectiveness of the management plan.

Knowledge Gaps and Recreation Management Experiments

Presently, little information is available that relates the frequency, spatial scale, periodicity, or daily and seasonal timing of various recreational disturbances to wildlife variables. Knowledge about the impacts of pets and how different visitor party sizes influence wildlife is limited. We do not understand how effects on individuals influence the age structure or persistence of populations. With few exceptions (e.g., Skagen et al. 1991), impacts of recreationists on the structure and functioning of guilds and communities have not been examined. We do not know how effects from recreational perturbations ''ripple'' (Emlen et al. 1992) through communities by way of interspecific interactions, and long-term data on impacts are rare. Cumulative effects of several different simultaneous disturbances (e.g., hiking, wildlife photography, camping) deserve attention. And it would be valuable to know what types of visitor education programs and what kinds of recreation-facility designs reduce impacts on wildlife most effectively.

Management experiments, when designed properly, are capable of filling these information voids. Management experiments are much cheaper to implement than are identical experiments that use hired personnel to mimic recreationists. Through cooperation among wildlife and land-management agencies, experiments at the landscape scale, the scale at which many recreational impacts actually occur, can be conducted. Management experiments can be used to resolve site-specific problems or to find solutions to wildlife-recreation conflicts that pervade many sites (e.g., parks or refuges in a region). General appearances of natural systems can be misleading; some or many of the component species and processes may inconspicuously be in various stages of decline even though the system as a whole appears intact (Redford 1992). Subtle influences, whose effects may not be discernible with a cursory examination, may be at work in these systems. Management experiments can identify insidious recreation impacts that might be obscured by the extraneous or confounding sources of variation that often plague observational studies. While establishing facts about cause-and-effect relations, recreation management experiments also will provide sound evidence about the effectiveness of alternative management schemes.

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Answering Basic Questions to Address Management Needs: Case Studies of Wood Duck Nest Box Programs

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Introduction

Basic and applied wildlife research often are thought of as distinct disciplines, with answers to basic questions leading by, at best, circuitous routes to real world applications. In fact, the opposite may be true. Indeed, we may be selling short our ability to address specific management dilemmas by not first considering the basic behavioral ecology of the species in question. Such knowledge is necessary if we are to develop management recommendations that transcend local problems.

Often, it seems, research in wildlife biology proceeds piecemeal, with multiple investigations addressing similar questions in many places. The results may be useful locally, but as Gavin (1991) pointed out, they do not lead to a synthetic theory of management for a given species, nor to a set of protocols that can serve as the basis for management decisions in different areas. We believe that to improve the success and consistency of any management program requires an understanding of the ecological, physiological and social factors that affect the reproductive biology of the species involved.

This paper summarizes our efforts to identify the proximal mechanisms that lead to extreme brood parasitism (''dump nesting'') among box-nesting populations of wood ducks (*Aix sponsa*) (Semel and Sherman 1986, Semel et al. 1988). Once we had developed a hypothesis for *why* females dump nest, we were able to suggest management programs to alleviate the resulting detrimental effects (i.e., reduced egg hatchability) by addressing the appropriate factor—in this case, nest box placement (Semel et al. 1990). Our paper thus illustrates an attempt to develop management recommendations based on observations of the behavioral biology and nesting ecology of wood ducks.

Our study used adaptive resource management (ARM) to test general guidelines for managing local populations of nesting wood ducks. ARM helped us avoid duplicating efforts and the expenses associated with conducting multiple parallel studies in different sites. This paper summarizes our hypotheses and experimental tests of them, as well as the management recommendations based on the results.

Nest Box Studies

Nest boxes frequently are used as a management tool when the objective is to enhance local populations of cavity-nesting ducks by increasing the production of ducklings (e.g., McLaughlin and Grice 1952, Bellrose et al. 1964, Bolen 1967). Nest boxes also provide researchers access to nesting birds and their eggs, facilitating collection of data on breeding ecology. Few studies, however, have attempted to formulate *a priori* hypotheses about how the use or placement of nest boxes affects the birds' reproductive behavior. These issues must be addressed before conclusions can be drawn either about the efficacy of nest box programs or the breeding biology of cavity-nesting species based on nest box studies.

We employed a "management by experiment" approach to test several hypotheses regarding wood duck nesting ecology in relation to boxes. Our studies involved experiments directly comparing different management protocols in the same area, and were based upon the hypothetico-deductive method (*see* Nudds and Morrison 1991). Our results suggest new ways to manage wood ducks using nest boxes. We believe that adoption of our protocols can increase nesting efficiency and population productivity, leading to the enhancement of local wood duck populations.

Brood Parasitism

Intraspecific brood parasitism occurs when a female lays her egg(s) in the nest of a conspecific. Intraspecific brood parasitism has been documented in at least 82 species of birds (less than 2 percent of all avian species), 35 of which (more than 43 percent) are waterfowl (MacWhirter 1989). Parasitic egg-laying is particularly prevalent among cavity-nesting waterfowl such as black-bellied whistling ducks (*Dendrocygna autumnalis*) (Bolen 1967, McCamant and Bolen 1979), shelducks (*Tadorna tadorna*) (Pienkowski and Evans 1982) and wood ducks (Bellrose et al. 1964, Semel and Sherman 1986). Brood parasitism reaches extremes when these species nest in boxes: the majority of nests contain eggs laid by more than one female, and clutches of 30–50 eggs commonly occur (e.g., Jones and Leopold 1967, Delnicki et al. 1967, Clawson et al. 1979).

Why is parasitism so prevalent in box-nesting populations of waterfowl? This question has been studied most intensively in wood ducks. In this species parasitism occurs in less than 30 percent of natural nest cavities, but in up to 95 percent of nest boxes (Semel and Sherman 1986, 1992). Bellrose et al. (1964) and Haramis (1975) suggested that parasitism occurs when nest sites are limited, especially in expanding populations. Jones and Leopold (1967:228) argued that nest boxes "concentrated ducks abnormally," thus resulting in intense nesting interference. Clawson (1975) suggested that the combined effects of high nest box density and conspicuousness of nest boxes provided the stimuli and opportunity for increased parasitism. Heusmann and Bellville (1982:32) agreed, and reported that female wood ducks "have a strong decoying effect on one another."

In studies of the nesting ecology of wood ducks in Missouri, Semel and Sherman (1986) observed that when nest boxes were located in visible sites (e.g., over open water) it was virtually impossible for females to enter or exit from their nest without being seen and followed by conspecifics. They suggested that the frequency and distribution of parasitic egg laying was due largely to the artificial social conditions imposed by densely clumped, highly visible nest boxes. In a follow-up experiment, Wilson (in press) confirmed that female wood ducks are attracted to and more apt to lay in boxes at which female decoys are present. Thus, both behavioral and demographic evidence indicates that nest box visibility (and perhaps density) influences the nesting behaviors of female wood ducks.

Nest Box Studies: Background

To test the hypothesis that nest box placement is a major factor responsible for extreme brood parasitism among wood ducks, Semel et al. (1988) used data from a long-term nest box program (1976–1987) at the Max McGraw Wildlife Foundation (MMWF) in northeastern Illinois. They found that isolated boxes, hidden in the woods near water, were parasitized significantly less often and accumulated smaller clutches than boxes that were erected in highly visible locations (over water), regardless of whether the boxes were alone or in groups. Semel et al. (1988) also reported a curvilinear relationship between clutch size and hatchability (Figure 1). Eggs in unparasitized clutches were more likely to hatch as clutch size increased, perhaps due to higher quality or older females laying larger clutches and incubating them more effectively. In sharp contrast, eggs in the most heavily parasitized clutches (which were in visible boxes) were the least likely to hatch. Low hatchability of parasitized clutches was due to frequent nest abandonment, egg breakage, inefficient incubation of eggs and large numbers of nonterm eggs (i.e., eggs laid after the start of incubation) (Morse and Wight 1969). In years of high wood duck populations, the frequency of parasitism increased and nesting efficiency (i.e., the number of ducklings produced/eggs laid) suffered in the visible boxes but not in the hidden boxes. Semel et al. (1988) concluded that nest box placement was largely responsible for variations in the frequency of parasitism and egg hatchability.

In a follow-up study, Semel et al. (1990) evaluated how nest box placement could be used to enhance nesting efficiency, while keeping parasitism in check. They found that

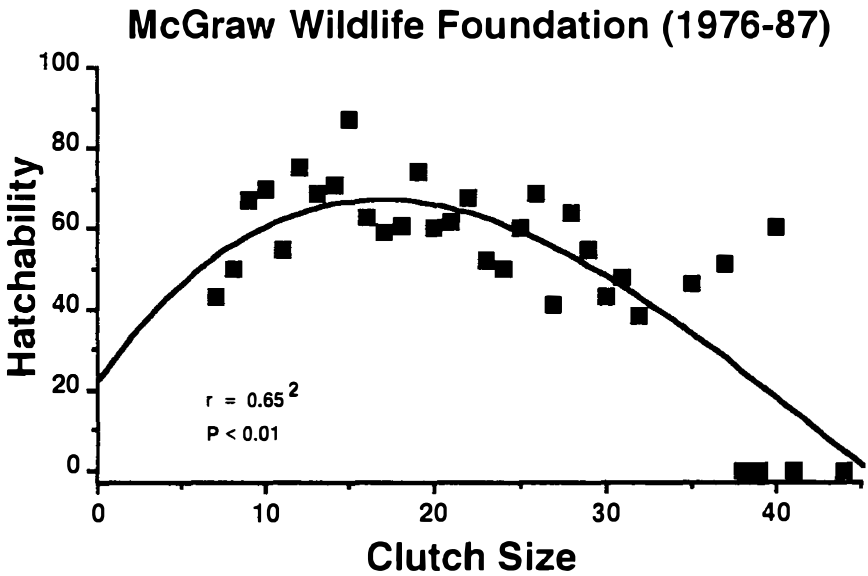

Figure 1. Relationship between mean clutch size and percent of wood duck eggs that hatched at the Max McGraw Wildlife Foundation from 1976 to 1987. The line ($y = 23.14 + 5.84x - 0.22x^2 + 0.0017x^3$) represents the best fitting regression. Data from Semel et al. (1988).

the negative relationship between clutch size and hatchability (Figure 1) was universal among wood duck nest box programs at refuges throughout the U. S. Their results led them to suggest an alternative to standard nest box placement protocols. Specifically, they proposed erecting nest boxes individually in visually occluded habitats near brood cover. Semel et al. (1990) hypothesized that this strategy would allow managers and researchers to retain the advantages of nest boxes while minimizing their associated deleterious consequences.

Nest Box Studies: The Tests

To evaluate this ''non-traditional'' nest box program, we initiated two field studies designed: (1) to reconfirm that nest box placement influences the frequency of parasitism; and (2) to simultaneously compare nesting efficiency and productivity under different management regimes. We selected refuge areas with existing nest box programs as study sites and, with the cooperation of local personnel, designed an Adaptive Resource Management protocol to test our hypothesis.

Briefly, the Moraine Hills State Park (MHSP) in northeastern Illinois and the Montezuma National Wildlife Refuge (MNWR) in central New York each were divided into two adjacent study areas. In one area, nest boxes were positioned in visible locations and at high densities, while in the adjacent area boxes were dispersed and hidden in deciduous woodlands. At both study sites the first area duplicates standard management practices, and the second mimics the distribution and density of natural nest cavities.

At MNWR visible boxes (n=81) were made of wood and attached in pairs (duplexes) to individual 2.5–meter-tall wooden posts in a shallow-water marsh. Predator-deterrent conical metal guards were mounted just beneath each box (Webster and Uhler 1964). Duplexes were placed 30–50 meters apart throughout the wetland, and always over or near open water so that wood duck pairs could observe nesting activity around each box. Hidden boxes (n=30) also were made of wood; they were attached 3–5 meters off the ground on the trunks of trees in a green-tree impoundment. A 0.75–meter wide section of metal flashing was mounted below each box to deter predators. Hidden boxes were located at least 150 meters apart. Each one was inconspicuous to human observers and, presumably, to wood duck pairs.

At MHSP, visible boxes (n=28) were made of wood and attached in pairs to individual 2.5–meter-tall wooden posts furnished with a conical metal predator guard. Duplexes were placed 60–80 meters apart with the entrance holes facing open water so that nesting activity at any box could be readily observed by other ducks in the wetland. Hidden boxes were constructed of metal and had conical lids to deter predators (Webster and Uhler 1964). Most (n=25) were attached 5–6 meters off the ground on the trunks of trees more than 38 centimeters in diameter at breast height; a few (n=7), were erected on 2.5–meter posts adjacent to heavily thicketed, flooded ditches. Boxes were placed at least 180 meters apart with the entrance hole always facing away from water; each box was presumably inconspicuous to wood duck pairs feeding or loafing on the nearest wetlands.

We tested two alternative hypotheses to explain why parasitism reaches extremes among wood ducks nesting in boxes. First, dump nesting may result from the low *availability* of suitable nesting sites (e.g., Bellrose et al. 1964, Grice and Rogers 1965, Jones and Leopold 1967, Clawson et al. 1979, Haramis and Thompson 1985). This is the ''traditional'' explanation for dump nesting. The idea is that when local populations increase (i.e., due to high nesting success in predator-proof boxes and female philopatry), nest sites become increasingly limited. Thus, females lay in each others' nests because all of the easily accessible nesting sites are occupied.

An alternative hypothesis is that dump nesting is due primarily to the *placement* of nest boxes (McCamant and Bolen 1979, Heusmann et al. 1980, Semel et al. 1988). Because Semel et al. (1988, 1990) found no differences in rates of parasitism between grouped, visible boxes and solitary, visible boxes, our experiment consisted of two treatments: grouped, visible boxes versus isolated boxes hidden in woodlands. Boxes positioned in highly visible locations over open water make it virtually impossible for a laying female to visit her nest without being seen and followed by conspecifics. In contrast, hidden boxes enable females to use surreptitious behaviors to avoid being followed to their nest site (Semel and Sherman 1986).

The two alternative hypotheses yield different critical predictions. The nest site limitation hypothesis predicts that parasitism rates should be inversely related to the proportion of unoccupied boxes in each habitat, regardless of nest box placement. The box placement hypothesis predicts that parasitism rates should be lower among the hidden than the visible boxes, and not dependent on the fraction of unoccupied boxes available. We tested these predictions directly. In addition, by evaluating the nesting efficiency and productivity of wood ducks nesting simultaneously in side-by-side experimental areas at each site, we could compare the efficiency of these two ''management protocols.'' This is the essence of ARM.

During 1989–91 at MHSP, parasitism rates and the number of parasitic eggs laid per nest were significantly lower in the hidden boxes (Figure 2) (Semel and Sherman submitted). Moreover, parasitism frequently occurred at low population densities and when there were numerous unoccupied boxes available: the greatest parasitism rates occurred when 50 percent (hidden) or 71 percent (visible) of the boxes were unoccupied. Contrary to the nest site limitation hypothesis, rates of parasitism were greatest early in the season when many boxes were available, and parasitism declined as box occupancy increased. Finally, the frequency of parasitism increased in the visible boxes as the population grew over the three-year study, but remained fairly constant in the hidden boxes across all years (Figure 2).

Other investigators have reported results similar to these. For example, Morse and Wight (1969) found no relationship between the proportion of unused nest boxes available weekly and the frequency of parasitism in an Oregon wood duck population. Semel and Sherman (1986) reported that 95 percent of wood duck clutches in a southeastern Missouri population were parasitized when only 54 percent of nest boxes were in use. Other studies of wood ducks (Heusmann et al. 1980), mandarin ducks (Davies and Baggott 1989), black-bellied whistling ducks (McCamant and Bolen 1979), goldeneye (Andersson and Eriksson 1982, Andersson 1984) and European shelducks (Pienkowski and Evans 1982) all have rejected nest site limitation as the sole or primary cause of parasitism.

Additional data from MHSP (Semel and Sherman unpublished) revealed that differences in parasitism rates, clutch sizes and egg hatchability between study areas became progressively greater from 1989 through 1992. Parasitism rates always were greater among the visible boxes, and eggs in visible boxes were 4 percent, 10 percent, 26 percent and 34 percent less likely to hatch in 1989–92, respectively, than were eggs in hidden boxes. The greater frequency of parasitism among visible boxes resulted in significantly larger clutch sizes and reduced hatchability: across all four years, 64 percent of eggs laid in hidden boxes hatched versus only 45 percent of the eggs laid in visible boxes (t=4.65,

P<0.0001). The effect of depressed hatchability was an average loss of 10.9 eggs per visible nest versus only 4.4 eggs per hidden nest. Therefore, although 608 more eggs were laid in the visible boxes than in hidden boxes (an average of six more eggs per nest), 90 fewer ducklings hatched from visible boxes. It was clear that the low hatchability of eggs in our visible boxes was a consequence of dump nesting.

At our New York study site (Montezuma NWR), the principal objective was to simultaneously compare productivity between a well-established "traditional" nest box program and a newly established "non-traditional" arrangement. During 1991, the first year of this study, visible boxes received on average 6.8 more eggs per clutch than hidden

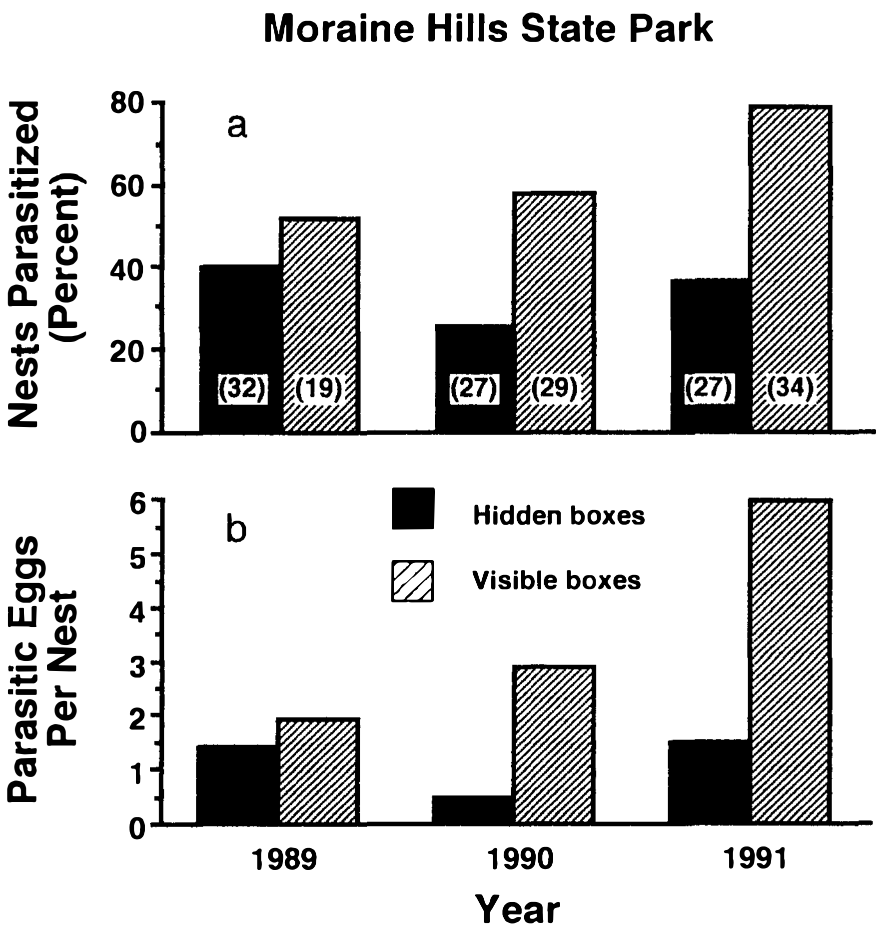

Figure 2. Comparison of (a) the frequency of brood parasitism and (b) the mean number of parasitic eggs laid per nest in hidden and visible nest boxes during the three-year study (1989–1991) at the Moraine Hills State Park, Illinois. Numbers in bars are number of nest starts per year in each box designation. Parasitism was inferred when more than one egg appeared in a nest on a given day. Data from Semel and Sherman (submitted).

boxes. Despite this difference, the average number of ducklings hatched from boxes in each of the two areas was nearly equal: 5.5 ducklings per visible box and 5.7 ducklings per hidden box. Thus, parasitism and the reduced hatchability associated with it (e.g., Figure 1) resulted in the production of essentially the same number of ducklings from both box types, despite there having been nearly 7 more eggs per box in the visible area. During 1991, reduced hatchability in the visible boxes accounted for an estimated loss of 549 ducklings (Figure 3).

An obvious confounding factor is that 1991 was the first year hidden boxes were erected at MNWR. Therefore, perhaps differences in parasitism rates were affected by the use of new boxes, as well as by box placement. However, our data indicate that after 4 years at MHSP and 12 years at MMWF, hidden boxes still had lower clutch sizes (i.e., parasitism rates) than visible boxes and the differences between areas actually have expanded over time. It seems unlikely, therefore, that the sole reason for smaller clutch sizes and increased hatchability in the hidden boxes was that they were newly erected. Moreover, in 1992 the disparity in clutch sizes and hatchability was even greater (unpublished data).

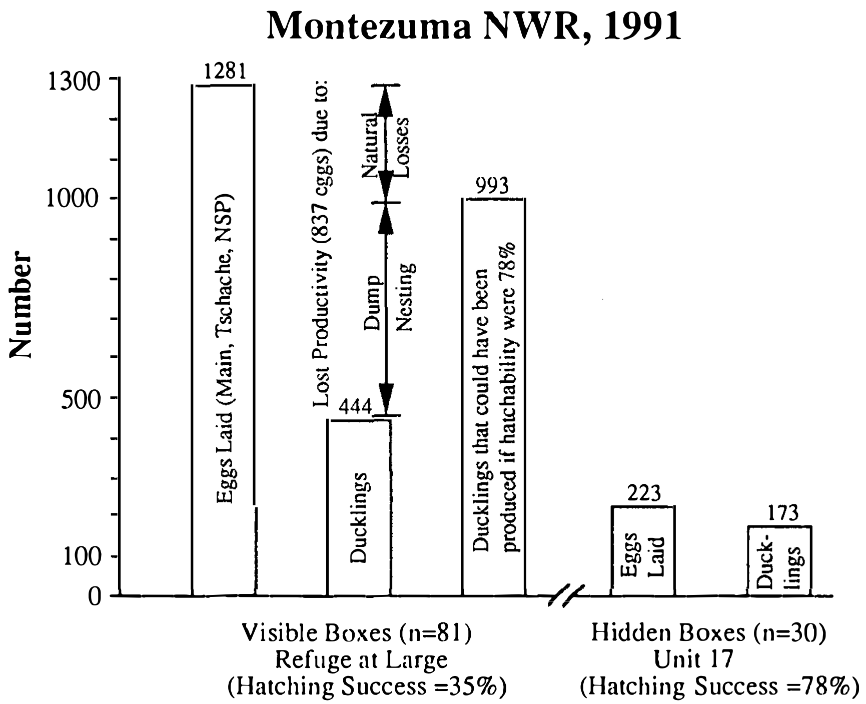

Figure 3. Loss of reproductive potential resulting from frequent brood parasitism in visible boxes at the Montezuma National Wildlife Refuge, New York, in 1991. Egg hatchability in heavily parasitized nests was only 35 percent, while that in hidden boxes was 78 percent. Thus, despite females laying on average 6.8 more eggs per visible box, reduced hatchability resulted in an estimated loss of 549 ducklings. We inferred the "natural loss" rate (22 percent) based on the success of hidden boxes.

In summary, the relationships between (1) nest box placement and the frequency of parasitism (Figure 4a), and (2) clutch size, itself strongly affected by parasitism, and hatchability were responsible for a greater loss in reproductive efficiency in visible boxes than in hidden boxes in two of our three study sites (Figure 4b).

Nest Boxes: Advantages of a "Non-traditional" Program

To better visualize the lost reproductive potential resulting from dump nesting, we calculated duckling production at the different levels of parasitism documented for hidden and visible nest boxes at MNWR in 1991. Parasitism in hidden boxes was infrequent: the average clutch size was 11.8 eggs, and 78 percent of those eggs hatched. In contrast, clutches in visible boxes were heavily parasitized: the average clutch size was 18.6 eggs, and only 35 percent of those eggs hatched (Figure 3). Because both box placement strategies were evaluated simultaneously at one refuge, we can use these clutch sizes and hatchabilities to compare their efficacy. For example, assuming that the 1991 data are representative, if 75 boxes had been available for distribution on the refuge, almost 200 more ducklings would have been produced if boxes had been erected inconspicuously in woodlands adjacent to wetlands than if they were erected in visible sites over water (Figure 5a). From a different perspective, if the production goal for the MNWR nest box program were 500 ducklings, then 75 boxes would be needed if the boxes were erected in visible locations (Figure 5b). In contrast, if the boxes were hidden, only 53 would have been necessary to reach the same production goal.

Obviously, other economic costs and maintenance requirements must be considered when deciding whether to adopt a "non-traditional" program of hiding boxes. As discussed by Semel et al. (1990), nest boxes scattered throughout woodlands may require more time for maintenance. However, by hiding boxes, fewer would be needed and maintenance costs would be lower while maintaining or increasing duckling production. Moreover, it may not be necessary to clean all boxes each year. Indeed, some programs refurbish boxes on a two-or-three-year rotational schedule (Keran 1978, New York Department of Environmental Conservation 1986). Also, placing boxes in woodlands, rather than over water, affords year-round access. This is a particular advantage in northern areas where access to boxes over water is restricted to times when ice is safe for personnel to reach them. Finally, boxes erected on trees in woodlands do not require the additional costs of support posts and brackets.

A major concern for any nest box program obviously is predation. The traditional reason for placing boxes over water is to reduce predation losses. However, most of the major predators on cavity-nesting waterfowl (e.g., raccoons, snakes) swim well, and water alone will not deter them. Hidden boxes on trees are no more likely to be preyed upon than boxes over water if predator deterrent mountings are used (Beshears 1974). Moreover, visible boxes experience greater avian interference. For example, wood ducks nesting in visible boxes at MHSP experienced greater starling (*Sturnus vulgaris*) interference than those nesting in hidden boxes: 34 percent versus 4 percent of nesting starts. Numerous studies have described in detail the detrimental effects starlings have on wood duck nesting success (e.g., Grice and Rogers 1965, Heusmann and Bellville 1982). The results of our study clearly indicate that in areas where starling competition for nesting sites is a problem, erecting boxes in hidden sites will significantly reduce starling use. This negates the necessity and costs of using the least-preferred and marginally effective nest boxes modified to deter them (Heusmann and Bellville 1982).

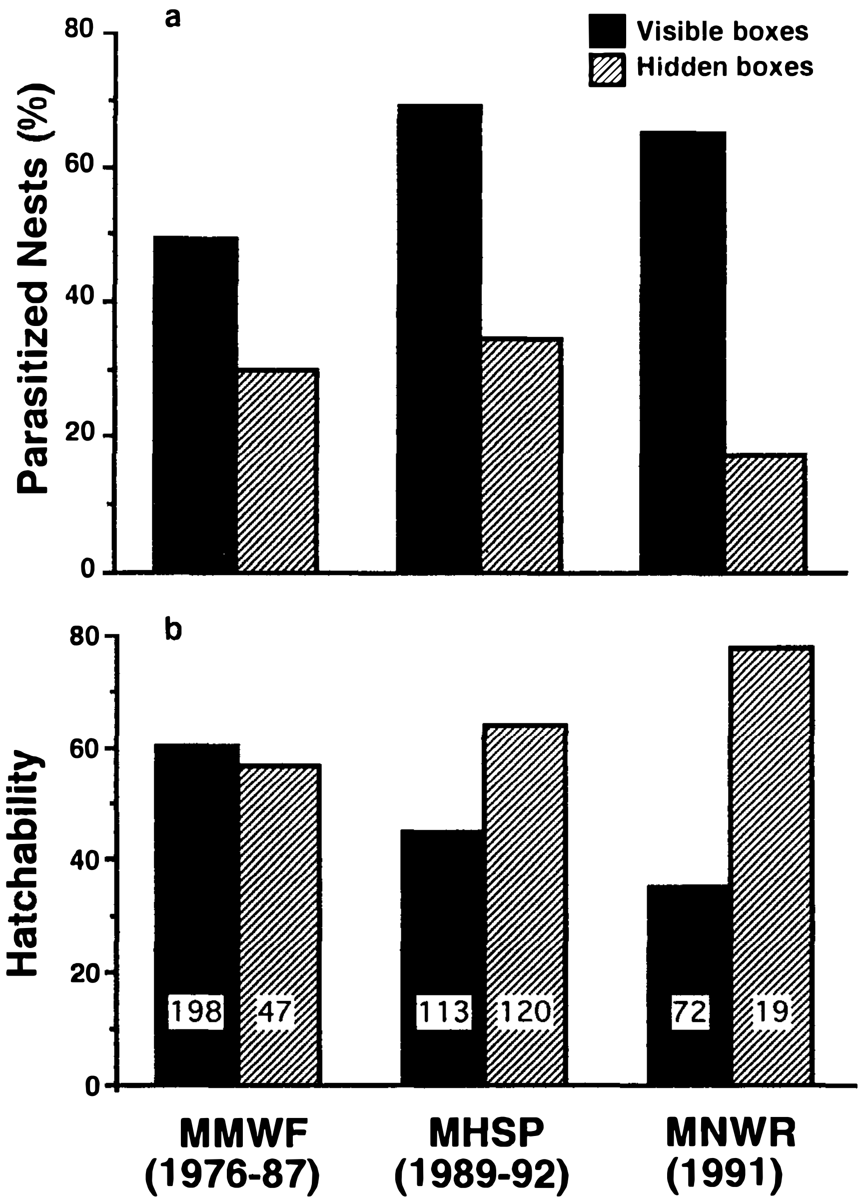

Figure 4. (a) Significant differences in the frequency of parasitism were found between clutches laid in hidden boxes and those in visible boxes at the Max McGraw Wildlife Foundation (1976–1987), the Moraine Hills State Park (1989–1992), and the Montezuma National Wildlife Refuge (1991). (b) Significant differences in egg hatachability were found at MHSP and MNWR, but not MMWF. Numbers in bars are numbers of nest starts per year in each box designation.

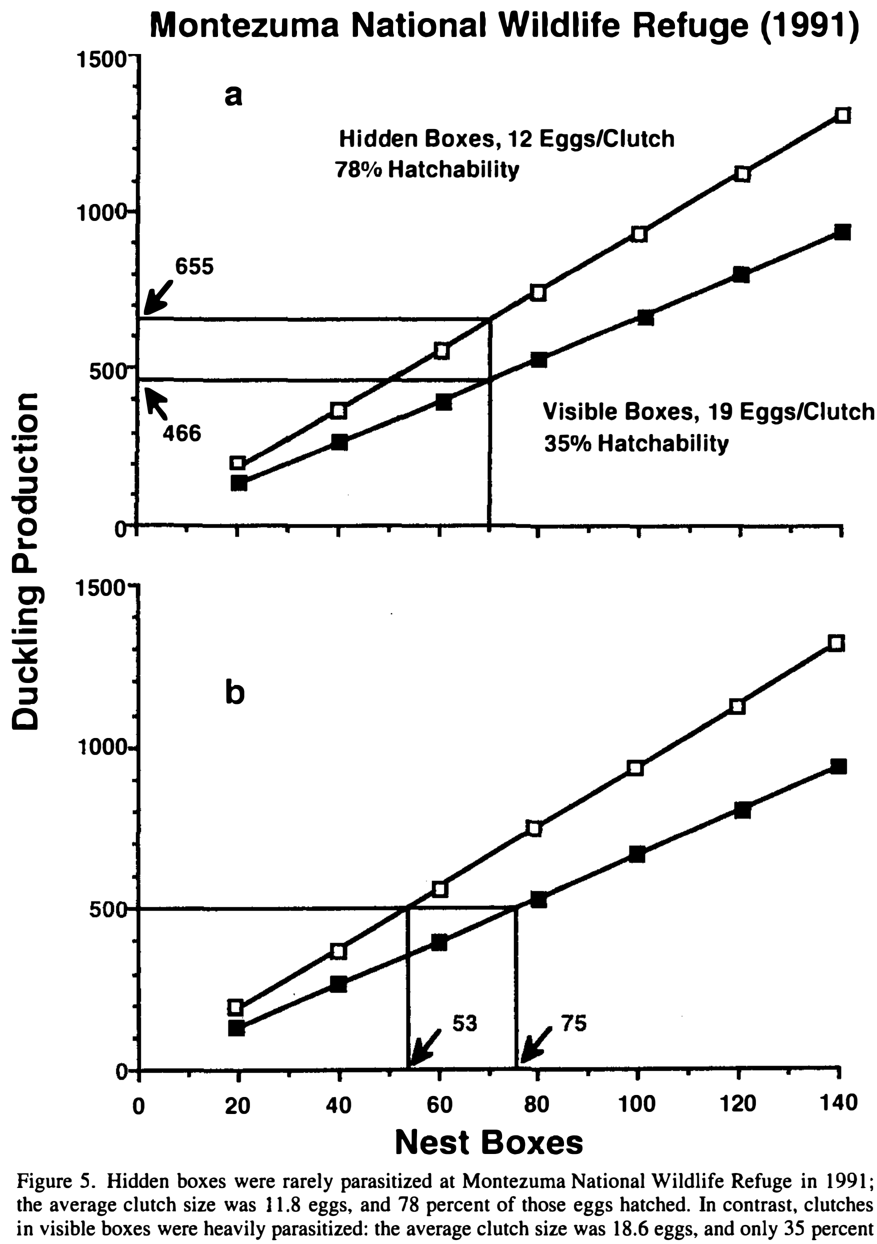

Figure 5. Hidden boxes were rarely parasitized at Montezuma National Wildlife Refuge in 1991; the average clutch size was 11.8 eggs, and 78 percent of those eggs hatched. In contrast, clutches in visible boxes were heavily parasitized: the average clutch size was 18.6 eggs, and only 35 percent of those eggs hatched. The figure uses these clutch sizes and hatchabilities to compare productivity of hypothetical nest box programs at MNWR that incorporate the two different placement strategies. If 75 boxes were available for distribution, almost 200 more ducklings would have been produced if the boxes were erected inconspicuously in woodlands adjacent to wetlands than if they were erected on poles over water (a). Looked at in another way, if the production goal were 500 ducklings, then 75 boxes would be needed if the boxes were erected in visible locations, but only 53 hidden boxes would be necessary to reach the same production goal (b).

An alternative to our suggested ''non-traditional'' box program is to regularly add new boxes to an area (e.g., Fleskes et al.1990). Although this tends to increase the number of ducklings produced, the effect is due more to the provisioning of additional sites for renesting rather than to improved hatchability (i.e., due to the high rates at which dump nests are abandoned early in the season, renesting is frequent). Most importantly, this approach requires an ever-increasing commitment of effort and money to build and maintain boxes. As box numbers increase, duckling production also increases but with diminishing returns. The implication is that efforts to increase productivity are better spent on minimizing parasitism by positioning existing boxes in less visible locations than by increasing the number of next boxes available.

Discussion

Intraspecific brood parasitism undoubtedly evolved as an integral part of the reproductive ecology of wood ducks (e.g., Andersson 1984, Eadie et al. 1988, Sayler 1992), However, density strife and frequent dump nesting result when this normally solitary bird is forced to nest in visible sites, especially when population densities are high. Our comparative studies at MMWF, MHSP and MNWR demonstrate the potential benefits of positioning nest boxes in ways that mimic the density and locations of natural cavities. Parasitism did occur in about 30 percent of our hidden boxes (about the same rate as in natural cavities: Semel and Sherman 1986), but without the detrimental effects on hatchability that occurred in visible boxes due to rampant dump nesting. Although no more ducklings exited from each hidden box than each visible box, far more eggs were laid in each visible box, representing a considerable energetic loss to the population of laying females (Drobney 1980). In other words, the number of ducklings that hatched from each of our three study populations nesting in hidden boxes was closer to the populations' full reproductive potential (number of eggs laid) than was the productivity of the three populations nesting in visible boxes. The massive loss of wood duck eggs that occurs at refuges across the country every year (e.g., Figure 6) (Semel et al. 1990) represents a tremendous waste of reproductive energy and potential productivity, a wastage that, in most cases, could be corrected in a cost-effective way by hiding nest boxes.

Data have been collected on the ''efficacy'' of wood duck nest box programs for years, but until recently the effects of nest box placement have been considered primarily in the context of increasing box occupancy (Lacki et al. 1987). It was simply assumed that dump nesting, nest abandonment and reduced hatchability were inevitable concomitants of nest box programs. By studying the nesting biology of wood ducks we discovered that parasitism occurs far less frequently in natural cavities than in most populations managed with nest boxes. One reason managers may not have recognized the serious negative consequences of dump nesting is that the index of productivity typically recorded is the total number of ducklings produced per year (or per box). These numbers are used to contrast productivity from one year to the next or between sites. The problem comes in not considering how many ducklings *could have been* produced from the same number of boxes if a greater percentage of the eggs they contained had hatched. Data from long-term nest box programs such as MNWR (Figure 6) clearly show the tremendous lost potential productivity due to unhatched eggs. Similar losses in potential productivity, apparently due to dump nesting, are evident in the records of 9 of the 10 wildlife refuges from which we have obtained appropriate date. All of these refuges use ''traditional'' placement of nest boxes.

Our data sets from MHSP and MNWR allow us to comparatively evaluate trends in wood duck productivity. The data reveal that dump nesting and nesting efficiency are inversely related. As local breeding populations increase, differences in mean clutch size, frequency of brood parasitism, hatchability, and duckling production between box designations grow. We predict that in areas managed by placing boxes at high densities, dump nesting will increase and productivity will decrease, until a population "crash" finally occurs (e.g., Haramis and Thompson 1985). Indeed, Semel et al. (1990) reported the details of such a crash that occurred at the Great Swamp National Wildlife Refuge in 1977–79. Our data, together with those of others, indicate that over time hidden boxes will allow populations to more nearly achieve their full reproductive potential than visible boxes.

There are two "take-home" messages from our studies. First, management goals can effectively be met using protocols founded on a detailed knowledge of the behavioral biology of the species in question. Second, ARM enabled us to experimentally evaluate alternative management hypotheses simultaneously, and permitted us to develop synthetic, broadly applicable guidelines for managing wood ducks, rather than relying on the accumulation of year-by-year descriptive data from isolated studies of this species (*see* Gavin 1991).

Acknowledgments

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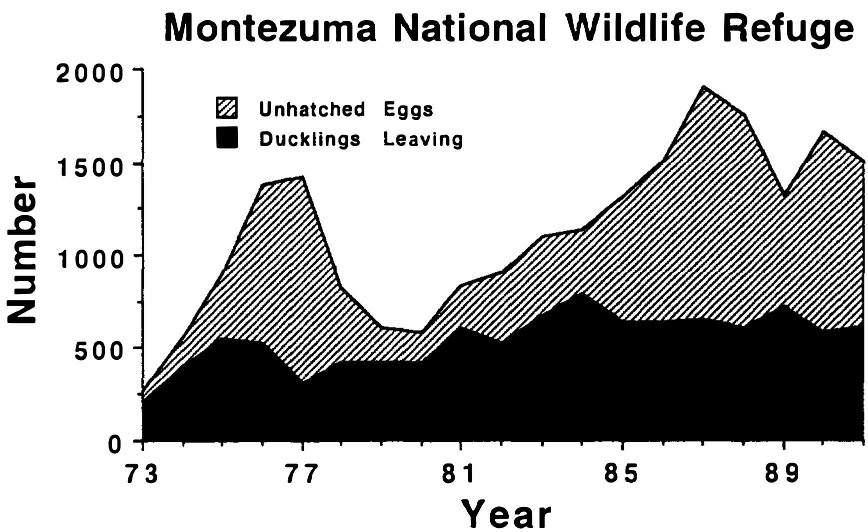

Figure 6. The number of eggs laid and ducklings produced during a 19–year period at the Montezuma National Wildlife Refuge. Note the tremendous loss of productivity due to unhatched eggs (stippled area), itself a result of dump nesting. Data courtesy of MNWR.

ing us implement the ARM approach. Field assistance by D. Kohler and J. Rosenfield is gratefully acknowledged. R. Lancia, M. Morrison, and J. Thompson provided helpful comments on an earlier draft of the manuscript. Financial support was obtained from the MMWF and Cornell University (Hatch Grant #NYC-191411).

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Restoring Upland Habitats in the Canadian Prairies: Lost Opportunity or Management by Design?

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Introduction

The Prairie Habitat Joint Venture (PHJV), a component of the North American Waterfowl Management Plan (NAWMP), is one of the largest habitat restorations ever undertaken. The PHJV aims to change the landscape of the Canadian prairies by employing three general techniques. First, PHJV hopes to influence agricultural policy, thereby recovering or reducing impacts on remaining tracts of low-quality agricultural land. It is these remnant areas that are used intensively by many species of wildlife. Second, conservation farming techniques will be promoted to benefit particular species of wildlife. And third, the landscape will be modified to infuse an array of intensively managed areas (uplands and wetlands) that may enhance the success of nesting ducks and other birds.

There are several reasons for this approach. During the 1960s and 1970s, when world market prices for cereal grains were relatively high, Canadian agricultural policy encouraged a widespread assault on areas that previously had been considered unsuitable for farming. Thus, it seems reasonable to assume that a reversal of this policy could have substantial beneficial effects on remaining natural areas. However, given that future Canadian policy on agricultural production ultimately will be determined by "global" negotiations of the General Agreements on Tariffs and Trade, and swings in production associated with the vagaries of weather (Auer 1989 Furtan et al. 1989), rather than by natural resource agencies, the likelihood for change remains somewhat speculative. Nonetheless, there have been other opportunities for resource agencies to form partnerships with agriculture.

In recent years, Agriculture Canada launched a nation-wide soil and water conservation campaign. PHJV recognized the need to forge stronger links with agriculture and joined them in promoting these practices. There is little argument that extensive management techniques such as stubble retention can reduce problems of water and air quality or soil loss, but the direct significance for nesting ducks, and wildlife in general, is uncertain.

The PHJV has implemented several "intensive" programs that have the potential to produce substantial changes in the distribution and breeding success of ducks and other wildlife. Provincial technical committees designed these wisely by incorporating alternatives that farmers could consider and integrate into their farm operations (e.g., Anonymous 1989). Combinations of extensive (agricultural) and intensive programs arm wildlife managers with different options for farmers. This gives them greater flexibility when delivering PHJV programs, ensuring that targeted goals for habitat acquisition or modification could be achieved. Importantly, impacts on wildlife of intensive programs can be evaluated and compared with similar data from extensive programs (Nelson et al. 1991, Nudds and Clark 1993). The last issues form the focus for this paper because it is uncertain: (1) which of several intensive management techniques is most effective for ducks and other wildlife; (2) whether intensive programs are more effective than extensive ones; and (3) whether current intensive programs could be made more effective. For instance, habitat restoration (e.g., planting cover, delaying haying, interpothole seeding) programs typically involve acquiring relatively small areas (e.g., less than 180 acres) of habitat and these small areas may be less productive than larger ones.

Our objectives are three-fold. We review first the conceptual framework and evidence for the effects of habitat configuration on breeding success of nesting birds. Then we review briefly the PHJV program, and ask whether existing information can tell us which habitat patch sizes, composition and arrangement might improve avian breeding success. We conclude that: (1) experiments are needed to resolve these questions; and (2) management and experiment should occur in tandem (Walters 1986). Ideas then are offered for the design of these experiments.

It is not our intention to review critically the implementation of current, well-organized PHJV programs. Rather, this paper was written to pinpoint fundamental weaknesses in our understanding of the effects of habitat manipulations on prairie birds and, more importantly, to show how managers and researchers involved in PHJV or other habitat management programs could begin to resolve effectively the questions we raise. In our opinion, an excellent opportunity to address these problems may be lost unless we combine efforts soon.

Background

Effects of Habitat Configuration on Ducks and Other Birds

Although this subject has received limited direct investigation in the Canadian prairies, there is much theoretical and empirical evidence that enables us to predict how habitat configuration (or modification) could affect success of breeding birds. Furthermore, the effect of intensive agriculture on the distribution and success of nesting ducks has been studied (e.g., Sugden and Beyersbergen 1984, Cowardin et al. 1985, Greenwood et al. 1987), along with the effects of cover establishment on use and nesting success (e.g., Duebbert et al. 1981). Also, Nelson et al. (1991:451) identified optimum habitat size of intensively managed areas as a principal category of research need within the NAWMP. However, the relationships between number, size and composition of habitat patches and breeding success of prairie birds rarely have been examined, or are difficult to evaluate from existing information (Clark and Nudds 1991).

Design of wildlife habitats by PHJV. To the extent that the patches of habitat being provided by PHJV (albeit, primarily as nesting cover for waterfowl) constitute a large number of small islands of habitat in a sea of agriculture, we must examine the implications of relevant theory for this program. The appropriate theoretical context arises from "island biogeographic" approaches that have been used widely in designing natural reserves in many parts of the world (reviewed by Shafer 1990). It might be argued that because the patches are established to provide nesting cover for waterfowl, and provide only a small fraction of their annual habitat requirements, biogeographic principles are not applicable. We disagree chiefly for two reasons: (1) we do not know the extent to which biogeographic principles might apply to nesting ducks, but the magnitude and objectives of this program require us to find out; and (2) biogeographic principles may apply more to other species which are likely to use those habitats and, because a portion of the program is justified by its benefits to wildlife other than waterfowl, we have a responsibility to take those implications fully into account.

The two most measurable characteristics of a patch of habitat, or island, are its area and its isolation (the distance to the next patch or island). Small oceanic islands generally support fewer species than larger islands, and islands close to the mainland support more than distant islands. MacArthur and Wilson (1963, 1967) interpreted total species number on an island as determined by an equilibrium between extinction rate (which is inversely related to area) and likelihood of colonization (inversely related to isolation).

The equilibrium theory of island biogeography remains controversial, but it has spawned a considerable amount of new research on topics of direct relevance to habitat restoration programs such as PHJV, including the design of reserve systems (Diamond 1975), the minimum size of viable populations (Shaffer 1981) and patch dynamics (Pickett and Thompson 1978). The main elements of the theory and their application to reserve design can be summarized as follows (Shafer 1990): (1) the number of species increases with the area of habitat sampled up to a point, and less steeply thereafter, (2) species number often, but not always, decreases with increasing distance from other islands or patches (e.g., Opdam et al. 1984); (3) clustering small patches close together in ''archipelagos'' raises the overall species richness of the patches; and (4) interspecific competition may lower species richness in small areas (''density compensation'' effect).

Biogeographic theory has been widely used to develop design principles for nature reserves, again following the analogy that reserves can be treated as analogues of islands (Diamond 1975). The most robust recommendations are that reserves should be as large and as close together as possible, as nearly circular as possible (to minimize edges) and connected where possible by corridors. The fundamental principle that the insularity of reserves should be minimized (Diamond 1981) remains an appropriate summary.

Species-area relationship. Species number invariably increases with area in woodlots surrounded by agriculture (e.g., Whitcomb et al. 1981, Butcher et al. 1981, Lynch 1987, Martin 1988, Freemark and Collins 1992), and in marsh habitats in North America (Brown and Dinsmore 1986) and in Europe (Tscharntke 1992). Species differ in the smallest area they will occupy; in Iowa prairie marshes, for example, Brown and Dinsmore (1986) found that 10 of 25 species of bird required marshes at least 12 acres (5 ha) in area, and 7 species showed positive correlations between frequency of occurrence and marsh area. A critical corollary is that the addition of extra species creates a new community structure in larger patches. This is particularly important if the added species are predators or competitors of the species occupying smaller patches, or of species with which they interact.

A major biological difference between habitat patches and real islands is that, in the former, species occupying both the patches and the matrix between them can penetrate each other's habitats; thus, a bird breeding in a patch of natural habitat in agricultural land is exposed to competitors and predators living in the surrounding fields (Andren and Angelstam 1988). This offers the potential for competition and predation to vary with patch area independently of the increase in species number. Higher predation on artificial nests in smaller patches has been documented in forests by Wilcove (1985) in the U. S., and Telleria and Santos (1992) in Spain, and in tallgrass prairie by Johnson and Temple (1990). Cases where this effect has not been found (e.g., Yahner and Wright [1985]) may be related to the overall amount of fragmentation in the landscape studied (Andren and Angelstam 1988).

The "edge effect." Simple geometry dictates that the ratio of perimeter to area increases as the area of a patch decreases; small patches thus have relatively more edge than large ones. Edges are widely viewed as "good for wildlife," partly because many game species are adapted to edges, but also because of a frequent rise in the number of individuals and species near disjunctions between habitats (references in Gates and Gysel 1978). The "edge effect" has been reviewed thoroughly by Harris (1988) and Reese and Ratti (1988).

A variety of studies have found higher rates of nest predation in birds near edges between forest and open habitats, both in the forest (Wilcove et al. 1986, Andren and Angelstrom 1988), in the open habitat (Moller 1989) or on both sides of the edge (Gates and Gysel 1978). The study by Gates and Gysel (1978) is particularly instructive in showing that density of nesting and intensity of predation and parasitism by brown-headed cowbirds (*Molothrus ater*) were higher near the edge and that fledging success increased further away from it. Increased predation near edges probably was a function partly of increased nest density and partly of increased activity by predators which may treat the edge as a barrier and move parallel to it (Bider 1968). Most studies of habitat patches as "islands" have been of patches of forest within agricultural landscapes, with fewer investigations of patches of grassland (see below).

Sources, sinks and the effects of landscape composition on breeding birds. Habitat-specific reproductive rates determine whether an area is a "source" (reproductive rate offsets or exceeds mortality) or "sink" (local reproduction cannot offset mortality) habitat (*see* Van Horne 1983, Pulliam 1988). In many areas of the prairies, overall nesting success apparently is insufficient to maintain stable mallard (*Anas platyrhynchos*) populations (e.g., Cowardin et al. 1985), although local habitats vary substantially. Certain intensively farmed regions of the prairies appear to act as sinks for mallards (e.g., Klett et al. 1988). Presumably, source areas also exist; these may be areas of the prairies or boreal forest that either consistently or periodically produce many new mallards. Information for other bird species generally is lacking. An obvious goal of PHJV would be to establish habitats that consistently function as sources of ducks and other wildlife.

Empirical Evidence from the Canadian Prairies

The conversion of wetland and natural habitats to agricultural production has continued unabated since the turn of the century. Trends in agricultural land use, numbers of wetlands and area of natural habitats frequently have been documented so we do not dwell on these here (e.g., Boyd 1985, Turner et al. 1987). Perhaps of greater concern, however, was the impact of agricultural policy that increasingly brought marginal agricultural lands into production during the 1960s (Nudds and Clark 1993, citing a personal communication from J. Patterson). For example, the number of Saskatchewan farms decreased 35 percent from 1961 to 1991, but area of farmland increased and the percentage of cultivated land on an average farm rose from 66 percent in 1961 to 75 percent in 1991 (Saskatchewan Agriculture Food 1992). In many areas of the Saskatchewan parklands more than 80 percent of the land area was cultivated by the early 1980s (Sugden and Beyersbergen 1984).

Climatic patterns, and trends in duck nesting success and duck populations. Prairie wildlife has evolved in response to highly variable temperature and precipitation regimes. For instance, Boyd (1981) found that long-term trends in conserved soil moisture indices and duck numbers were closely related. The annual survey of breeding North American ducks reveals that dabbling duck populations are characterized by wide fluctuations, but species such as northern pintail (*Anas acuta*), blue-winged teal (*A. discors*) and mallard have reached very low numbers in successive years during the past decade (e.g., Dickson 1989). However, the crucial question is whether (some) duck population fluctuations continue to match variations in wetland numbers—an historical correlation that seems to have been diminished by loss of upland habitat to expansion of agriculture (Johnson and Shaffer 1987, Bethke and Nudds, University of Guelph, unpublished data). To our knowledge, similar analyses, though valuable, have not been conducted for other avian species, possibly owing to data limitations (below).

Historical trends in duck nesting success are difficult to evaluate because of variations in techniques and methods of reporting nesting success. However, a recent analysis by Beauchamp (1992) indicated that duck nesting success has declined since the 1930s. Although year accounted for only 10 percent of variation in nesting success, the pattern was found in five species and in both prairie and parkland regions. By contrast, Klett et al. (1988) found no change in duck nesting success in the northern U. S. prairie during three time periods spanning 1964–1985. However, it is possible that agricultural landscape modifications in that region before 1960 produced consistently low nesting success prior to Klett et al.'s studies (L. M. Cowardin personal communication).

The hypothesis that loss of upland habitat in the Canadian prairies has driven recent population declines in ducks leads to the prediction that populations of other grassland birds have suffered comparable declines. Of 18 species with sufficient samples for statistical analysis in the grasslands (''southern prairies'' of Collins and Wendt [1989]), and not associated with wetlands or human habitation, significant declines over this period are shown only by song sparrow (*Melospiza melodia*) and western meadowlark (*Sturnella neglecta*). American robin (*Turdus migratorius*), house wren (*Troglodytes aedon*) and mourning dove (*Zenaida macroura*) increased over this period, although these three species usually are associated with woodland habitats. In the parklands (''central prairies'' of Collins and Wendt [1989]), of 16 species not associated with wetlands, habitation or tall trees, five species declined significantly (horned lark [*Eremophila alpestris*], clay-colored sparrow [*Spizella palida*], song and white-throated [*Zonotrichia albicollis*] sparrows, and western meadowlark), while none increased.

The temporal patterns found by Johnson and Shaffer (1987) with mallards, and Bethke and Nudds (unpublished data) with several duck species, prompt us to look also for declines after the mid-1970s compared with earlier population levels. Collins and Wendt (1989) show trends separately for the periods 1966–1974 and 1975–1983. Species showing comparable declines with waterfowl would show a significant decline in the second period but not in the first. Clay-colored and song sparrows both show this pattern in the grassland. Clay-colored and song sparrows, Brewer's blackbird (*Euphagus cyanocephalus*) and brown-headed cowbird also show the predicted trend in the parkland. In both cases (overall decline from 1966–83 and decline only after 1974) more species fit the pattern in the parkland than the grassland, but fewer species than we expect do so; this may be due, at least in part, to the preponderance of roadsides in the habitats sampled by the Breeding Bird Survey (BBS).

Conceptual model for the effects of increased agricultural land use on birds. It generally is hypothesized that increased agricultural development in the Canadian prairies has forced ducks and other birds to nest in remnant tracts of natural vegetation or in agricultural areas. Assuming that the foraging efficiency of predators increases with increasing prey density, reduced search area, and (or) in agricultural fields, avian breeding success in remnant or human-altered patches should decline. A complementary mechanism creating a similar outcome is that composition and abundance of predator communities changed, favoring those that were more effective predators of ducks and other birds (e.g., Johnson and Sargeant 1977). The potentially negative effects of increasing nest density (reviewed by Clark and Nudds 1991) or interspecific competition also may have reduced avian breeding success. Barring immigration from other sources, the net result eventually would be a reduction in population size of the prey species.

This general pattern of declining nesting success and populations has been observed with some ducks, such as mallard and pintail (e.g., Nudds and Cole 1991, Beauchamp 1992), and it also seems to be a reasonable hypothesis to account for population declines in other prairie birds. However, one cannot discount other factors. For example, wintering ground conditions, and increasing pesticide and herbicide use in the Canadian prairies (e.g., Sheehan et al. 1987, Forsyth 1989) are two forces that may exert strong direct and indirect effects on avian productivity and survival.

Effects of habitat manipulations on distribution and breeding success of birds. The general observations and evidence outlined above suggest that increasing habitat patch size, reducing patch isolation and increasing the density of habitat patches are management actions that might benefit a variety of birds. Larger habitat patches are predicted to accommodate more species of birds and other wildlife, enhance their breeding success and help buffer against general adverse activities associated with agriculture. Unfortunately, it remains uncertain whether this is true and, if it is, how large a patch, or how many patches, may be required to create ''source'' habitats (Clark and Nudds 1991).

Earlier, Clark and Nudds (1991) attempted to test whether duck nesting success increases with increasing habitat patch size. Their result was unclear, however, because evidence conflicted, suggesting that success might increase or decrease with habitat patch size. More importantly, studies were conducted in different areas and years, so confounding effects due to variations in weather, predators, duck population and nest densities, or alternate prey could not be controlled. Results of new studies conducted since that review have done little to clarify these questions, possibly because work continues to focus on relatively small areas of comparatively isolated habitat (e.g., <180 acres [73 ha]), some of which were established during implementation of the PHJV. Recent estimates of duck nesting success in small areas of managed cover are variable but low (i.e., usually <15 percent, ranging from 2–20 percent) (Guyn and Clark, Canadian Wildlife Service unpublished data; Arts and Meisser, University of Saskatchewan unpublished data; Duncan and McKinnon, Saskatchewan Wetland Conservation Corporation unpublished data; Howerter et al. 1992; Higgins et al. 1992). By contrast, Devries and Taylor (Canadian Wildlife Service unpublished data) studied upland-nesting ducks in a large (>19,000 acre [8,000 ha]) contiguous grassland in Saskatchewan and found that success ranged from 20–35 percent across five species (overall, 25 percent Mayfield estimate). This finding is consistent with earlier reports (Greenwood et al. 1987) of relatively high mallard nesting success (i.e., >20 percent) on large (1,120–1,760 acres [460–715 ha]) grass-shrubland areas of some Canadian pastures.

There are few studies of the relation between habitat patch size and nesting density or success in grassland birds other than ducks. In roadside vegetation in Illinois, Warner (1992) found higher nesting densities of songbirds in wider roadside strips (i.e., larger patches), and also in patches with less hay and more small grains (i.e., less alternative, suitable habitat) in the nearby landscape. Johnson and Temple (1986) found higher nesting densities of grasshopper sparrows and western meadowlarks in large patches (320–1,200 acres [130–486 ha]) of tall-grass prairie than in small (40–80 acres [16–32 ha]) fragments. They also found that nesting success in all five grassland species studied was positively related to the distance from forest edge, but not to patch size. Both these studies suggest that prairie passerines, like waterfowl, may be influenced by landscape characteristics in their breeding distribution and success.

Opportunity Seized or Lost?

The PHJV Program

Approaches employed in PHJV programs may not help to dispel uncertainty about the sizes and numbers of habitat patches that will maximize wildlife benefits. There are many options involving intensive management, but within any of these there is limited variation in the way it is implemented because decisions about land acquisition currently are determined by two important factors: Land values and predicted rural population attitudes toward PHJV programs.

Land values are driven primarily by international market prices for cereal and oilseed crops because farmers have limited crop choices in most areas of the Canadian prairies. An important factor that mediates this relationship is farmers' expectations; if they believe that conditions will improve, they will retain their land and wait for a market upswing (Weisensel et al. 1988, D. Brewin, PFRA, Regina, personal communication). For current farm conditions to ameliorate, however, a substantial resurgence in commodity prices will be required, together with continued farm subsidy supports (Weisensel et al. 1988). According to economists, this is an unlikely scenario (Furtan et al. 1989). Although predicting future land value is plagued by uncertainty, prices likely will not rise substantially in the near future (Figure 1) and, if they do, concurrent subsidy cuts likely would be made, offsetting financial gains to farmers (R. Gray, University of Saskatchewan, personal communication). Given an aging farm population faced with escalating operating expenses (Auer 1989), wildlife agencies actually may be able to **assist** farmers by purchasing their land. Indeed, a recent economic analysis of the PHJV reported favorably on its impact, and indicated also that land purchase was an economically viable alternative to leasing or paying agricultural subsidies (Gray 1992).

Finally, a recent public opinion poll of Saskatchewan farmers in several PHJV target areas suggests that fears of a negative reaction to land acquisition may be unwarranted (Tanka Research 1990). This survey found that 27 percent and 14 percent of farmers would be "very likely" to participate in programs to purchase non-productive and productive land, respectively. Farmers were at least as likely to sell non-productive land as to participate in any other program identified in the survey.

The second factor that determines levels of land acquisition by the PHJV is a computer planning tool (CPT) that was developed from a mallard population model (Cowardin and Johnson 1979, Johnson et al. 1987, Cowardin et al. 1988). The CPT generates **predictions** about mallard population responses (e.g., duckling recruits) to variations in land use and wetland characteristics. CPT is used during PHJV implementation to set limits for land management in different areas. Although this is a logical approach for program development, there is a danger that the CPT will not be used to **test** predictions (Conroy

1993). To learn, one should perturb systems by experimentation, in this case by varying the size or numbers of habitat patches to include a range of values above and below levels generated by the CPT. Additionally, surpassing current program levels might benefit some species more than mallards.

Adaptive Management Approaches

During implementation of PHJV, we suggest that implementors and researchers design plans that intentionally push habitat management goals beyond current levels (while retaining controls). In our estimation, the two following tests of land management are both feasible and potentially important.

Effect of habitat patch size. Empirical evidence for the relationships among habitat area, isolation and avian breeding success supports the prediction that size and success should be positively correlated (above), yet the pattern is unclear with ducks. For this

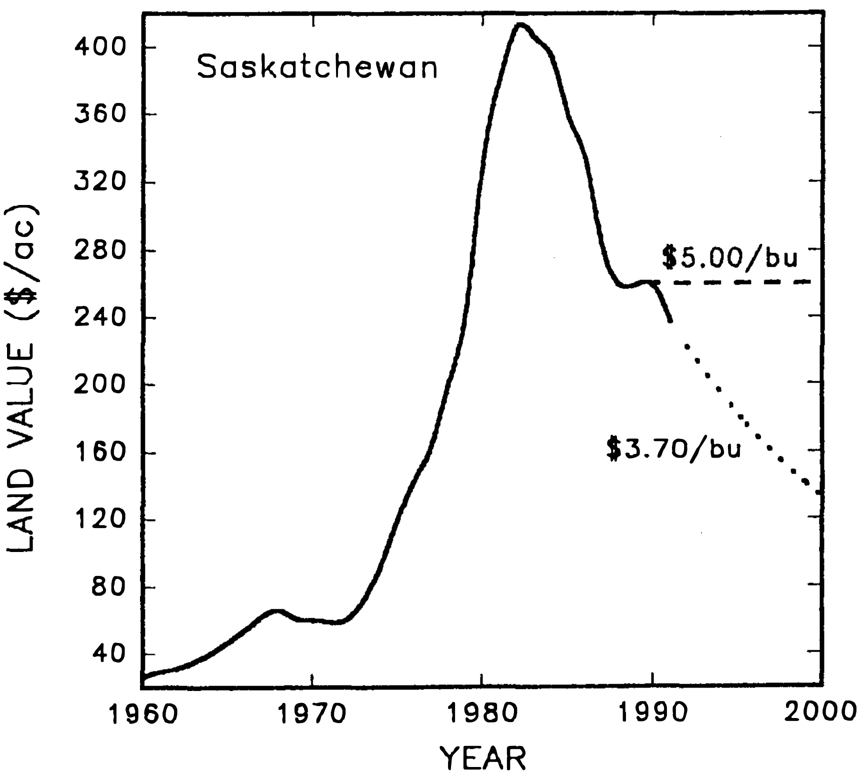

Figure 1. Farmland values (Canadian $/acre) in Saskatchewan, 1960–1991 (Saskatchewan Agriculture and Food 1992), with projections to Year 2000 (broken lines) based on wheat price scenarios (after Weisensel et al. 1988). Average wheat prices during 1986–1991 were about $3.70/per bushel (Saskatchewan Agriculture and Food 1992); Weisensel et al. determined that about $5.00 per bushel would maintain relatively stable land values.

reason, Clark and Nudds (1991) outlined an experimental protocol that could help to resolve this issue. Nudds and Clark (1993) also examined how experimental manipulation of habitat size could help to determine whether acquiring large habitat patches might increase duck nesting success to levels that match or exceed those obtained from more intensive and costly management practices. To briefly reiterate the main points, replicated areas of habitat should be acquired and seeded to natural cover across a wide range of plot size (e.g., 5, 50, 500, 1,000 ha). PHJV need not necessarily acquire the largest plots for an experiment; these could consist of existing land holdings controlled by private groups, or provincial and federal governments. Breeding bird densities and their success would be evaluated in these plots, and compared with information from unmanaged habitats. This would be done in the same general area to reduce potentially confounding effects accruing from variations in weather, wetlands, alternate prey, predators and so on. More than one region should be examined.

An additional concern is the potential responses by predators to habitats of different size. It is possible that breeding success declines in plots of intermediate size because birds are attracted to them in high density, then suffer high predation because the area is effectively searched by predators encountering abundant prey (Clark and Nudds 1991: 536). Small and large plots may have higher nesting success because birds nest at lower density, making these patches less profitable for foraging predators (Figure 2). Ironically, if habitats currently established by PHJV fall within the range of undesirable sizes, they may not be those that are most effective in enhancing avian breeding success in the long-term, even when they appear to create higher nesting success than unmanaged areas. Although this is untested, Klett et al. (1988) found that five dabbling duck species preferred planted cover over seven other natural and agricultural habitats. However, nesting success in planted cover was variable and consistently lower than estimates needed to maintain stable populations of either mallards (~15%) or other ducks (~20 percent; *see* Klett et al. 1988:439, for assumptions). In other words, planted cover apparently acted effectively as a "sink" rather than "source" habitat.

Number (density) of habitat patches. Although habitat patch size alone is a controversial issue that must be resolved, a related question is, "how many patches should be established in an area?" Current plans to evaluate the effectiveness of PHJV focus on comparisons of mallard habitat use, nesting success and duckling recruitment in landscapes that differ with respect to levels of intensive and extensive programs (Sankowski et al. 1991). This assessment project also tests specific assumptions of the CPT. Work will be conducted in areas that receive conventional program delivery (e.g., guided by CPT); responses by species other than mallard are not considered.

To examine the influence of numbers of habitat patches, we believe that a productive approach is to enhance some areas according to CPT projections, and to increase that level in several neighboring areas while leaving others as unmanipulated controls (Figure 3). In support of this idea, the authors of the mallard simulation model that was used to generate the CPT stated clearly that the model's predictions **should** be tested (e.g., Cowardin et al. 1988:26). Rather than rely exclusively on ceiling levels produced by the CPT, we strongly recommend that the level be exceeded so that the chances of detecting an effect are increased. A failure to detect increased (mallard) production could conceivably result from levels of treatment (habitat restoration) lying below the threshold for effects to occur (Figure 3).

Land removed from cropping and seeded to permanent cover in the Dakotas has risen dramatically since 1985 as part of the Conservation Reserve Program (CRP). Duck nesting success on CRP areas appears to be substantially higher than that recorded in neighboring Waterfowl Production Areas (WPA) (Kantrud in press). These results are consistent with theoretical predictions outlined above because CRP fields are more abundant than WPAs and are, on average, twice the area of WPAs. Although his study was not designed to test effects of patch sizes or numbers on duck nesting success, we concur with Kantrud (in press) that these areas provide rich opportunity to evaluate these questions.

Finally, there are other reasons why this approach has merit. Predictions applicable to mallards may not apply to ducks that have different nest site and social spacing requirements (e.g., Anderson and Titman 1992), or may be inappropriate for other groups of birds. Habitat development beyond that predicted by the CPT could substantially increase

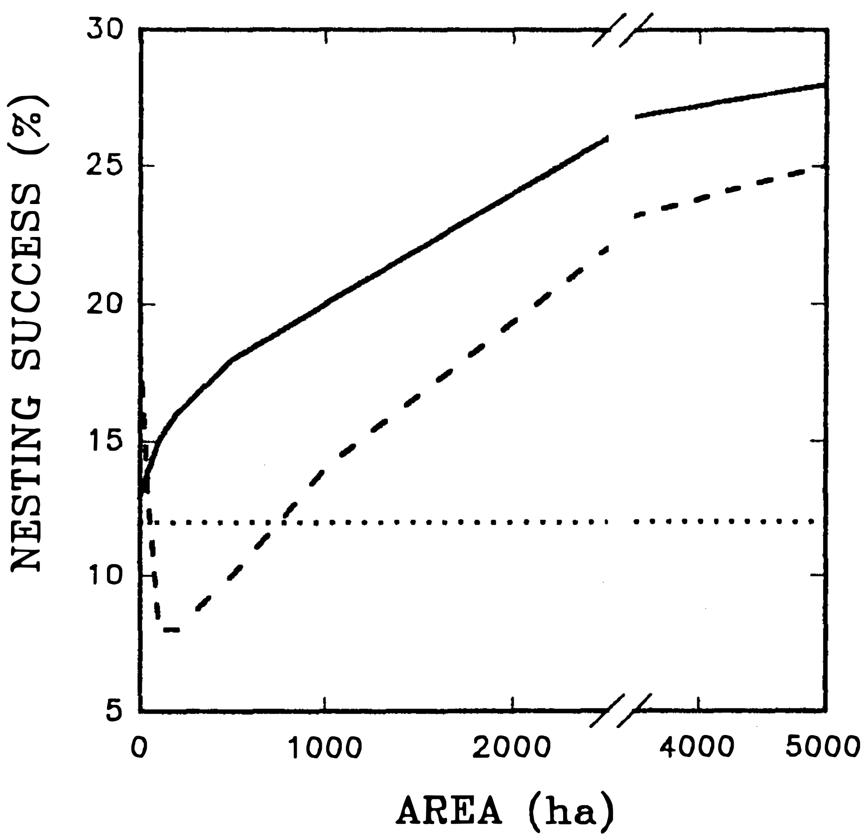

Figure 2. Hypothesized relationships between habitat patch size and duck nesting success (avian breeding success) in which habitat size and success are: (1) related positively (solid line); (2) correlated negatively from small to intermediate patch sizes and then become positively correlated (broken line); and (3) unrelated (dotted line). Data from managed plots should be contrasted with those from unmanaged (control) areas, with replication. Many other alternatives exist (modified from Clark and Nudds 1991).

benefits for species such as blue-winged teal, northern shoveler (*Anas clypeata*) or diving ducks that are more likely to use nesting habitats immediately adjacent to wetlands rather than travel to plots of managed cover. We suspect that this action also might increase mallard nesting success by supplying more habitat than is needed to accommodate breeding pairs, enabling females to disperse nests at low density and nest more successfully.

Conclusions

''If there is opportunity to acquire land parcels in configurations of different sizes in many locations, what is the best way to proceed?'' Apart from the reasonable approach that has been guided by the CPT, the answer to this question is not readily apparent. We briefly reviewed how habitat configuration influences avian breeding success. Although empirical and theoretical evidence support the notion that these principles should apply to breeding ducks and other birds in the prairies, current habitat restorations do not seriously consider them. Nonetheless, we have tried to show that there is an outstanding opportunity for the PHJV to apply these principles because they provide testable predictions, and the current socio-economic climate is ideal for flexible land acquisition. More important is the overwhelming evidence from the broader field of ecology that indicates why habitat manipulations might work. We must determine the level needed to achieve the desired goals—a tricky yet necessary step. In our opinion, one should exhaust all management alternatives via habitat manipulations because, in comparison with some other intensive options, restored habitats can be self-sustaining, can have multiple benefits and potentially can thwart predators either by making nests more difficult to find or by creating more productive environments that sustain mixed populations of predators and alternate prey.

For practical reasons, the outcome of implementation is a patchwork of different program in each PHJV target area. However, by organizing ongoing and planned implementation we will be able to achieve a constrained experimental design that is preferable to none at all (Nichols 1991, *see also* Sankowski et al. 1991). Experiments conducted as an integral part of PHJV habitat establishment programs would (1) enable managers to deliver programs while (2) providing researchers access to a study designed to test

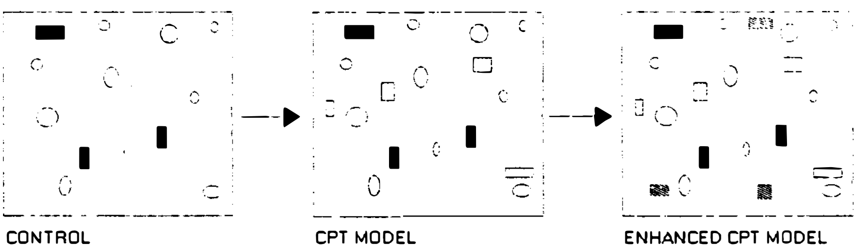

Figure 3. Hypothetical landscapes that may be created to examine the relationship between density of habitat patches (closed and stipped rectangles) and duck nesting success (or avian breeding success). Land management decisions based on the CPT model (stippled rectangles) may fall below levels required to detect substantial increases in success for mallards, ducks in general, or a variety of other birds. Consequently, to test this possibility, some areas should receive a ''treatment'' that is greater than the level generated by the CPT (enhanced CPT model; *see* text). Open circular symbols represent wetlands. Control areas and replicates also are needed (*see* Figure 2 caption).

the effects of habitat manipulation on breeding success of birds and therefore (3) arm program administrators and managers with reliable information about alternatives for habitat management. We should conduct these management experiments soon, lest we lose the opportunity to evaluate thoroughly the full potential of habitat management for waterfowl and other birds.

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Developing an Adaptive Management Strategy for Harvesting Waterfowl in North America

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Introduction

"... *we will soon eliminate the guesswork of waterfowl numbers and utilization.*"
J. C. Salyer (1936)

In the half-century since the noted biologist J. C. Salyer made his prediction, North American waterfowl populations have become among the most intensively-studied avian communities in the world. The resulting information has led to vast improvements in the consumptive use of these economically and culturally important resources. Nonetheless, we believe that Salyer's prophecy remains largely unfulfilled, in part because resource agencies too often have treated research (i.e., the *accumulation* of information and understanding) and management (i.e., the *application* of information) as mutually exclusive pursuits. Given limited fiscal resources, we question whether waterfowl managers can continue to rely on traditional research to provide the knowledge necessary to meet the challenges of the future. Populations of many waterfowl species and the wetlands that support them have declined, demands for hunting opportunity remain high, and harvest management policies are subject to increasing scrutiny by a conservation-minded public. Moreover, we suggest that the efficacy of waterfowl harvest management will be limited as long as managers feel compelled to use risk-aversive regulations as a hedge against uncertainty. As paradoxical as it may seem, we suggest that harvest management could improve dramatically if uncertainty were not only acknowledged, but incorporated as an integral part of the decision-making process. We propose an extension to the current approach for harvesting waterfowl in which management decisions play a dominant role in reducing uncertainty about population dynamics without sacrificing the objective of maximizing harvests. We then discuss some practical considerations for implementing this strategy for managing waterfowl harvests in North America.

Development of an Adaptive Approach to Harvest Management

Evolution of the Regulations Process

The development of the process by which waterfowl harvest in North America is regulated can be characterized by an increasing trend in the amount and quality of information used in management. We recognize three phases in this development, starting before initiation of waterfowl monitoring programs, and leading to the present process, in which regulations are tied to biological data bases.

The initial phase. The passage of the Migratory Bird Treat Act in 1918, which provided legal status for migratory birds and mandated the regulation of their harvests, marked the beginning of the modern era of waterfowl harvest management. During the early development of mechanisms for regulating harvests, few if any population monitoring tools were in place, and formal procedures for review, assessment and public input were yet to be developed. In the absence of reliable data about populations and regulatory impacts, regulations were very subjective. There was little or no monitoring of populations except at a local level, and most information about population status was anecdotal. The lack of adequate monitoring meant that the promulgation of regulations was necessarily an ill-defined process.

The principal aims in harvest regulation during the early phase of development revolved around the maintenance of hunting opportunity. Without reliable information about regulatory consequences, regulations were based primarily on tradition and the desire to satisfy hunters. Under these conditions it was impossible to adjust regulations based on population status, and the potential existed for over-harvest and subsequent population declines.

The pre-adaptive phase. Monitoring programs, including the Waterfowl Breeding Population and Habitat Survey, waterfowl harvest surveys and operational banding programs, were eventually initiated (Anderson and Henny 1972). As these programs were implemented, it became possible to monitor the status of waterfowl populations and to use the resulting information in the setting of regulations. In essence, the anecdotal information of the early phase was replaced by survey and monitoring data, which now could be used informatively. Regulations in year t influenced the level of harvest and, through harvest, the population status in year t+1 (Figure 1A). Harvest and population data for year t+1 were collected through the monitoring program, and this information was used in setting regulations during the next regulations cycle.

During this "pre-adaptive" period, tradition played a diminishing role as managers placed new emphasis on information regarding population status. The availability of population data on a regular basis provided managers greater capability to provide hunting opportunity consistent with the maintenance of viable populations. If, for example, regulations in year t were to lead to dramatic declines in populations the next year, then regulatory decisions in year t+1 could take these declines into account. This regulatory "feedback," in which the population status resulting from regulations could be used to adjust subsequent regulations, represented a great improvement in the regulatory process. However, there remained a need to acquire reliable population and harvest data over an extended period of time and to incorporate this information into the regulatory process.

The current regulatory process. The extensive knowledge accumulated through monitoring programs and research has led in recent years to the development of population "models" that characterize population dynamics in terms of population size, as influenced by harvest regulations. Early renditions of these models represented the influence of regulations by means of simple relationships (e.g., population status was assumed to be directly proportional to harvest, which also was assumed to be directly related to regulations). As reproductive and survival processes were better understood, models increased in complexity and realism. This in turn led to additional understanding of the relationships among population status, harvest levels and harvest regulations. By building on the information bases they were designed to represent, models added yet another information component to the regulations process. As before, the impact of harvest regulations on a waterfowl population is reflected in the data available from monitoring programs. However, these data now are used to update a model of the population, which is used to guide the regulatory process in the next cycle (Figure 1B). The model is updated periodically as new knowledge from monitoring and research programs becomes available, so that the model and the information base it represents constantly are evolving.

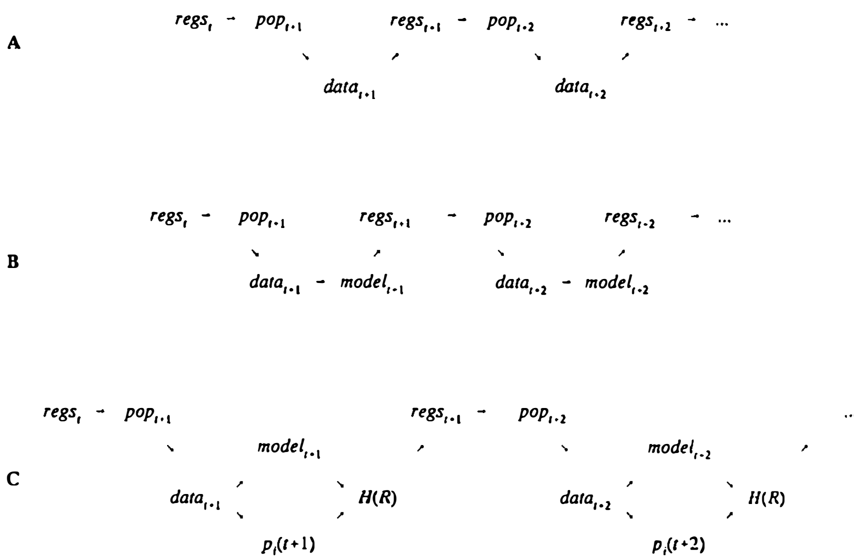

Figure 1. Evolution of the waterfowl regulations process in which regulations (regs), populations (pop), and data are linked in an iterative process: (A) the "pre-adaptive" period, after implementation of monitoring programs, but prior to the development of an extensive information base; (B) the current process in which long-term monitoring data and research results are incorporated into models that aid in the setting of regulations; and (C) the proposed process for actively adaptive regulatory management. The adaptive process recognizes uncertainty (represented by the likelihood weights $p_i(t)$) and attempts to reduce or eliminate it, pursuant to maximizing long-term harvest H(R).

In this expanded scenario it is important to recognize that regulations have both direct and indirect effects, and both are crucial to the effective management of waterfowl populations. First, regulations directly affect a population by influencing the amount of harvest and subsequent population status. Second, regulations indirectly affect populations by influencing the information that is captured in the population model and subsequently used in making regulatory decisions. Informative regulations should reduce uncertainty about system dynamics, thereby ensuring increasing efficacy of harvest regulations.

This regulatory scenario is an example of adaptive management, a strategic approach that recognizes the importance of information in management. For the management of waterfowl harvests, this involves annual updating of waterfowl data bases, incorporation of these data into improved population models, and use of this information in setting harvest regulations. A typical application would involve the use of population models to explore the impacts of a number of different regulations, with the objective of identifying regulations that maximize harvest while limiting the negative impacts on populations. The regulations thus identified can be incorporated into the decision-making process, thereby ensuring that harvest regulations account for current population status and potential impacts on future population status. Some regulatory strategies are likely to be more informative than others, in the sense that they lead to a reduction in uncertainty about the consequences of regulations. If one seeks through regulation to improve the information by which regulatory options are evaluated, the regulatory process can be described as actively adaptive (Walters and Holling 1990). If, on the other hand, improved information is simply an unplanned by-product of harvest regulations, the process can be described as passively adaptive. With the single exception of a large-scale experiment in which duck-harvest regulations were stabilized during 1980–84, waterfowl harvest management in recent years has been passively adaptive.

Limitation of the current regulatory process. There are two ways in which the regulatory process can fail to serve the needs of management: (1) by not providing regulations that are consonant with harvest goals and long-term conservation of populations; and (2) by not providing the necessary information on which to base regulatory decisions pursuant to these goals. We suggest that waterfowl harvest management, as it now is practiced, suffers from the second failing. We believe that managers are approaching the limits of their ability to improve harvest management, largely because of the passive nature of the process. The lack of information necessary for more definitive regulatory decisions has resulted in a risk-aversive tendency to manage populations for stability (i.e., to set regulations each year that control and hopefully eliminate population fluctuations). The inevitable effect is to "chase populations with regulations" (i.e., to liberalize regulations whenever populations are abundant and restrict regulations whenever populations are low). The logic for such a strategy is that managing to maintain steady state conditions avoids the twin evils of sacrificed hunting opportunity (overly restrictive regulations when birds are abundant) and over-exploitation (liberal regulations when birds are scarce). Indeed, a steady state regulatory strategy might be appropriate for a population, if its population dynamics, as influenced by harvest regulation, population status and environmental conditions, were completely understood. In the almost universal situation where our understanding of population dynamics falls short of this ideal, regulating for steady state conditions sacrifices the information needed for sound management. We note that this dilemma is well recognized and that an alternative approach, which limits annual regulatory adjustments, has been advocated in an Environmental Impact

Statement (U.S. Fish and Wildlife Service 1988a). Although periods of stable hunting regulations could enhance the understanding of managed systems, this approach falls short of the more aggressive approach to learning we believe is necessary.

It is important to clarify the role of information in regulating harvests. Adaptive management, as described here, recognizes no intrinsic value in information, nor in the biological monitoring, research and scientific assessment by which it is produced. We advocate an approach to harvest regulation that emphasizes resource management per se, such that value is ascribed to information and understanding only to the extent that they contribute to the stated goals of harvest management. From this point of view, any recognition of the importance of knowledge is firmly rooted in the need for that knowledge to serve management purposes. It should be reassuring to both researchers and managers that adaptive management, by recognizing the need for reliable information on which to base management decisions, leads to closer cooperation between these groups.

A Model for Adaptive Harvest Management

Here we formulate a general algorithm for adaptive harvest regulation that accounts for the importance of information in maximizing the harvest and long-term conservation of populations. In order to specify this strategy clearly and distinguish it from the current regulatory process, we describe four critical elements:

1. An array of regulatory options should be available for the regulation of waterfowl harvest. These options might include various combinations of regulations representing, for example, "restrictive," "liberal" and "moderate" regulations, with possible constraints on their use. The set of feasible options can be limited or expanded as the need and desirability to do so is recognized.
2. An objective function is a mathematical expression of controls and system behavior that is needed to measure the performance of various regulatory policies. We assume that the general form of the objective function is a weighted sum of harvests over some recognized time frame. This is consistent with traditional goals for waterfowl harvest management, and ensures that the focus is firmly on harvest and harvest opportunity.
3. Managers must be able to specify a set of models that represent an array of meaningful hypotheses about the impact of regulations on waterfowl populations. For example, the set might include a model incorporating the hypothesis of completely additive hunting mortality, and another incorporating the hypothesis of compensatory hunting mortality (Anderson and Burnham 1976). To simplify notation, we assume that there are a finite number of potential models, each developed from data bases that have accrued as a result of waterfowl monitoring and research programs.
4. Measures of credibility for each model should be available for use in selecting harvest regulations. The notion of credibility is included as a recognition that the "correct" model for use in evaluating regulatory options is not known with certainty, and that this uncertainty should be incorporated in the procedure for evaluating and selecting regulations. The measures of credibility are used to "weight" model outputs, and are updated each year as additional data about population status and the impacts of regulations become available.

To show how our approach to harvest regulation accounts for uncertainty, it is necessary to describe it more formally, beginning with a specification of the time frame. Assume that the appropriate time frame consists of the set $\{0,1,2,...,T\}$ of integers representing $T+1$ years, starting with $t=0$ for the current year. During each year the population status is monitored, regulations are imposed, and individuals are harvested from the population. In general, the number of years in the time frame is large, to allow for the long-term planning and management that is appropriate for renewable resources.

The population is characterized in terms of its size N(t) at some point in the annual life cycle (e.g., N(t) is the size of the population at the beginning of the breeding season in year t). We assume that population dynamics are influenced by harvest levels, which in turn are controlled by regulations that may vary from year to year as the population changes. Regulations over the time frame are described by a regulatory policy, which is a rule specifying a regulatory action R(N(t)) at time t for a population of size N(t). The idea is to choose the optimal set of regulations over the time frame (i.e., to choose a policy that maximizes average harvests). The choice of a policy should account for the inevitable uncertainties in characterizing population dynamics, and in particular should recognize that population dynamics are influenced each year by uncontrolled and stochastic environmental factors z(t).

We assume that there are a total of k population models M_i, and each model predicts population size in year t+1 based on population size N(t), the regulations imposed R(N(t)), and environmental conditions z(t) in year t:

$$N(t+1) = N(t) + f_i\,(N(t),R(N(t)),z(t)).$$

Each model represents a different hypothesis about population dynamics and the way regulations impact populations. We characterize uncertainty about which hypothesis is most appropriate by means of model weights p_i, such that $p_i(t)$ measures the likelihood that model M_i appropriately represents the system.

Finally, the objective function under a given policy R for adaptive regulation includes predicted harvests for each model, weighted by the values $p_i(t)$. If the harvest in year t is predicted to be $H_i(R{:}t)$ under model M_i for regulatory policy R, then the objective function includes the weighted harvest

$$H(R{:}t) = \sum_{i=1}^{k} p_i(t)\, H_i(R{:}t)$$

for year t, based on the likelihood weights $p_i(t)$. Thus, the overall objective function for adaptive regulation is the time average

$$H(R) = \frac{\sum_{t=0}^{T} H(R{:}t)}{T+1}.$$

The optimal policy, R^*, will be that which results in the highest value of H(R):

$$H^*(R^*) = \max_R H(R).$$

In many of its details the adaptive management problem described here is analogous to the standard formulation of a problem in dynamic optimization (e.g., Bellman 1957, Anderson 1975, Williams 1982). Thus, both formulations include a set of feasible regulatory options, an objective function by which to evaluate policies and a model characterizing population responses to policies. The added feature in adaptive optimization concerns the uncertainty about the appropriate model to describe population dynamics, and the incorporation of that uncertainty (by means of the weights $p_i(t)$) into the decision-making process. At first glance, this does not seem to be a profound alteration of the optimization problem, since it manifests itself explicitly only in the objective function, through the weighting factors $p_i(t)$. However, the incorporation of uncertainty directly into the objective function means that the search for an optimal policy must account not only for harvest values, but also for the likelihoods associated with those values. These likelihoods also must be updated as information becomes available through time. We suggest an approach similar to that proposed by Hilborn and Walters (1992) that relies on Bayes' theorem. Specifically,

$$p_i(t+1) = \frac{p_i(t)\ P_i[N(t),N(t+1)]}{\sum_{i=1}^{k} p_i(t)\ P_i[N(t),N(t+1)]}, \qquad (1)$$

where $P_i[N(t),N(t+1)]$ is the transition probability assigned by model M_i to the change in population size from $N(t)$ to $N(t+1)$. The new weight $p_i(t+1)$, then, is a function of how well model M_i predicted the population change that occurred (the numerator), relative to how well any of the k models predicted that change (the denominator).

As an aside, we note that our formulation of the adaptive optimization problem can be extended to include a continuous range of alternative models. In particular, the problem can be described in terms of models that are characterized by an unknown parameter α. In this case, the set of models M_i is replaced by a continuous family of models M_α, with a different model for each value that α can take. The objective function is altered similarly, with likelihoods $p_i(t)$ replaced by the continuous distribution $f(\alpha|t)$, the harvest $H_i(t)$ for model M_i replaced by H_α for model M_α, and the sum

$$H(R{:}t) = \sum_{i=1}^{k} p_i(t) H_i(R{:}t),$$

replaced by the integral

$$H(R{:}t) = \int_\alpha f(\alpha|t) H_\alpha(R{:}t).$$

Regardless of these changes, the objective function continues to represent a weighted average of harvests, with weight $f(\alpha|t)$ representing the relative likelihood that model M_α is appropriate for the population. The goal of the process continues to be the selection of regulations that maximize the weighted harvest. By incorporating the distribution $f(\alpha|t)$ directly into the objective function, this selection accounts for the values of harvest, as well as the information content represented by the distribution $f(\alpha|t)$ associated with these values.

Implementing an Adaptive Harvest Strategy

Important Features of an Actively-adaptive Harvest Strategy

Like the current approach, our proposed strategy uses monitoring data and modelling to inform the regulations process. Unlike the current approach, however, the existence of alternative models plays an important role in the selection of regulations (Figure 1C). Any particular model M_i will strongly influence the choice of regulations if: (1) the values

$H_i(t)$ are relatively large so that model M_i appears to yield high harvests over the long term; or (2) the likelihood weights $p_i(t)$ are large (relative to other weights). Because of the multiplicative nature of these two factors, the optimizing policy is equally likely to be driven by models with large likelihoods as it is to be driven by models with high harvests.

Each year these likelihood weights are updated, based on data that are collected in monitoring programs. This updating is essentially a three-step process:

1. The optimal regulations for year t having been determined, one predicts population changes from year t to year t+1 for each model under consideration.
2. When data from the monitoring program become available the next year, predicted changes from the models are compared with the actual changes provided by the monitoring program.
3. The weights $p_i(t)$ are updated to $p_i(t+1)$ based on the comparison of actual and predicted population changes (equation 1). The weight for model M_i is increased to the extent that the predicted and actual changes correspond, and is decreased to the extent that they do not correspond.

The iterative process of updating the weights and then using them in the objective function defines the active nature of adaptive optimization. Assume, for example, that two models are under consideration, and model M_1 is appropriate for the population that is being managed. If the iterative regulations process begins (i.e., t=0) with optimization of an objective function based on equal weights for the two models, then the resulting regulations are oriented toward the model with highest long-term harvest. The monitoring program generates harvest and population data, which generally indicate a better fit for model M_1 than for M_2. This is reflected in an increased value for the weight $p_1(1)$ for model M_1, and a decreased value for the weight $p_2(1)$ for model M_2. When these updated weights are used in the objective function, the dominant influence of $p_1(1)$ causes the optimal policy to be oriented more strongly toward model M_1. That is, the optimization process tends to be responsive to the element $p_i(1)H_i(1)$ in the objective function, and that element is in part determined by the weight $p_i(1)$. The resulting regulations again yield data that can be used to update the weights, leading to a further increase in the weight for model M_1 and a decrease in the weight for model M_2. These updated weights again are incorporated in the objective function, which is optimized to produce new regulations, and so on. By iteratively updating weights and optimizing an objective function that includes them, the process eventually recognizes M_1 as the appropriate model, and leads to the regulations policy that maximizes harvest under M_1.

By choosing regulations that maximize a weighted sum of harvest values, the strategy proposed here "locks on" to the appropriate model at the same time that it accommodates the objective of maximizing average harvest. It thus produces the most informative regulations (in the sense of large changes in the harvest weights) when uncertainty is prevalent, and produces the largest harvest yields as uncertainty is eliminated. The strategy clearly is adaptive, in the sense that it incorporates information into the decision-making process at each iteration of the regulations cycle. It is actively adaptive, in that regulations are used in a way the ensures improved information about population response. Finally, it is optimal in the sense that it focuses at each time on maximizing an average of long-term harvest yields.

Limitations of the Actively Adaptive Strategy

There are two conditions under which the iterative process fails to converge to the appropriate model and the optimal regulatory policy for that model. The first is where regulations fail to influence the model weights, in that any set of regulations produces the same change in all weights. It is possible to have identical updates for all models if the predicted population changes for the models all are equally good (or bad) at representing the actual population change. The second condition for failure is where model weights do not influence regulations, in the sense that any set of weights produces the same optimal policy. This in turn suggests a fixed regulatory policy irrespective of the appropriate model, so that information about which model is the most appropriate is irrelevant to management.

Thus, the adaptive regulatory strategy is likely to yield improved harvest management in all cases except when: (1) the alternative models under consideration are indistinguishable as to their fit to monitoring data; or (2) information about model appropriateness is irrelevant with respect to policy choice. It is conceivable that either of these conditions could arise in the context of waterfowl management. However, with well-monitored populations and carefully chosen model sets, we believe that neither condition is likely.

Management Objectives

Thus far, we have focused solely on a management objective of maximizing harvest over some recognized time frame, with resource maintenance a necessary condition for maximizing long-term harvests. Nonetheless, managers likely would be interested in placing some constraints on the exploitation process. For example, some minimum population size may be required to provide adequate opportunities for non-consumptive uses, or to maintain desired biological diversity or ecosystem integrity. Perhaps the most relevant example of a necessary constraint on maximizing harvests is the desire for less variability in annual harvest regulations (U.S. Department of the Interior 1988a). The implication of this constraint is that yield is sacrificed to some degree for the socio-economic and administrative benefits accruing from more stable regulations. We also suspect that a constraint on regulation variability might result in slower learning rates than those realized in an actively adaptive policy without such a constraint. However, we recognize that considerable knowledge can be gained using periods of stability with contrasting hunting regulations (e.g., Smith and Reynolds 1992).

Whatever the motivation, constraints on the exploitation process can be accommodated readily in the adaptive strategy we propose. In the case of a constraint on minimum population size (γ), it simply is a matter of discarding from consideration at time t those harvest regulations that have an unacceptably high probability of resulting in a population size $< \gamma$ at time $t+1$. In the mechanics of dynamic optimization this is accomplished in the objective function by assigning zero value to future population sizes $< \gamma$. If managers were interested in reducing annual variability in regulations, then a measure of variability could be included in the objective function, such that the optimal harvest decision at time t is conditional on not only the state of the system at time t, but also on the harvest decision at time $t-1$.

Regardless of the various constraints that could be imposed on the state of the system or regulatory policies, the fundamental objective is still one of maximizing harvest. However, managers have expressed a desire to maximize hunting *opportunity*, rather than harvest per se (Sparrowe and Babcock 1989). We see no theoretical problems in pursuing this objective in our proposed approach to waterfowl harvest management; however, we recognize major challenges in application. First, some standard metric or "currency" for hunting opportunity must be established. Is opportunity to be measured as the number of days in the hunting season, the number of active hunters, the number of hunter-days or some other measure? Second, managers should have a good understanding of the relationship between population dynamics and hunting opportunity. In other words, managers would need to define (at least probabilistically) the functional relationship between hunting opportunity, harvest and population size. We contend that this well be very difficult to do using historic information, because hunting opportunity (however defined), harvests and population size over the period of record all are highly correlated (Nichols and Johnson 1989). Inferences regarding the directionality of cause-and-effect relationships would be weak, at best. Moreover, it seems clear that hunter participation is driven not only by opportunity, but by socio-economic phenomena that are poorly understood. However, an objective function that included hunter opportunity should provide a better understanding of the relationship between hunter opportunity and population dynamics, and as a by- product, useful knowledge regarding the relationship between hunter opportunity and activity.

The Value of Learning

As we have suggested, an objective to learn is legitimate only insofar as the expected information will contribute to more effective harvest management. Thus, an obligate step in considering an actively adaptive approach is to estimate the benefit (i.e., increase in average yield) expected as a result of reducing uncertainty about system dynamics. The expected benefit will be high only if the competing models which collectively express uncertainty about the system give rise to very different management strategies. From a manager's perspective, there is absolutely no value in distinguishing between alternative models that differ in their mathematical form or biological realism, but which suggest similar harvest strategies. In fact, selection of such a model set is sufficient to induce failure of the proposed strategy to identify the ''correct'' model (through the failure of likelihood weights to change). We illustrate these points with the following example.

Arguably, the most important question in harvest management is the degree to which hunting losses are compensated for by decreases in natural mortality. Despite exhaustive attempts to resolve the issue, the effects of exploitation on waterfowl survival and subsequent population growth remain equivocal (Nichols et al. 1984, Nichols 1991). Indeed, the pendulum of evidence has swung from that supporting completely additive hunting mortality (Geis 1963) to that supporting complete compensation for kill rates below some threshold (Anderson and Burnham 1976). Recently, Smith and Reynolds (1992) found evidence of some additity and Conroy and Krementz (1990) have emphasized the importance of considering intermediate models (i.e., partial compensation). The ensuing ''battle of the models'' has resulted in endless and unproductive debate concerning appropriate hunting regulations. Moreover, the ability to resolve this issue has been limited by the way in which regulations have been promulgated. Several researchers have suggested that only large-scale field experimentation will provide a clearer understanding of the effect of hunting on waterfowl populations (Anderson and Burnham 1976, Nichols et al. 1984, Anderson et al. 1987, Conroy and Krementz 1990).

We attempted to estimate the ''value'' of identifying the model which correctly expresses the relationship between annual kill rates and survival in mallards. In this example, competing models are expressed simply as various discrete values of the parameter β, which describes the slope of the linear relationship between annual survival and kill rates:

$$S_t = \theta(1 - \beta K_t), \qquad (2)$$

where S_t = annual survival rate in year t, θ = annual survival rate in the absence of hunting, and K_t = kill rate in year t (Burnham et al. 1984). We chose three values of β (0.1, 0.5, 0.9) which span the range between almost complete compensation ($\beta = 0.1$) and almost complete additivity ($\beta = 0.9$). These values also were chosen because they are similar to estimates reported previously for mallards (Burnham et al. 1984, Smith and Reynolds 1992, G. W. Smith unpublished data).

In order to estimate the "value" of learning, we first constructed a year-specific population model for mallards breeding in central North America. The model we present is similar to that presented by Martin et al. (1979), and was constructed using the same data bases. We first define the following parameters:

$N_{s,t}$ and $N'_{s,t}$ = number of adult and young mallards, respectively, of sex s in the population on September 1 (the anniversary date of our model) of year t;
$S_{s,t}$ and $S'_{s,t}$ = annual survival probabilities for adults and young, respectively, of sex s in year t;
θ_s and θ'_s = survival probabilities in the absence of hunting for adults and young, respectively, of sex s (estimates are: $\theta_{♀} = 0.638$, $\theta_{♂} = 0.814$, $\theta'_{♀} = 0.789$, $\theta'_{♂} = 0.824$);
$K_{♀,t}$ = annual kill rate of adult females in year t, equivalent to the harvest rate adjusted for a crippling loss rate of 0.2;
d_s and d'_s = differential hunting mortality, relative to adult females, of adults and young, respectively, of sex s (e.g., the kill rate of young females = $K_{♀,t}d'_{♀}$) (estimates are: $d_{♂} = 1.92$, $d'_{♀} = 1.90$, $d'_{♂} = 2.59$);
β = the slope of the linear relationship between annual survival rate and annual kill rate, such that $0 \leq \beta \leq 1$;
A_t = production rate in year t, expressed as the number of young females per adult female in the fall population (the sex ratio of fledged young was assumed to be 1:1, so that the number of young males was simply equal to the number of young females);
P_t = number of ponds present in May in Prairie Canada and the northcentral U. S. in year t;
m_s and m'_s = proportion of annual mortality occurring during the breeding season (May-September) for adults and young, respectively, of sex s (estimates are: $m_{♂} = m'_{♂} = 0.05$, $m_{♀} = 0.70$, $m'_{♀} = 0.30$);
B_t = number of mallards in the population in May of year t.

Given these definitions we can specify the following population model:

$$N_{s,t+1} = N_{s,t}\, S_{s,t} + N'_{s,t}S'_{s,t};\ \text{where } S_{s,t} = \theta_s(1 - \beta K_{♀,t}\, d_s),$$

$$S'_{s,t} = \theta'_s(1 - \beta K_{♀,t}\, d'_s),\ \text{and } N'_{s,t} = N_{♀,t}A_t.$$

The production rate, A_t, was assumed to be a function of population density, expressed as breeding population size divided by the number of ponds in Prairie Canada and the northcentral U. S. during the previous May (in year t−1). Breeding population size in year t−1 was determined from fall populations and winter survival in year t−1:

$$B_{t-1} = N_{♂,t-1}[1 - (1 - m_{♂})(1 - S_{♂,t-1}) + N'_{♂,t-1}[1 - (1 - m'_{♂})(1 - S'_{♂,t-1})] + N_{♀,t-1}[1 - (1 - m_{♀})(1 - S_{♀,t-1})] + N'_{♀,t-1}[1 - (1 - m'_{♀})(1 - S'_{♀,t-1})].$$

The number of ponds in May of year t−1 were projected based on pond abundance the previous year and annual precipitation:

$$P_{t-1} = -5706572.07 + 0.53\,(P_{t-2}) + 19110.06\,(r_{t-1}),$$

where r_{t-1} = weighted average precipitation (mm) in Prairie Canada and the northcentral U. S. between June 1 in year t−2 to May 31 in year t−1. Annual precipitation was simulated as a normally distributed random variable with mean 403.7 and standard deviation 46.7.

The production rate in year t was:

$$A_t = 0.490 + \frac{0.578}{1 + e^{3.867\,(density_{t-1} - 1.237)}},$$

where $density_{t-1} = B_{t-1}/P_{t-1}$.

We used the mallard model to simulate the effects of various harvest rates under the alternative models for compensation. The harvest rate of adult females was specified, and harvest rates for the other three age-sex classes were computed using the differential hunting-mortality constants. Each set of harvest rates was simulated over 10 years with 100 replications. These simulations were initiated using the estimated breeding population size, number of ponds, and summer survival in 1992. We restricted the maximum simulated harvest rate to 0.20 because this roughly is the limit (given our estimates of θ) beyond which hunting mortality must be completely additive (c.f., Conroy and Krementz 1990).

As expected, finite rates of population growth declined with increasing harvest rates for all models, although the rate of decline was very low for the model specifying almost complete compensation (Table 1). Average annual harvests also increased with increasing harvest rates over the entire range 0.05–0.20, except when hunting mortality was almost completely additive. Had we simulated harvest rates above the maximum for which any compensation could occur, harvests would have begun to decline eventually for all models.

Table 1. Expected annual harvests (h, in millions) and finite growth rates (λ)resulting from various harvest rates of adult females and alternative models of partially additive hunting mortality in mallards[a]. The models represented by $\beta = 0.1$, $\beta = 0.5$, and $\beta = 0.9$ express increasing levels of additive hunting mortality.

Harvest rate	Parameter	Model $\beta = 0.1$	$\beta = 0.5$	$\beta = 0.9$
0.050	h	1.068	0.926	0.855
	λ	1.094	1.064	1.044
0.075	h	1.583	1.281	1.139
	λ	1.091	1.046	1.017
0.100	h	2.073	1.634	1.390
	λ	1.087	1.037	1.000
0.125	h	2.542	1.923	1.576
	λ	1.083	1.021	0.982
0.150	h	2.979	2.193	1.668
	λ	1.078	1.014	0.955
0.175	h	3.462	2.474	1.623
	λ	1.076	1.003	0.918
0.200	h	3.889	2.704	1.507
	λ	1.073	0.995	0.870

[a]Based on simulating each harvest rate for 10 years with 100 replications.

We estimated the "value" of determining the most appropriate model for mid-continent mallards using the procedure described by Hilborn and Walters (1992:496). The "value" (V) of identifying the "correct" model was estimated as the mean of the differences between the maximum harvest (conditional on a population growth rate ≥ 1.0) that could be realized under each model, and the harvest that would be obtained under the most appropriate non-adaptive choice (i.e., that harvest rate that results in a finite growth rate ≥ 1.0 regardless of the true underlying model). Of course, the mean should be taken as a weighted average, with the difference for each model weighted by some prior probability expressing our confidence that the particular model is correct. These probabilities might be based on judgment or could be estimated empirically if data were available (e.g., using estimates of the variance (β) resulting from previous banding studies). We first illustrate the calculation of V assuming equal prior odds on the three models. Using the information in Table 1, we calculate $V = (0.33)(3.889 - 2.073) + (0.33)(2.474 - 1.634) + (0.33)(1.390 - 1.390) = 0.885$, suggesting that the "value" of knowing the correct value of β is an average annual harvest of 885,000 mallards. One way of interpreting this "value" is to determine the expenditures by hunters necessary to achieve this harvest. Using information presented by the U. S. Fish and Wildlife Service (1988b), an annual harvest of 885,000 mallards probably represents over 17 million dollars in hunter expenditures.

These types of simulations also have value beyond helping to determine whether an actively adaptive approach is worthy of consideration. First, they are useful for narrowing the range of uncertainty in selecting appropriate harvest pressure. Conditional on our model, harvest rates for adult females below 0.1 do not appear to be necessary for resource maintenance, even in the face of almost completely additive hunting mortality. Second, the exercise could reveal a harvest strategy that performs well regardless of the true underlying model. Given equal prior odds on the various values of β, a regulation strategy which results in a relatively stable harvest rate of 0.100 − 0.125 will produce an average annual harvest of almost 2 million mallards, without adverse effect on the population. We believe that such a harvest compares favorably with the average mallard harvest in the Central and Mississippi flyways (where most of the harvest of mid-continent mallards occurs) during a period (1968–78) when regulations were changed annually in an attempt to maximize harvests (c.f., Trost et al. 1987).

The Relevance of Management Decisions to Learning

In the preceding example, we illustrated the "value" of learning using simulations of constant harvest rates (i.e., no temporal variability in regulatory decisions) under various models specifying the degree of additive hunting mortality. However, one of the basic premises underlying adaptive harvest management is that the sequence of management decisions over time influences the ability to learn about the managed system. We examined this premise by simulating various temporal sequences of regulatory decisions, using an empirical relationship between mallard harvest rates and regulations. Using these simulations, we examined the ability to distinguish among our alternative models (i.e., $\beta = 0.1$, $\beta = 0.5$, $\beta = 0.9$), given a model and regulatory sequence.

We first estimated direct recovery rates (defined as the probability that a banded bird is recovered during the first hunting season following banding) of mallards banded preseason in a portion of Prairie Canada for the period 1952–91. We next compiled records of season length (in days) in the Mississippi Flyway for the same period of years. We subjectively classified regulations with season lengths < 45 days as "restrictive," season lengths >50 days as ''liberal,'' and seasons of 45–50 days as ''moderate.'' We then estimated mean recovery rates by regulations class. Using a procedure similar to that suggested by Burnham et al. (1987), we partitioned the estimated variances of the mean recovery rates into sampling error and temporal components. We next assumed that the realized annual recovery rates for each regulations class were normally distributed, using our estimated mean and temporal variance for each regulations class. Using these distributions, we randomly generated sets of recovery and survival rates under various regulatory sequences for the three values of β in equation (2). For these simulations, we used the differential hunting-mortality and crippling-loss constants provided earlier and a band-reporting rate of 0.32 (Nichols et al. 1991).

We considered a six-year period, with different sequences of regulations occurring over the six years. For example, the sequence RRRLLL represents three consecutive years of restrictive regulations followed by three years of liberal regulations. For each sequence, we randomly generated 100 sets of recovery and survival rates as described above. Each set consisted of six recovery rates and five survival rates for each age-sex class.

For each of the resulting 300 sets of survival and recovery rates (100 sets for each of the three values of β) we generated 25 band-recovery data sets. Each band-recovery data set included all four age-sex classes and was based on average banded sample sizes achieved for mallards in a portion of Prairie Canada (6,000 total bandings annually). Each data set was then analyzed with program SURVIV (White 1983) using a series of models similar to those of Burnham et al. (1984), but extended to handle four age-sex classes simultaneously. Rather than estimating β with a general model, we used three infrastructural band-recovery models (using equation 2) with β specified as 0.1, 0.5, or 0.9. Each randomly generated data set was fit to each of the three models, and the model with the largest likelihood was selected as the most likely to have generated the data. We then tallied the number of times that the likelihood-based discrimination procedure ''selected'' the ''correct'' underlying model and the two ''incorrect'' models.

We have explored a number of different management sequences using the described approach. Here, we report the results of two sequences of regulations to illustrate the relevance of regulatory decision to the ability to discriminate among competing models/hypotheses. One sequence, RRRRRR, depicts a stable, risk-aversive strategy, whereas the other sequence, RMLRML, reflects highly variable regulations. The classification matrix for the RRRRRR sequence indicates that the likelihood approach correctly classified band-recovery data sets about 68 percent of the time when the true model was $\beta = 0.1$ or $\beta = 0.9$, and only 38 percent of the time when the correct model was $\beta = 0.05$ (Table 2). However, the classification matrix for the other regulations sequence, RMLRML, indicates much higher probabilities of correctly discriminating among the three competing models. Band-recovery data sets generated under $\beta = 0.1$ and $\beta = 0.9$ were correctly classified about 91 percent of the time, whereas correct classification occurred about 80 percent of the time when the true model was $\beta = 0.5$.

This example illustrates several points. Comparison of the two classification matrices in Table 2 effectively demonstrates that sequences of regulatory decisions are differentially informative. Our example also suggests the potential utility of *a priori* designs for learning about system dynamics. Finally, we must acknowledge that sources of information other than population estimates (i.e., band-recovery data) can (should!) be used in updating model weights. Indeed, adaptive optimization will produce a harvest policy that is ''globally optimal'' only if the updating of model weights considers *all* of the information that historical data has to offer (Walters 1986:267). Although beyond the scope of this paper, formulation of comprehensive approaches for updating model weights is a challenging and important component of developing an effective adaptive management strategy for waterfowl.

Identification of Alternative Hypotheses: The Model Set

One of the most important steps in implementation of an adaptive management strategy involves the identification of the alternative hypotheses to be included in the model set. We know of no objective approach guaranteed to produce a useful model set. Instead, we discuss some considerations relevant to developing a model set for mallard management.

We have suggested that two characteristics of the model set are required for an adaptive strategy to perform well. First, the different models being considered must predict different responses to at least some management actions (e.g., hunting regulations). Our three alternative mallard models ($\beta = 0.1$, $\beta = 0.5$, $\beta = 0.9$) meet this criterion, as they yield different predicted population responses to a given set of harvest regulations (e.g., the different λ values for a given value of h; Table 1). Second, the different models must not produce the same optimal policy. The mallard example appears to meet this criterion also, as a specific harvest rate yields different average harvests under the three alternative models.

We also believe that at least one of the elements in the model set should predict reasonably well the responses of the system under a wide range of real-world conditions. Despite the ability of the three models in the previous example to cover the possible responses of mallard survival to hunting, they may still represent a poor model set if the most appropriate (best able to predict population response) model in the set changes over time. For example, assume that the relationship between mallard survival and harvest mortality depends heavily on mallard density, expressed either as number of birds or as a ratio of birds per unit resource. As virtually all of the speculation about mechanisms underlying the compensatory mortality hypothesis involves density-dependent responses (Anderson and Burnham 1976, Nichols et al. 1984, Conroy and Krementz 1990, Nichols 1991), we might expect a relatively small β when density is high and a large β when density is low.

The response of the adaptive optimization algorithm to changes in population size/density, and thus in the best-approximation model, would depend on the magnitude and

Table 2. Classification matrix depicting the probabilities of classifying band-recovery matrices based on the magnitude of the likelihoods for three models ($\beta = 0.1$, $\beta = 0.5$, and $\beta = 0.9$) expressing varying levels of additive hunting mortality.

Regulations sequence[a]	Correct model	Likelihood classification $\beta = 0.1$	$\beta = 0.5$	$\beta = 0.9$
RRRRRR	$\beta = 0.1$	0.681	0.248	0.071
	$\beta = 0.5$	0.328	0.378	0.294
	$\beta = 0.9$	0.116	0.208	0.676
RMLRML	$\beta = 0.1$	0.906	0.092	0.002
	$\beta = 0.5$	0.130	0.795	0.075
	$\beta = 0.9$	0.009	0.078	0.912

[a]Six-year sequences, where R, M and L denote restrictive, moderate and liberal regulations, respectively.

frequency of such changes. If changes in mallard population size were relatively gradual, the model weights will shift, beginning with a relatively high value associated with the old "correct" model, to similar weights for the two models, to high weight (and hence policy convergence) on the new "correct" model. The period of similar weights for two of the competing models likely would be a period of reduced yield relative to that which could be attained if the shift in models could have been predicted. If density, and hence the best-approximation model, changes too frequently, then the adaptive process could fail to converge on a single model (even temporarily), because under this scenario there is no single "correct" model.

We view the three models in our example, as well as the completely additive and compensatory mortality hypotheses described by Anderson and Burnham (1976) and Nichols et al. (1984), as primarily phenomenological in the sense that they define a statistical relationship between annual survival rate and hunting mortality rate, yet incorporate no underlying mechanism. We believe that the risk of including such models in a set to be used for adaptive management is that they are less likely than more mechanistic models to continue to be useful (i.e., to provide reasonable descriptions and predictions) when conditions relevant to the underlying processes change over time. The above scenario in which mallard density was relevant to the relationship between annual survival rate and hunting mortality rate provides an example of the limitations of phenomenological models.

If we suspect that compensation for hunting mortality occurs because of density-dependent changes in nonhunting mortality occurring after the hunting season, then we can incorporate this hypothesis into a more mechanistic model. For example, we now are considering models of the form:

$$S_t = \theta_t \, (1 - K_t), \tag{3}$$

where we model survival after the hunting season as:

$$\theta_t = \frac{e^{a+bN_t(1-K_t)}}{1 + e^{a+bN_t(1-K_t)}}, \tag{4}$$

where N_t is the fall (preseason) population size for the group of mallards for which the survival model is being constructed. The above general model (equations 3 and 4) expresses the probability of surviving nonhunting mortality sources following the hunting season as a linear-logistic function of population size at the end of the hunting season. Negative values of b provide evidence of density- dependent nonhunting mortality and, hence, of some degree of compensation. Values of b near zero indicate absence of density-dependence and correspond to the completely additive mortality hypothesis. We could define models for inclusion in a new model set by different values of b.

If the real-world process is well-described by equations (3) and (4), then it should be clear that for periods over which post-hunting season density changes little, equation (2) should perform adequately. However, as post-hunting mallard numbers change, the more mechanistic model (equations 3 and 4) should continue to perform reasonably, whereas the more phenomenological model (equation 2) should perform poorly. Of course, the utility of the more mechanistic models will depend on whether we have correctly identified the mechanisms that are relevant to the studied system. For example, the ratio of mallard numbers to some limiting resource may be the primary determinant of nonhunting mortality. In this event, mallard numbers alone would not necessarily produce useful predictions, and we would want to include an additional covariate, an estimate of the level of the critical resource, in the model. Other environmental factors (e.g., pond numbers) also may influence nonhunting mortality and could be incorporated into our model, once identified.

The importance of the model set clearly indicates the need for continued research on population dynamics to help managers formulate meaningful and useful hypotheses about the dynamics of managed systems. In general, we suspect that "mechanistic" models will make better candidates for inclusion in model sets than more "phenomenological" models. We realize that this categorization does not define two discrete classes of models, and that such characterization of models is not objective, but lies very much in the "eye of the beholder." Nevertheless, we believe that the distinction is useful in deliberations about candidates for inclusion in the model set.

Applicability of Adaptive Optimization

Adaptive optimization, or any formal management approach, requires explicit descriptions of system dynamics (i.e., models) and two other important components. First, one must be able to effectively monitor the state of the system (e.g., the breeding population size of mallards and the number of ponds in Prairie Canada) on a periodic basis. For instance, assume that two models predict very different responses to a given harvest. If the precision of the measured response (via the monitoring program) is so poor that it is difficult to determine which predicted response is more accurate, then the ability to update model weights will be limited. In other words, the rate of learning will be low in the management of populations that are poorly monitored. Fortunately, a variety of high-quality monitoring plans for many duck and goose populations in North America should allow meaningful updates of model likelihoods. Second, management must be relevant to the population of interest (i.e., management decision must have a demonstrable effect on population dynamics). The impact of harvest regulations will be obscured to the extent that a population is influenced by other management actions that are ancillary to the relevant regulations.

We suspect that our ability to construct meaningful models that characterize waterfowl population dynamics and responses to hunting always will vary dramatically among species. On the other hand, there is no waterfowl species managed in complete ignorance of its dynamics. The adaptive strategy we have described is an attempt to: (1) use the best approximation of reality to make the most appropriate management decision; and (2) concurrently improve that approximation of reality over time. This logic is applicable to species whose dynamics are understood relatively well, as well as to species about which we know very little. More specifically, management decisions must be made, regardless of the quantity or quality of available information. These decisions always are based on a model of the dynamics of a population, even if that model represents a manager's "gut feeling." We argue that by synthesizing available data, anecdotal information and expert opinion into a formal set of models (however rudimentary) and assigning weights (sometimes subjectively) to those models, we: (1) exploit the information that is available in an optimal way; (2) provide a formal framework from which to deduce the best management policy; and (3) better identify and acquire the knowledge required for improved management.

Summary and Recommendations

We suggest that managers are approaching the limits of their ability to improve waterfowl harvest management, primarily because the information needed to make better decisions is being sacrificed by the current approach to setting regulations. We propose an actively adaptive management strategy in which regulatory decisions play a dominant role in reducing uncertainty about population dynamics. The proposed strategy recognizes ''value'' in acquiring knowledge only to the extent that it contributes to the objective of optimizing harvests. To implement this strategy, managers will need: (1) a set of regulatory options, with possible constraints on their use; (2) quantifiable harvest management objectives; (3) a set of models that represent an array of meaningful hypotheses about the effects of regulations on populations; and (4) a measure of credibility (or likelihood) for each model, which can be updated regularly using information from waterfowl monitoring programs.

Adaptive optimization is an iterative process in which the harvest-management policy converges over time to one that maximizes harvest under the most appropriate model. At each time step, an optimal regulatory decision is identified based on the state of the system and the model likelihoods. In the next time step, predicted population changes from the alternative models are compared with the actual changes provided by the monitoring program. The likelihoods are increased or decreased to the extent that predicted and actual population changes correspond. These updated likelihoods then are used in setting regulations in the next cycle and the process begins again. This iterative process produces the most informative regulations when uncertainty is prevalent and produces maximum sustainable yields as uncertainty is eliminated.

We see no major obstacles to implementing this adaptive strategy, although there are a number of practical considerations. First and foremost, managers should assess the ''value'' of learning. Only when there is a high degree of uncertainty about the effects of hunting regulations on population dynamics will the merit of our proposed strategy be evident. We suggest that this almost always will be true given our current understanding of the relationship between annual regulations, survival and population growth in waterfowl. Nonetheless, careful consideration should be given to formulating the set of alternative models. There is no value in distinguishing between models which differ in their mathematical formulation or biological realism, but which suggest similar harvest strategies. We suspect that ''mechanistic'' models (i.e., those that attempt to capture the essence of biological processes) will make better candidates for model sets than so-called ''phenomenological'' models. Assuming that all model sets include a good approximation of reality, learning rates will be dependent on the quality of monitoring programs. Fortunately, a variety of high-quality monitoring plans for many duck and goose populations in North America, when used with our adaptive approach, should provide new knowledge about population dynamics and the response to hunting, and, thus, lead to improved management.

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Adaptive Management, Adaptive Science and the Effects of Forest Fragmentation on Boreal Birds in Northern Alberta.

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The circumpolar boreal forest is one of the most extensive and significant terrestrial ecosystems in the world (Shugart et al. 1992). The boreal forest region covers about 34 percent of Canada and accounts for over 75 percent of all forested land (McLaren 1990). Recently, the mixedwood portion of this region, dominated by trembling aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*), has come under pressure. Industrial innovation, fuelled by a disappearing softwood resource, has rendered these poplars economically viable sources of pulp. The province of Alberta contains over half (290,000 km^2) the total extent of this ecoregion in Canada (Rowe 1972). In less than two years (1987–88), the Alberta government leased more than 220,000 square kilometers of this forest to pulp and paper companies. There were no cost/benefit analyses, no environmental assessments and no public hearings (Nikiforuk and Struzik 1989).

Many *ex post facto* analyses of the implications of this industrial boom have followed (e.g., Samail 1988, Dancik et al. 1990, Alberta Forestry, Lands and Wildlife 1991, Navratil and Chapman 1991). A common conclusion is that the inventory of wildlife and habitat is inadequate to assess the impacts of forest harvesting and to formulate forest-wildlife management guidelines. A report on the status of wildlife in Canada (Anonymous 1991) identifies the boreal forest as one of the key national issues. Increasing public and institutional pressure is being placed on the forest industry to address these concerns.

Alberta Pacific Forest Industries (AlPac) was granted deciduous timber rights to over 61,000 square kilometers of land in northcentral Alberta and presently is completing construction of the world's largest single-line kraft mill. AlPac's annual harvesting of trees will be about 3 million cubic meters over a 1,000 square kilometer area. In its preliminary forest management plan, Alpac committed to "developing, managing and protecting the forest resource on a renewable and economic basis... (and) pursue improvements to, and minimization of impacts on, the environment" (AlPac 1992). Further, the planning and operating rules negotiated by Alberta Forestry, Lands and Wildlife and AlPac stipulate that the company will strive to "maintain viable populations of all resident wildlife species with good geographic distribution throughout the FMA (Forest Management Area)" (Alberta Energy/Forestry, Lands and Wildlife 1992, Sec. 4.2.1). With recognition of the inadequate state of knowledge and with government and industry committed to integrated resource management, there was an opportunity for pro-active research involvement and the stage was set for adaptive resource management (Walters 1986).

Implications of Proposed Forest Harvesting

The first steps in designing an adaptive resource management paradigm are to identify possible outcomes of current management practices and to demonstrate that a significant change in policy should be considered (Walters and Holling 1990). Current provincial operating rules for harvest of the mixedwood forest (Alberta Energy/Forestry, Lands and Wildlife 1992) dictate an average deciduous cutblock size that is not to exceed 40 hectares, under a two- or three-pass clear-cut harvesting system, with a projected rotation period of 40 to 70 years. Before subsequent-pass cutblocks are harvested, previously logged cutblocks must be 3 meters in height, and 10 years must have elapsed since the previous harvest. There are no provisions for retention of areas of forest older than 70 years, or greater than 10 hectares in size, except where they exist along riparian buffer strips and other limited reserve lands.

The proposed broad-scale harvesting has three predictable outcomes: (1) the forested landscape will become severely fragmented; (2) areas of older forest will become increasingly small and isolated; and (3) there will be a significant truncation in the natural age distribution of the forest. It seems unlikely, given these scenarios, that industry or the government agencies involved will be able to achieve their stated management objectives.

Theoretical Framework for Addressing Management Concerns

It is not sufficient to point an authoritative finger at a management strategy and state, in general terms, that it will not work. Rather, it is important that the predicted outcome(s) of that strategy be explicitly stated in the context of relevant ecological theory (Sinclair 1991). The effect of forest fragmentation on wildlife has been the subject of many studies (e.g., Forman et al. 1976, Harris 1984, Freemark and Merriam 1986, Vaisanen et al. 1986, Bennett 1990, Verboom and Van Apeldoorn 1990, Lamberson et al. 1992). The theoretical framework for generating hypotheses about this issue draws upon many areas of both community and population ecology. These are given succinct treatment here; for a thorough review, *see* Simberloff (1988).

At the community level, habitat fragmentation is hypothesized to increase local rates of extinction, and thus decrease the number of species in a fragment, compared with the number of species in the fragment when it was part of a larger, continuous habitat (after MacArthur and Wilson 1963, 1967). Broad-scale information on species richness also can be used to test the nested subset hypothesis (Patterson and Atmar 1986), which posits that communities are organized, and that species in a species-poor biota are a subset of those in richer biota. With habitat fragmentation, this hypothesis would be supported if species in the smallest habitat units were the most common, and rarer species were added at increasingly larger spatial scales.

In fragmented environments, where discrete patches of area are habitable and the intervening regions are not, a species population distribution will be patchy, and the set of local populations may constitute a metapopulation (Gilpin 1987). Metapopulation theory suggests that the flow of individuals between fragments is important to the genetic differentiation of the fragments, the population dynamics of each fragment and the demographic stability of the entire system (Hanski and Gilpin 1991). Several different metapopulation models are available, each one generating slightly different predictions (*see* Schoener 1991).

At the population level, the probability of extinction may be more closely examined. The MacArthur and Wilson extinction model (1967) is based on the intrinsic variation in natality and mortality in a population (Belovsky 1987). The most useful current model (Goodman 1987) considers a wider variety of influences on demography and extinction rate, such as habitat quality, environmental variation (including intra- and inter-specific competition) and the genetic composition of the population. These factors will influence local population persistence in fragments (Opdam 1991).

Finally, the role of corridors in conservation has recently received much attention (e.g., Hobbs 1992, Simberloff et al. 1992). Island biogeography theory predicts that, due to higher immigration rates, connected areas will maintain more species than unconnected areas. However, there have been few empirical studies of movement rates of animals through corridors. Hobbs (1992) suggests that width is the most important attribute of a corridor; if a corridor is too narrow, then edge effects will predominate, whereas wider corridors may provide some interior area.

Selection of Birds as "Biological Indicators"

Morrison (1986) defines a biological indicator as an organism that is strictly associated with certain environmental conditions, such that its presence is indicative of those conditions. Birds as a group, and some species in particular, are known to be sensitive to the effects of forest fragmentation (Morton 1992, Reed 1992) and have been used as indicators of forest condition in the eastern boreal forest of Canada (Welsh 1987). Neotropical migrants are thought to be particularly sensitive to fragmentation, especially in eastern deciduous forests where their numbers are declining due to loss of area and habitat, isolation effects, and edge effects (Robbins et al. 1989a, 1989b). Of particular concern are enhanced cowbird (*Molothrus*) parasitism (Brittingham and Temple 1983, Robinson 1992) and predation due to edge effects (Wilcove 1985). Cavity-nesting birds and those requiring large trees for nesting (e.g., some raptors) also may suffer from harvesting if snag or live tree retention is not adequate, because the rotation period will substantially reduce the availability of old trees. Birds are good indicators of the effects of forest fragmentation because they are ecologically versatile, function at a variety of scales, are relatively conspicuous, and census and other study methods are well-developed (Koskimies 1989). Also, they are the richest vertebrate taxa in the boreal mixedwood forest.

Research Design

We propose to investigate the effects of forest harvesting on birds in the boreal mixedwood forest and to explore options for a reserve system. We shall study community, metapopulation and population dynamics before and after experimental forest fragmentation, through modification of an existing clear-cut harvesting plan (Figure 1). The first experiment involves the creation of fragments of old mixedwood forest, 1, 10, 40 and 100 hectares in size, with a consistent rectangular shape, by isolation from adjacent forest by a clear-cut of at least 200 meters on all four sides. Each size class will be replicated three times, as determined by *a priori* power analyses. An equal number of controls (three replicates of each of the four size classes) have been established within an adjacent, continuous forested area of > 3,500 hectares which will remain unharvested.

A second experiment involves the creation of fragments connected to 100-meter wide riparian buffer strips. Replicates of the three smaller size classes (1, 10, 40 ha) will be isolated from adjacent forest by a minimum distance of 200 meters on three sides to determine whether the presence of possible travel corridors increases conservation potential. We also will assess whether these buffer strips are providing productive habitat for birds, as they will contain the few remaining areas of older forest after the second or third pass, under the current operating guidelines.

Pre-fragmentation conditions will be established in 1993. Harvesting treatments will be applied in the winter of 1993–94, and responses to treatments will be monitored in 1994 and 1995. We also will monitor bird communities in the clear-cut areas and in a 10-year-old cut-over site within the study area, to model anticipated patterns in forest habitat availability and avifauna after a second-pass harvest.

Selection of Study Area

Several criteria were set for selection of a suitable study area. First, the area had to be representative of the boreal mixedwood ecoregion (Strong and Leggat 1981). Primary

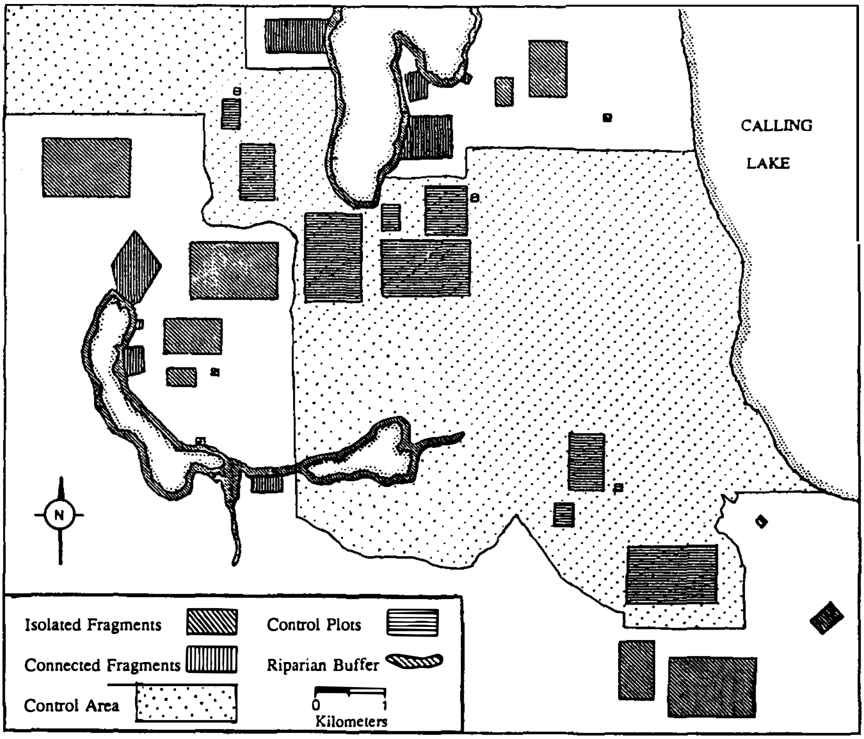

Figure 1. Experimental layout of fragmentation study.

succession in this ecoregion is dominated by trembling aspen, with lesser quantities of balsam poplar. Later succession is mainly by white spruce (*Picea glauca*), with some balsam fir (*Abies balsamea*). Jack pine (*Pinus banksiana*) communities occur on sandy sites. Black spruce (*Picea mariana*) dominates the poorly drained sites and wetlands comprise about one quarter of the region. Historically, frequent disturbances, such as fire and defoliating insect outbreaks, have been a common theme across the boreal forest and have contributed to the mosaic of stand types of different ages present today (Bonan and Shugart 1989).

Second, the area was selected for its similarity to an ongoing biodiversity study (1991–96) being conducted by the Alberta Environmental Centre (AEC). The primary objective of the AEC study is to examine the plant and animal communities of stands of differing age classes (Stelfox 1992). Twelve aspen/mixedwood stands, each a minimum of 100 hectares, have been identified by the AEC. Four young stands (average tree age 20–30 years) have high tree densities and some natural thinning. Four mature stands (average tree age 60–80 years) have closed canopies, minimal rotting of standing trees, and few snags and downed trees. The final four old stands are older than 100 years, have openings in the forest canopy, numerous snags and downed logs, a coniferous component, and a dense shrub understory. Detailed biophysical studies, including micro- and macro-climatic conditions, and monitoring of species composition of invertebrates, vertebrates, and vascular and non-vascular plants, are being undertaken in both summer and winter (Stelfox 1992).

Finally, the area had to be in a township (approximately 10 by 10 kilometers) slated for harvesting in winter 1993–94. Harvesting the boreal mixedwood forest at the scale proposed requires long-term planning for road networks and detailed inventory data on trees before harvesting plans are approved. Because AlPac's FMA is so large, these data exist for only part of the area at present (March 1993). Five townships fulfilled these criteria. Site visits and ease of access led to the selection of the Calling Lake area (55°15'N 113°19'W) in the southern portion of the boreal mixedwood ecoregion, approximately 250 kilometers north of Edmonton, Alberta (Figure 2). The study area encompasses about 120 square kilometers (12,000 ha), or just over a township.

Constraints on Experimental Design

The sizes and shapes of study plots are based on the planned harvesting operations. Forty hectares is the average anticipated cutblock size, and also the average anticipated uncut fragment size, under a two-pass clear-cut harvesting system of alternate cut and leave areas. Cutblocks will tend to be rectangular, with irregular edges, due to the current operating ground rules and physical characteristics of the boreal mixedwood region. Experimental size classes of 1, 10, 40 and 100 hectares were selected to bracket the average anticipated leave area. The ten-fold increase over the 1-, 10-, and 100-hectare plots should result in animals perceiving each size class as a different type of habitat (Hunter 1987), and it provides species/area data over three logarithmic scales. A consistent rectangular shape (1.5:1) is maintained over all study plots, to control for variation in species parameters that might be accounted for by differences in shape. One set of plots: 1, 10 and 40 hectares each replicated three times, will remain connected to 100-meter-wide buffer strips situated on two lakes and a stream. The operating ground rules for harvesting stipulate that buffer strips must be left along all permanent lakes and streams. In this case, these are strips of riparian vegetation adjacent to a water body, grading into stands

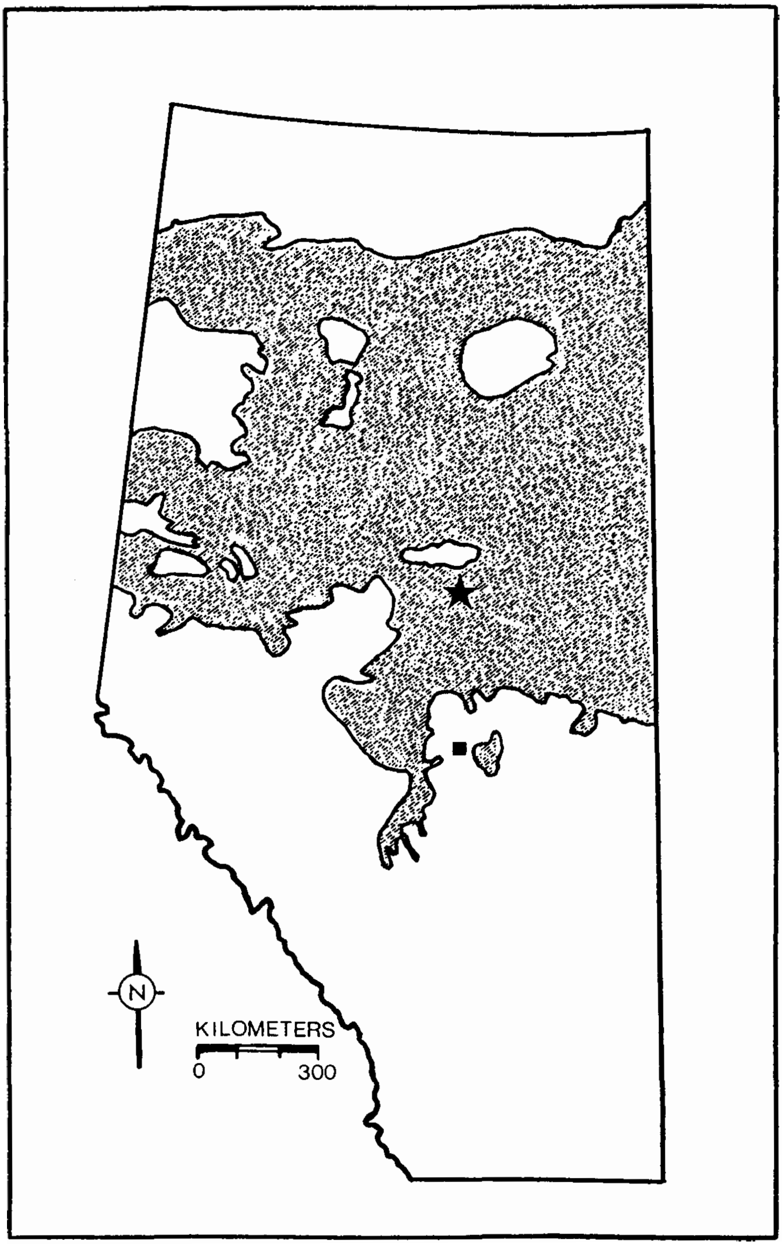

Figure 2. Location of the boreal mixedwood forest region, and the experimental fragmentation study area (★), in Alberta, Canada.

of older aspen. We were unable to find big enough areas to permit 100-hectare plots connected to riparian buffers.

Although we only will have data for experimental areas from one year before fragmentation, we expect annual variation in breeding bird diversity to be considerable (Virkkala 1991). Variation within the control areas, for which we will have three years of data, will be used to correct for stochastic environmental effects. All study plots are in old stands (80–130 years) of aspen/mixedwood in both experimental and control areas. The detail provided by the Alberta Vegetation Inventory (AVI) mapping scheme, combined with extensive ground truthing, allowed us to select sites that are similar in canopy height, canopy closure, tree species composition and understory features.

A minimum isolation distance of 200 meters for the experimental fragmentation was chosen because previous studies have demonstrated that 100 meters or less can act as barrier to bird species sensitive to forest fragmentation (Soulé et al. 1988, Bierregaard and Lovejoy 1989). We expect 200 meters of unforested habitat will act as a barrier to many forest birds in our study area. The maximum cutblock width (isolation distance) permitted by current operating rules is 400 meters, although in practice it often is much narrower. Had we chosen 400 meters as a minimum isolation distance, the experimental layout would not have been feasible. For example, one 1-hectare study plot surrounded by 200-meter cuts on all sides requires 25 hectares of forest; the same plot surrounded by 400-meter cuts would require 81 hectares of forest.

Level of Replication

It is important to consider both Type I and Type II errors when designing experiments to test for faunal collapse (Schmiegelow 1992). Power analyses were used to determine replication level by establishing "comparative detectable effect size": the maximum effect size that could go undetected when beta=alpha (i.e., equal probability of Type I and Type II error) (Rotenberry and Wiens 1985). In the context of island biogeography theory, effect size can be defined as the percentage loss of species associated with an increase in slope, *or* decrease in intercept, of the species/area regression. Estimates of variance for slopes and intercepts describing avian species/area relations (which are few and far between) over similar size ranges to those proposed here (three orders of magnitude), were obtained from the literature (Table 1). Average values were used to calculate power (beta), with alpha fixed at 0.05 when effect and sample size were varied.

Table 1. Estimates of variance for slopes and intercepts describing avian species/area relationships.

Sample size	Slope (variance)	Intercept (variance)	Source
10	0.224 (0.024)		Hatt et al. 1948
4	0.202 (0.039)		Dobson 1952
6	0.175 (0.045)		Lack 1942, 1969
8	0.322 (0.108)		Diamond 1969
15	0.286 (0.089)		Vuilleumier 1970
15	0.302 (0.085)		Vuilleumier 1970
13	0.274 (0.055)		Abbott 1973
18	0.32 (0.013)	0.75 (0.08)	Schmiegelow and Nudds 1987
10	0.12 (0.023)	1.16 (0.11)	Schmiegelow 1990
24	0.48 (0.021)	0.57 (0.022)	Schmiegelow 1990

(For slopes, average estimates of variance were calculated for sample sizes less than 10 and greater than or equal to 10.) We used two-tailed tests and PowerPack (Version 2.2) computer software.

Theory predicts that species loss due to fragmentation will be reflected in both a higher slope and a lower intercept of the species/area regression (MacArthur and Wilson 1963, 1967). Thus, for each sample size, estimates of power to detect a given effect size were averaged, allowing generation of a series of power curves (Figure 3). This analysis indicated that three replicates of each of the size classes (total sample size 12) should provide sufficient power (beta = alpha $\leq$ 0.05) to detect a 20-percent loss of species for a 50-hectare area, the mid-point along the species/area curve that will result from this study. With the usual comparison method, where only differences in slope are considered, estimates of power were substantially higher. For example, a sample size of four provides sufficient power to detect a 20-percent loss of species in a 50-hectare area. Therefore, the curves presented here were derived conservatively, and we may be able to detect much smaller effects.

Sampling Methodology

Bird Studies

Bird species richness and evenness measures will be obtained for all study areas before and after experimental fragmentation. Point count stations have been established along transect lines on a 200- by 200- meter grid. Number of point count stations is proportional to area. Summer surveys will be conducted from the last week in May until the first week in July, the peak of the breeding season (Erskine personal communication). Birds will be censused by recording all individuals seen or heard within a 50-meter radius of each station during a five minute interval between dawn and 10:00 a.m., following standards recommended by Ralph et al. (1992). A minimum of four complete surveys of each study area, each year, should provide accurate estimates of species richness and relative abundance, based on species accumulation curves for comparable habitat (Sodhi et al. in preparation). Observer and diurnal variation, as well as order of surveying, will be standardized across all areas, within each season, in each year.

Winter surveys will be conducted during February and March along the transect lines that connect point count stations. Transect counts should provide a better measure of winter bird activity than point counts due to highly variable movement patterns of birds in winter (e.g., *see* Robbins 1981). All birds seen or heard within a 50-meter strip on either side of the transect line will be recorded. Four complete surveys of each area will be completed each year. Transect length and surveying time are proportional to area.

When analyzing these data, we will distinguish between types of species, as a change in species composition could go undetected if only simple composite measures of species diversity were used. We predict that there will be immediate effects on community composition and organization as a result of fragmentation (i.e., Bierregaard and Lovejoy 1989), whereby fragmented areas will have fewer species than equivalent-sized unfragmented areas, with smaller fragments having fewer forest-interior or rare species. We also predict that isolated fragments will have fewer species than connected fragments of the same size. Finally, we predict that the bird communities in the clear-cut areas and in the very young forest (the 10-year-old cut-over area) will be different from those in older forest.

Presence/absence and relative abundance data alone can be misleading indicators of habitat quality (Van Horne 1983, Pulliam 1988, Gibbs and Faaborg 1990, Martin 1992). We expect the relative abundances of some species in recently fragmented areas to be higher than in unfragmented areas, because of displacements caused by cutting (Bierregaard and Lovejoy 1989). Such crowding may be particularly apparent for resident birds during and immediately after the winter cutting. However, we predict that birds in small fragments will have lower pairing success, higher reproductive failure and higher turnover rates than those in large fragments and continuous areas. To test these predictions, we will conduct more detailed studies to determine what mechanisms cause species loss in fragmented areas, and to distinguish "source" from "sink" areas (i.e., Pulliam 1988).

Community "productivity" in each study area will be estimated using composite measures. Species at each point count station will be classified as a possible, probable or confirmed breeder based on standard bird-atlas criteria (e.g., Semenchuk 1992). Incidence of begging calls (non-specific) will be recorded while observers are travelling between stations and any nest sites identified will be monitored throughout the breeding season. All birds captured in the mist-netting program outlined below will be sexed, aged and weighed. Tarsal length and body fat (e.g., Rogers 1991) will be measured, and each

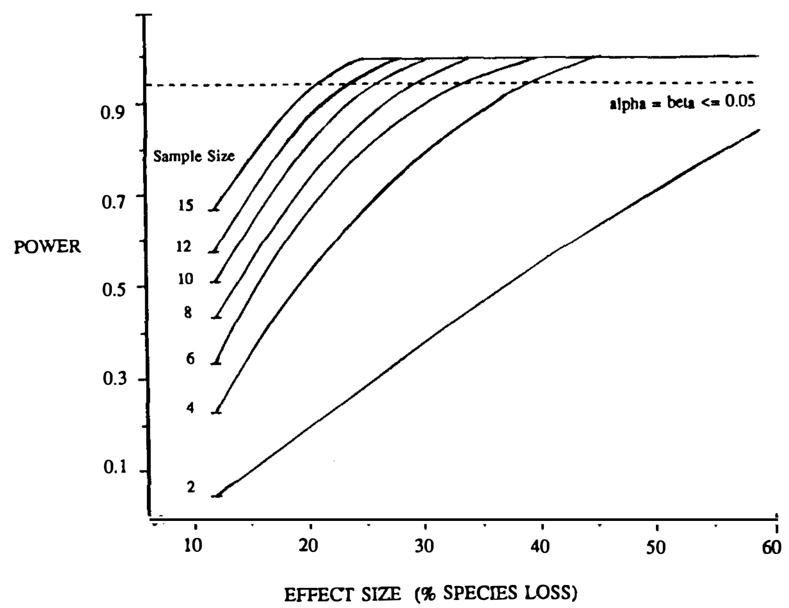

Figure 3. Power as a function of sample size over a range of effect sizes. Power calculations are based on average slope and intercept variances for avian species/area relationships (Table 1).

will be banded using a standard metal leg band. This will provide information on breeding status, adult/juvenile and sex ratios, condition, and turnover rates of individuals.

Movement patterns of birds within the breeding season will be documented through mist-netting and observational studies. Prior to harvesting, movement rates between adjacent areas of old forest, and between old forest and very young forest will be measured. After harvesting, we will continue to measure these rates as well as rates across the newly created interfaces of old forest/clear-cut and young forest/clear-cut. We predict that movement rates of all forest species will be lower across clear-cut areas than forested areas and that, for canopy species, these rates will remain low across areas of young forest. Movement patterns of birds through the riparian buffer strips and productivity in these areas will similarly be determined. This information will be used to assess whether these corridors are important for breeding and dispersal, or if they are ecological traps.

We also will collect more intensive data at the population level on four types of key species: Neotropical migrants (negatively affected by forest fragmentation in other areas); corvids (nest predators) and cowbirds (nest parasites) (species that may benefit from fragmentation); a resident cavity nester (a species that requires older aspen); and small raptors (accipiters and small owls) that require mature aspen for nesting and that may respond to fragmentation on a larger scale. All studies will be conducted before, during and after harvesting.

Habitat Assessment

We will consider three levels of habitat patchiness, as suggested by Kotliar and Wiens (1990). Structural and compositional aspects of habitat will be measured at each song station to determine if local habitat heterogeneity affects species composition. These measurements include: canopy cover and height; tree species, density and diameter at breast height (dbh); shrub species, density and height; and height, density and species composition of the herbaceous vegetation. As well, the number and composition of stands, and the proportion of coniferous vegetation in each study area will be measured from AVI maps, aerial photographs, and by ground surveys, as a measure of fragment heterogeneity. Finally, the spatial context of each fragment will be assessed using characteristics of neighbouring areas (i.e., *see* Lauga and Joachim 1992) as a measure of landscape heterogeneity.

Discussion

The boreal forest is naturally patchy due to small, stand-level disturbances such as individual tree-fall gaps and medium- to large-scale disturbances such as insect outbreaks and fires. Very little is known about bird communities in these successional mosaics (Raivio 1992). Existing research primarily has been in coniferous forests in Europe (e.g., Haila et al. 1987, Raivio and Haila 1990). Species inhabiting such spatially and temporally patchy environments might be adapted to natural fragmentation, and might not be as susceptible to the effects of harvesting-induced fragmentation as has been demonstrated elsewhere (i.e., in the tropics and in eastern deciduous forests). The answer to this may depend on spatial and temporal scale (Fahrig 1992) and on the degree to which clear-cutting mimics natural disturbance in initiating secondary succession (Hunter 1992).

Forest fragmentation, by commercial logging or other land uses, not only reduces forested area, but also simultaneously increases the area of other habitats (Rolstad 1991). The important question with respect to the effects of forest fragmentation is not whether smaller areas have fewer species than larger areas; that is one of the few universal laws of ecology. Rather, we must ask: (1) whether forest fragments have fewer species per unit area than when they were part of a larger, continuous forested area; (2) whether there has been a non-random loss of species with respect to area, whereby rarer species are found only in larger fragments; and (3) whether there is a spatial (area threshold or context) or temporal (frequency of disturbance) scale at which these phenomena are no longer apparent. Further, the mechanisms responsible for such patterns must be investigated if our objective is to ameliorate negative effects by modifying management.

We designed this project to enable us to explore both pattern and process in response of forest birds to fragmentation. It is similar conceptually to the Biological Dynamics of Forest Fragments project (Minimum Critical Size of Ecosystems) in the Amazonian tropical rainforest (Lovejoy and Oren 1981), although, at this stage our project is much narrower in scope. However, we are not aware of any comparable experimental research efforts in temperate forests. The principal guiding force is to provide information that can be used to direct management decisions in the boreal mixedwood forest. To this end, we are collaborating with other research initiatives. These projects include the biodiversity study conducted by the Alberta Environmental Centre (Stelfox 1992), and the development of a spatial model of landscape-level dynamics, and a suitable GIS user-interface, by Burton et al. (1992) at the University of British Columbia.

Research and management need not be alternative processes (Sinclair 1991). Communication with representatives of industry (Alberta Pacific Forest Industries) and with representatives of the government agencies charged with responsibility for management (Alberta Forestry, Lands and Wildlife), from the inception of this project, was key to the successful adoption of this experimental design. The presentation of the power analyses provided a "powerful" tool for establishing the need for a carefully controlled and replicated management experiment that far exceeded what is considered acceptable under the current operating ground rules. We encourage researchers to publish estimates of variance so that such analyses can be routinely performed. Numerous meetings and exchanges fostered understanding and compromise on all sides. We do not suggest that this particular experiment, at the scale or in the short time frame proposed here, will provide all the answers about the effects of broad-scale forest harvesting on wildlife that are required to develop a comprehensive management plan. Nevertheless, we feel that it will make two major contributions. First, it will generate information that can be applied to some very immediate issues and will provide a baseline for longer-term studies within the established experimental framework. Second, the interchange between researchers, resource users and decision-makers now established can be expanded to encompass future experimental management projects.

Management of the western boreal forest is at a crossroad. Traditional forest harvesting is likely to result in the environmental degradation and social fall-out symptomatic of other intensively managed forest systems (Holling et al. 1986). However, there is a real opportunity, at this early stage in the development of the industry, to incorporate public and ecological concerns into policy options that will lead to a greater understanding of the dynamics of the system and will promote both social and environmental objectives (Walters and Holling 1990). That is the key to adaptive management (Walters 1986), the principle on which this research is founded.

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Experimental Evaluation of Forest Management: The Missouri Ozark Forest Ecosystem Project

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Calls for new directions and approaches to natural resource science are becoming more prevalent in the literature. Several directives, while not necessarily new, seem to be clearly mandated. Among these are: the adoption of a framework of deductive methodology whereby management actions are treated and evaluated as experiments (Nudds and Morrison 1991); a shift from individual-investigator studies to multi-disciplinary studies (Levin 1992) that foster the merger of the physical, social, biological and natural resource sciences (National Research Council [NRC] 1990, Kessler et al. 1992); and a recognition of the need to build closer ties, or partnerships, between natural resource sciences and managers and policy makers (NRC 1990, Sinclair 1991, Hilborn 1992).

The call for change is being championed by a wide array of participants. The Wildlife Society has, through special sessions at the North American Wildlife and Natural Resources Conference and a special section in *The Journal of Wildlife Management*, provided the opportunity for individual scientists to express their convictions on science, its relationship to management and its future direction. The National Research Council report, *Forestry Research: A Mandate for Change* (NRC 1990), recommends future research emphasis on studies that include the merger of forestry research with other natural and social sciences. The Sustainable Biosphere Initiative is an effort by the Ecological Society of America to define ecological research priorities and foster partnerships with decision makers (Lubchenco et al. 1991, Levin 1992). The USDA Forest Service, in their report, *Strategy for the '90s*, calls for greater involvement in interdisciplinary systems research directed toward the understanding of how ecosystems are affected by patterns of resource use (USDA Forest Service 1990). Clearly, the need for change, and some of the mechanisms for achieving change, have been identified. Application of these mechanisms at the state agency level, however, remains largely an uncharted course. We believe that if management as experiment is to be widely adopted and implemented within the natural resource professions, state agencies must play a major role.

The objective of this paper is to chronicle our experience as a state natural resource management agency in the development and application of a long-term ecological research project that is a management experiment. We emphasize those aspects (i.e., interdisciplinary coordination, experimental design, and integration of management and research) that we believe relate to the mandates now confronting our profession. We also discuss how we dealt with project development, spatial and temporal constraints, and administrative concerns. Our experiences should serve as a blueprint from which others may benefit and improve upon.

MOFEP—An Overview

The Missouri Ozark Forest Ecosystem Project (MOFEP) was initiated by the Missouri Department of Conservation's (MDC) Forestry and Wildlife Research staffs in 1990 as a long-term, manipulative experiment to study the effects of forest management, as typically practiced on MDC lands, on plants and animals of the Ozark forest. Responsible management of the forest community necessitates planning for the needs of all indigenous forest species and consideration of the diverse desires of forest users. A broader understanding of the effects of timber management therefore is critical if resource managers are to succeed in this goal.

To date, most forest wildlife studies in Missouri and in the Midwest primarily have relied on correlational or observational information to examine species/habitat relationships at the forest stand level. Although these studies provided valuable insights and may be used to construct hypotheses, experiments are required to test these hypotheses and measure the effects of forest manipulation. State-owned forest lands in Missouri typically are managed in compartments that are 250–400 hectares in size. The MOFEP study was designed to examine the effects of three silvicultural treatments (even-aged, uneven-aged, non-manipulative) on selected biotic and abiotic characteristics at the compartment level. Experimental design includes a pre-treatment data collection period and involves three randomly assigned replicates of the three treatments on nine experimental units (compartments) ranging in size from 300 to 450 hectares.

Current studies within MOFEP investigate the effects of forest manipulation at the compartment scale on: (1) composition and spatial distribution of woody vegetation; (2) herbaceous plant species diversity; (3) forest bird diversity and productivity; and (4) oak (*Quercus* spp.) mast production. Associated studies, being conducted at a smaller scale (e.g., stand-level) include: (1) density and diversity of small mammals; (2) density and diversity of reptiles and amphibians; (3) site productivity; (4) water movement and quality; (5) tree canopy invertebrates; (6) forest litter invertebrates; (7) genetic diversity in selected woody plants; and (8) sulphur cycling. A study of public perceptions of management practices is in the planning phase, and options for integration and funding of other tangential studies continually are being evaluated.

Project Inception

The ontogeny of the MOFEP project was unique for MDC. Historically, MDC research projects fall into the form of two- to three-year graduate student projects or multi-year (2–10) staff-conducted research examining single questions usually related to single species. We constrained our thinking and our research options by only considering these traditional approaches for wildlife research. Expanding the research process beyond these traditional approaches was a result of the synergism of several factors.

Research

The catalyst for MOFEP was a proposal to study productivity and nest predation/ parasitism rates among select neotropical migrant birds in the Missouri Ozarks. The design proposed to the MDC Wildlife Research staff was typical of previous research, utilizing a short-term correlational approach and being conducted as a graduate research study. Specifically, we wondered if temporary openings in the forest canopy created by forest management would produce edge-related effects and what ramifications these might have for forest birds. As a result of discussions among Wildlife Research staff during a review of the project proposal, an experimental approach was proposed. Previous discussion among our staff of issues raised by Romesburg (1981, 1991), MacNab (1983), Walters and Holling (1990), and others formed the basis for the critical thinking that allowed us to evolve toward suggesting larger-scale experiments and experimental evaluation of management programs. Rather than implement the correlational study, we decided to develop, over the next fiscal year, a more extensive, experimental study for budget consideration. This decision was made with the knowledge that such a study would be large scale, long term, and expensive. In essence, we decided not to limit ourselves in the design of the project based on funding, but rather to determine the design needed to test the desired hypotheses and then decide if the costs were worth the expected benefits.

Equally important, an atmosphere existed that stimulated individual creativity. Within our research section, biologists primarily are responsible for research direction within their programs. Projects are not usually assigned to staff through an administrative process. Individual biologists are expected to be abreast of the variety of issues relating to their programs (e.g., management, administrative, populations, public concerns), prioritize research needs and design research studies. Thus, few limitations are placed on creative thinking.

The key element, however, was communication. The MDC wildlife research project review process (Torgerson and Sheriff 1985), developed in the mid-1980s, formalizes communication among staff. This process enhanced discussion and communication regarding individual research projects and agency research direction, and provided for formal communication among management and research staff. In addition, we were able to work closely on project development with the Forestry Research staff. Without the time and mandate to work as a collective MDC staff, we may never have evolved in the direction necessary to attempt this large-scale management experiment.

Administration

The latitude provided MDC researchers in program development established the climate necessary for inception of long-term management experiments. However, an equally essential aspect of project inception was a clearly mandated direction from Administration. Within MDC, such direction is provided through an agency-level strategic plan and division-level operational plans. These documents identified the need for interdisciplinary research, expanded research efforts and broader community/ecosystem studies. Thus, MOFEP was conceived with clearly mandated direction from Administration and administrative support for initiating a long-term project. Such support is vital to successful implementation of innovative programs. Setting and communicating priorities (Walters and Holling 1990) is a major challenge because agency administrators deal with a much greater list of management and research opportunities than fiscal resources allow. Administrators must decide which projects to fund, and it is a major step to fund a project costing millions of dollars with no assurance as to when and how the benefits will be realized. Implementation of a project must involve faith, commitment, optimism and vision on the part of the administration.

Our experiences suggest that project coordinators must tell it like it is: provide your best estimate of the expected benefits of the project and when these benefits will come. Be clear about the life of the project. Long-term research should be defined as long term, not as a series of short-term studies. Provide the administration with the best cost estimates over the life of the project. Look for opportunities to cooperate among divisions and disciplines within and among agencies. Also, look for opportunities to consolidate many research and information needs into one large integrated project which will increase efficiency and the value of research. Finally, explore sources for funding outside the agency.

Administrators also must be made aware of the potential secondary benefits of long-term studies, and they must be made aware of project progress. We found formal tours of study sites, both for Administration and the Missouri Conservation Commission, to be an excellent method for enhanced communication.

Project Development

The desire to integrate other studies under the MOFEP umbrella led us to request input not only from within the MDC but from other natural resource management and research agencies. A series of 17 formal and numerous informal discussions were held during the period 1989–1990 to identify opportunities and priorities for forest-wildlife research in Missouri. These meetings primarily involved personnel from the Wildlife and Forestry Research and Management Sections of the MDC; the University of Missouri—Columbia (UMC); and the USDA Forest Service, North Central Forest Experiment Station (NCFES). Neotropical migrant bird issues, the effects of forest management on overstory and understory vegetation, and community-level responses of both plants and animals to silvicultural systems, particularly the recently adopted practice of uneven-aged silviculture, were the highest priority issues identified through this process.

Wildlife Research staff worked with the research staff of the MDC Forestry Division to institute a multidisciplinary approach to design the experiment. Ongoing forest management activities would provide an opportunity to experimentally test the effects of forest manipulation on other aspects of the forest ecosystem in addition to the bird community. Given that the treatments would need to be applied over a large area to derive reasonable estimates of bird population parameters, a multidisciplinary approach and the incorporation of other studies into our design were viewed as cost-effective measures. In other words, it seemed neither logical nor practical for each research entity within the MDC to develop separate, large-scale management experiments. In addition, we believe the benefits of the experimental approach, having a functional understanding of the impacts of forest management based on cause and effect, will be cheaper in the long run.

Leadership responsibilities for the various studies were assigned by area of expertise within MDC. The effort initially focused on concerns over testing the effects of typical forest management practices on population parameters of selected neotropical migrant forest bird species. The two major silvicultural systems used on state lands in the Missouri Ozarks and non-manipulative management were defined as treatments. Based on existing data (Thompson et al. 1992), the forest bird study needed study sites at least

300 hectares in size, in order to have adequate (≥30) samples of breeding males and nests for each species. In addition, forest management decisions on state lands in Missouri are made on similarly sized areas, designated as management compartments. These two factors dictated initial consideration of study area size. To determine what magnitude of difference we might be able to detect between breeding bird densities, we used the data of Thompson et al. (1992) to conduct power analyses (Snedecor and Cochran 1967: 113–114). Coefficients of variation for breeding bird densities ranged from about 40 to 100 percent. We found that with $P' = 0.80$, $\alpha = 0.10$, and $n=3$ for each treatment we could detect an 80-percent difference with a coefficient variation (CV) of 40 percent and only a 200 percent difference with a CV of 100 percent.

Data were not available for other variables of interest so no other power analyses were conducted. However, we plan to conduct power analyses and report power when results are published (Peterman 1990).

The design also defined the desired pre-treatment forest conditions. Potential study sites were defined as blocks of closed-canopy Ozark upland forest that had no timber harvests over the past 20 years. Potential study sites on state-owned land in the Ozark region then were surveyed. Despite more than 32,000 hectares of state forest land in this region, we were able to identify only 10 potential study compartments. Most other compartments were eliminated from consideration because of management activity (timber harvest) during the past 20 years. Therefore, on state lands, we were constrained to three replicates of each treatment. We considered adding study sites on USDA Forest Service and National Park Service lands in the region, but budgetary estimates indicated that it probably would not be feasible to exceed a total of nine study sites. Additional concerns over a lack of long-term control of management applications on federal lands also were considered in our decision to conduct the study on MDC-owned land.

Partnerships

All resource agencies are faced with fiscal limitations. The costs of conducting management experiments, especially large-scale experiments, should be allocated between both research and management. In addition, cooperative efforts with other resource agencies can serve as a means of distributing costs and enhancing outputs.

Managers and researchers are working as partners in the design and application of MOFEP. Initially, input from managers was a part of the process of defining research priorities. Land managers have been responsible for various tasks during the initial phase of the project, such as delineating timber stands, assisting with the development of stand-level prescriptions, providing logistics and functioning as a liaison between researchers and local communities when needed. In addition, managers will be responsible for the implementation of all treatments including the marking and sale of timber. These activities required managers to re-evaluate their work priorities as the study was developed and to integrate the needs of MOFEP with other job duties. This process was able to function smoothly due to the open communication among staff and the support of supervisors and Division Chiefs. As one might expect, this meant that some activities would be delayed and others removed from work plans to accomplish the goals of the study. However, given that managers viewed themselves as equally responsible for the evaluation of forest management practices, the shift in work objectives was accommodated with few exceptions.

An excellent example of partnerships that resulted from interagency collaboration is the MOFEP summer internship program conducted by the University of Missouri—

Columbia. The logistics of collecting data for the forest bird study were complex and potentially overwhelming. To determine bird densities, reproductive success, and nest predation and parasitism rates, a small army of 27–30 people was needed. We simply could have hired that many field workers, but we again saw an opportunity to go beyond the normal way of doing research in our state. University of Missouri—Columbia staff already was involved in designing the project, so we devised an innovative approach through which both agencies benefitted. The largest pool of potential workers was college students looking for summer employment and career-related experience. Through a summer internship program, we have been able to attract students from around the U. S., provide a learning experience that also enhances their degree programs, and collect the data we need.

Aside from the direct involvement of other resource agencies in project initiation, two other approaches were employed to involve other scientists/disciplines as partners in the study. The first was to solicit individuals through grant opportunities in select areas. For example, research on soil characteristics and hydrology were identified as needs that had to be addressed through outside expertise. Therefore, grants were offered to outside researchers to address these questions. This is one process to involve other researchers in the project, but application obviously is limited by budgetary constraints.

The second approach was to inform other scientists of the MOFEP study with the hopes that they would see opportunities to become involved with independent sources of funds. Options employed included presentation of poster papers at select national and regional meetings; the development of a one-day, in-state meeting to acquaint scientists with the scope and design of the study; and soliciting input through one-on-one contacts. These efforts have resulted in notoriety for the study and a few tangential studies. For example, research through the NCFES to investigate movements and habitat use by brown-headed cowbirds (*Molothrus ater*) is being conducted in part on MOFEP study areas, where we will be able to provide corresponding cowbird density estimates.

Design Considerations

Why an Experiment?

Wildlife and forestry studies can be divided into three basic conceptual designs: descriptive, correlational, and manipulative or experimental (White and Garrott 1990:14–16). Given the controversial nature of forest management practices as they impact wildlife populations, we decided to use the manipulative or experimental approach as the basis for determining the *effect* of forest management on the forest community of the Missouri Ozarks. By determining cause and effect, any impacts or benefits that might be measured during this study could be attributed to the forest management practices.

There were definite trade-offs in making this decision. A correlational study could have been conducted in a shorter time period and at less expense. However, the trade-off essentially was in terms of reliability. Using a correlational approach, one would not know that the results were caused by treatments and, therefore, recommendations from the research would be applied with greater uncertainty, and the findings could easily be disputed. Taking an experimental approach was deemed the best use of agency resources given the desired outputs.

Why this Statistical Design?

The selection of a manipulative or experimental approach for MOFEP appears to be a logical and obvious one, given that our goal is to attempt to show cause and effect relationships among forest management practices and their impacts on other biotic and abiotic components within the forest ecosystem. Many options exist that could have been used in the design of MOFEP. We selected a randomized block design (Cochran and Cox 1957) with pre- and post-treatment measures. Alternative designs include regression procedures (Draper and Smith 1966), and completely random or incomplete block designs (Cochran and Cox 1957). One of the benefits of the randomized block design we selected is that it will allow us to eliminate the variation due to differences among blocks (block effects) during data analysis. The selected design also includes replication, at least spatially. Replication and randomization (Hurlbert 1984, Eberhardt and Thomas 1991) are what sets MOFEP apart from other studies of this type in the oak-hickory forest regions of the United States. Instead of collecting data from areas scheduled for timber harvest and comparing these data to those from areas where timber harvest is not scheduled, the main goal of MOFEP, from a statistical view, is to replicate the treatments and assign them to compartments at random. However, the design allows the forest manager to prescribe specific timber harvest treatments at the stand level.

Disadvantages of the MOFEP Design

From the experimental design standpoint, one of MOFEP's biggest disadvantages is low statistical power of the design (Toft and Shea 1983, Hurlbert 1984, Peterman 1990). Because we have only three replicates for each treatment, the differences among treatments must be very large in comparison to the measurement error within compartments before a statistically significant difference can be detected. In some cases, researchers in the field may see a biological difference among treatments even though their data do not indicate a statistical difference (Tacha et al. 1982). As is true for every experiment, we need to be aware that even though we may not disprove our null hypothesis of equivalence for a variable, this does not mean that the alternative hypothesis is not true. In this case, forest management practices may impact the system in some positive or negative manner, even though we cannot disprove the null hypothesis that there is no effect.

The potential of not rejecting a null hypothesis when, in fact, there is an effect due to treatment (Type II error) is a major issue concerning MOFEP. The importance of knowing the probability of detecting a difference if it exists can not be cast aside as irrelevant (Toft and Shea 1983, Peterman 1990, Simberloff 1990, Toft 1990). As a solution to the problem of low statistical power due to the small number of replications, we suggest an $\alpha = 0.10$ or 0.15 probability of committing a Type I error (rejecting the null hypothesis when it is true) be selected rather than the usual $\alpha = 0.05$. Our willingness to increase the probability of committing a Type I error to increase the power of the experiment is based on our belief that the consequences of basing decisions on an experiment in which a Type II error has been made are more serious. Ideally, we would like to increase the number of replications to decrease the probability of both Type I and II errors. However, because only 10 study sites met our criteria, the number of replications cannot be increased.

Another disadvantage of the MOFEP design is the small number of compartments available for study, which makes it impossible to replicate the treatments temporally. In other words, the initial treatment (cutting of trees) will be applied in all compartments in the same year. There are not enough compartments to apply timber harvest to sets of compartments over several years under a replicated design. In addition, due to the small number of blocks and compartments, this design easily can be affected by catastrophic events, such as wildfire, tornado, etc.

Project Implementation

Outside Concerns

We found that doing a large-scale research project produced its own set of problems. Agency personnel and the local community have to be informed and continually updated to promote understanding and keep misinformation about the project to a minimum. Local and regional media can be allies in the effort through news releases, tours and personal contacts. Publics with interests in environmental affairs should be sought out and informed about the purpose and limitations of the project through presentations, tours and invitations to seminars/meetings. All of these efforts will pay dividends by engendering support and minimizing opposition to the project.

Secondary Benefits

Long-term studies have the potential to provide many secondary benefits. We stress the term *potential* because the degree to which these opportunities are capitalized on will greatly influence the overall benefits derived from the study. Interpretation and application of preliminary information provide numerous short-term benefits. To cite only a few examples from MOFEP: we have identified additional locations of rare and endangered flora, developed estimates of the proportion of overstory trees containing dens and cavities, and developed estimates of nest parasitism rates for neotropical migrant birds. This secondary information has been applied to management decisions and used to construct hypotheses for further study.

Secondary benefits also come in the form of public relations opportunities. A definite benefit has been the education of a diverse group of publics on forest management issues. Continual attention has been drawn to the subject of forest management through agency news releases and outside publications. The publicity most often has been positive rather than the more typical, reactionary response that occurs after negative or biased articles are published. An additional, secondary public relations benefit has been enhanced dialogue between resource managers and resource user groups.

Lastly, the benefits of working more closely in an interdisciplinary setting has spawned additional cooperative and collaborative research. While we cannot quantify the impacts of these secondary benefits, we believe their cumulative benefit to the agency equals if not exceeds the ultimate value of the hypothesis tests that are the formal basis of the study.

Conclusions

The Process

The major challenge that remains before us, in relation to MOFEP, is to keep communication a dynamic process among all parties; researchers, managers, administrators, agencies and publics. We anticipate devoting considerable effort to achieving this. Another dynamic process is project design and evaluation. Whereas we selected the "best" approach given our objectives and constraints, the analyses of pre-treatment data will assist us in more realistically evaluating the potential to fulfill those objectives. We fully expect modifications in design as we learn more about the systems under study. Through our experiences in MOFEP, we have become even more dedicated to both integrated research efforts and the concept of management as experiment. However, in our view, MOFEP is atypical because management as experiment often will not involve expensive, large-scale efforts. Therefore, it is imperative that the scope of MOFEP be considered independent of the need to embrace a management as experiment philosophy.

Is One MOFEP Enough?

Although we, as an agency, have begun to embrace the concept of management as experiment, we have yet to fully realize that treating management as experiment is, in essence, a call for a massive change in the philosophy of applied wildlife science: a paradigm shift. Our experience with MOFEP may help foster that change. However, we believe that the most critical aspect of our work, and yet the one that receives the least attention, is the underlying philosophy that we must learn from our management actions and that learning will occur only if we experimentally monitor and evaluate the effects of management actions.

Evaluating and learning from our management actions are fundamental responsibilities of the profession, and we currently devote too little attention and resources to them (Hilborn 1992). In this context, experimental evaluation of management practices and systems, such as the MOFEP study, must not remain an anomaly, but must become the standard approach to assessing the outcomes of management actions.

If state agencies or other natural resource management entities are to adopt management as experiment as a fundamental way of business, then the divergent pathways of research and management (Sinclair 1991) must move toward common ground. This challenge is not new. Implementing the necessary changes, however, will take farsighted leadership and time.

The typical state agency research staff has a myriad of responsibilities: population surveys, habitat surveys, user-group attitude surveys, technique evaluations, species and community-level studies, etc., in addition to primary accountability for evaluating the effects of management actions and alternatives on populations, species and habitats. This is not to say that the wildlife management staff are not equally overburdened. Yet, management budgets, which typically are much greater than research budgets, seldom are applied to the evaluation of management practices, particularly experimental evaluations. The point we wish to stress is that, within our profession, those who apply management practices to the land are seldom given the time (resources) or the responsibility to ensure that the desired outcome (habitat condition, population response, etc.) is achieved. All too often, success is measured in the number of units (acres) treated, not in whether the desired result is achieved. This fundamental lack of an evaluation and monitoring strategy circumvents much of the potential to learn from our management actions.

Only through a merger of research and management activities, in which wildlife managers serve as principals in the effort to monitor and evaluate, can we expect to make significant progress. Expanding the role of managers as participants in the design and implementation of management experiments, while maintaining other functions, will require a full agency commitment. For most wildlife and natural resource agencies, increased funding is not likely in the short term. Therefore, adopting an experimental approach to management could result in a reduction in traditional outputs, particularly within management. Even if this is the case, we believe the trade-off is worthwhile. The alternative of continuing to manage without monitoring and evaluation, without a plan to learn from what we do, does little to serve our profession or the natural resources we manage.

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Initial Experiences with Adaptive Resource Management for Determining Appropriate Antlerless Elk Harvest Rates in Idaho

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As a preamble, let me reiterate that managers are facing increasing demands to produce quantitative predictions of population responses to disturbances, such as harvesting. Prediction requires some sort of model, whose development is annoying but challenging.
C. J. Walters (1986)

Introduction

We have started an antlerless elk (*Cervus elaphus*) management program in Idaho that uses (1) some underlying principles of experimental design to evaluate current management, alternatives, and underlying assumptions about ecological and socioeconomic processes (Romesburg 1981, MacNab 1983, Hurlbert 1984); and (2) simple modeling exercises to clarify functional relationships, formulate alternative hypotheses, and ultimately predict harvest effects (Walters 1986, Mangel and Clark 1988). Our goal is to develop a number of models that will provide increasingly accurate and precise predictions about the effects of alternative management actions.

Idaho Elk Populations and Harvest Structure

Elk populations, harvest, and hunter numbers in Idaho are at an all time high (Unsworth 1991, Kuck and Nelson 1992, Nelson 1992). In 1991, an estimated 24,100 elk were legally harvested by rifle, archery and muzzleloader hunters, whereas in 1982 and 1972 the legal harvest was estimated at 11,550 and 9,300, respectively. High-quality habitat and a conservative approach to antlerless elk harvest have contributed to the growth of herds (Unsworth 1991).

Elk are hunted in 83 of Idaho's 99 Game Management Units. Units vary in management strategies and goals, and, thus, in harvest structure. General seasons (unlimited hunter participation) and controlled hunts (by controlled numbers of permits) are offered in most units, with various elk sex and age, weapon, and season timing and length restrictions. Much of Idaho's current elk management centers around meeting target population levels and bull:cow ratios, while providing a variety of hunting opportunities and experiences (Unsworth 1991).

Antlerless elk harvest opportunities occur in the form of general either-sex seasons in northern Idaho, antlerless controlled hunts throughout the remainder of the state and occasional depredation hunts wherever necessary (Unsworth 1991). In 1992, antlerless controlled-hunt permits were offered in 69 Game Management Units. The number of antlerless controlled-hunt permits (hereafter, "permits") offered has increased greatly over the last two decades and even more recently. Approximately 17,250 permits were sold in 1992, resulting in an estimated 7,814 antlerless animals harvested; 12,350 permits were sold and 6,813 animals were harvested in 1991. This compares with 1,655 permits sold in 1982 and none in 1972 (Kuck and Nelson 1992, Nelson 1992).

Antlerless Elk Management Goals

Antlerless elk harvest has a place in Idaho elk management now, and in all probability, in the future. Idaho has a broad and varied sportsmen base, and there is a demand for antlerless elk hunting opportunities. Many people want a chance to hunt for antlerless elk, and the meat they provide is an important reason for hunting (Unsworth 1991, Kuck and Nelson 1992).

Also, in Idaho antlerless elk harvest is closely tied to bull elk management. Increasing antlerless elk hunting opportunities may lessen the demand for large harvests of bull elk by satisfying those hunters that would be just as happy to harvest a cow or calf elk. And just as importantly, harvests of antlerless elk impact production and recruitment, and thus influence our ability to manage for sustainable yields of both bulls and cows.

Crop depredation by elk is becoming a major problem facing wildlife managers in some areas. In addition to providing significant hunting opportunities, harvest of antlerless elk is one tool managers use to reduce agricultural crop depredation (Unsworth 1991).

Antlerless elk hunting also generates a substantial revenue for the Department of Fish and Game and provides the major means to keep elk herds within the carrying capacity of the land. These multiple objectives require tradeoffs and a more thorough understanding of harvest effects than was previously necessary.

Determining Antlerless Elk Harvest Rates

Idaho's approach to antlerless elk harvest rates in the past was conservative, for several reasons. First, in many areas of the state, wildlife managers were attempting to increase population sizes and ranges. This occurred because public demand was high and much suitable but unoccupied habitat was available. Second, even where the goal was to reduce or stabilize herd size, population estimates were relatively imprecise, and confidence intervals around estimates were lacking. Thus, many managers attempted to err on the conservative side when setting permit levels. Only recently has there been a method of obtaining relatively accurate estimates of elk population size, and sex and age class composition with confidence intervals (Samuel et al. 1987, Unsworth et al. 1990). Thirdly, uncontrolled, general either-sex seasons over much of the state until the 1970s were followed by declining elk numbers in the mid-1970s. Thus, wildlife managers have been hesitant to harvest large numbers of antlerless elk. And last, despite the fact that harvest is one of the most important tools for managing elk populations (Mohler and

Toweill 1982), our understanding of the influence of cow elk harvest on elk population dynamics and distribution is rather imprecise. We still do not know what antlerless elk harvest rates are necessary to achieve desired management goals.

Few good studies have evaluated harvest effects under real-world or realistic circumstances, with at least some degree of experimental control and replication, so that causality and environmental variation can be established. Further, elk productivity and natural mortality can vary from region to region and over time, and it is unknown how these interact with antlerless elk harvest rates and affect population size and composition (Mohler and Toweill 1982, Taber et al. 1982).

In the past, determining the appropriate number of permits for particular Game Management Units has been based primarily on recent herd trends (e.g., 1–5 years) in relation to permit levels. Managers vary widely in their use of population and harvest data in computing permit numbers. There often also is a qualitative consideration of past winter and summer weather, and socioeconomic factors (e.g., crop depredation, local politics). Most managers assume harvest mortality is additive rather than compensatory with respect to natural mortality, but are less unanimous in their thinking about the relationship between harvest mortality and production and/or recruitment. Local management experience plays a major role in calculating permit numbers. In the end, arguments like "the population seems to be growing and our goal is to stabilize the herd, so let's bump up the number of permits by 25 or 50" usually win the day. This is entirely understandable because, until recently, managers have not had the information to be much more formal than this. The tools to monitor population change and composition were not in place, and confidence in harvest information for some Game Management Units was lacking. Currently, reasonably accurate and precise estimates of elk populations and harvests are attainable (Samuel et al. 1987, Kuck and Nelson 1992, Nelson 1992).

Methods

Recently, we began an attempt to provide for continued antlerless elk harvest *while also* investigating the impact of antlerless harvest on reaching management goals and how to obtain desired harvest rates. We decided to do this experimentally, on a large scale (MacNab 1983).

Alternative Hypotheses

We started with the general proposition that Idaho elk herds exhibit one or both of the two major, and familiar, population dynamics. This proposition results in three general, simplistic models.

One of these models (hypotheses) we call the "completely compensatory model," where hunting mortality is wholly compensated by decreased natural mortality and/or increased productivity so that population change is slight. This implies that either or both productivity and natural mortality rates are sensitive to population density.

The second model we call the "completely additive model," where hunting mortality is wholly additive; i.e., natural mortality is insensitive to population density and thus is added to harvest mortality so that a greater percentage of elk die than under the completely compensatory model.

Finally, we have a "threshold model," where beyond some unknown, but nontrivial, threshold mortality rate, hunting mortality is wholly additive. Below the threshold, hunting mortality is wholly compensated by other dynamic factors.

Preliminary research in northern and northcentral Idaho has indicated that cow elk survival rates in populations with an either-sex general season and those with a "light" Native American harvest are at or above 0.88 (Leptich and Zager 1991, Unsworth et al. 1993). Thus, we initially hypothesize that if a threshold for harvest effects exists, it occurs at a mortality rate of about 0.12 (12 percent). We consider this a minimum because it does not consider the compensation that could be contributed by increased productivity and/or recruitment.

Modeling Exercises and Problem Bounding

Initially constructing a number of simple age-structured, deterministic simulation models helped clarify what possible population responses to different harvest rates we could expect, and if differences would likely be measurable over time using our current elk survey methodology.

We now are developing a number of simple, dynamic balance models (Walters 1986, Mangel and Clark 1988), which should add more realism to our investigations by allowing, for example, stochastic weather and predation events to influence recruitment, and hunter success rates to be tied to weather, hunter effort and elk density, among other factors. This process has helped identify important assumptions about a number of functional relationships and potential variations on our three major models. Key variables and parameters identified as being potentially important in modeling this system are shown in Figure 1.

These components can be somewhat arbitrarily divided into those related to the dynamics of elk herds and those related to the dynamics of the harvest system, with obvious linkages. Our inclination has thus been to initially develop two separate modeling efforts; one that has as its major problem predicting harvest rate effects, and the other predicting hunter success. We are obtaining initial parameter estimates from published literature sources, department reports and analyses of historical data from Idaho for modeling harvest effects. We hope to greatly improve on these parameter estimates by using data from our deliberate probing experiments. Predicting hunter success is mainly an empirical problem and we are beginning analyses of historical data.

Management by Experiment Design

In 1992 we began managing antlerless elk harvest by experiment with 11 Game Management Units across Idaho (Figure 2). These units were chosen because they represent Idaho's moderate-to-good elk ranges (yet still are regionally representative); with few exceptions, and so far as is known, they contain elk populations whose changes in abundance are dominated by processes other than immigration and emigration; and they have fewer conflicts than other units between our management experiment and other regional elk management plans.

We originally attempted to randomly assign a control, low or high harvest rate to each Game Management Unit included in the management experiment. However, random assignment of treatment level was not entirely possible because of conflicts in some units with other management goals. We attempted to obtain geographic clusters across Idaho, each with control, low and high harvest rate Game Management Units. Control units were assigned 2–5 percent harvest of the number of adult cows expected in the pre-hunting season population, based on the latest population surveys. Low harvest units were assigned 6–10 percent harvest of the expected number of cows; high harvest units were assigned more than 14 percent harvest of cows (Table 1). We hope to add more units to this design in the future, particularly at even higher harvest rates.

The size and composition of elk populations in these units were estimated before implementing treatments and will continue to be estimated by helicopter surveys every other year after treatment (Samual et al. 1987, Kuck and Nelson 1992). These estimates include 90 percent confidence intervals.

Permit levels assigned to each unit were calculated on the basis of desired harvest rate, estimated number of cow elk in the unit population and hunter success rate in the previous two years. We will attempt to maintain the same harvest rate in a unit each year

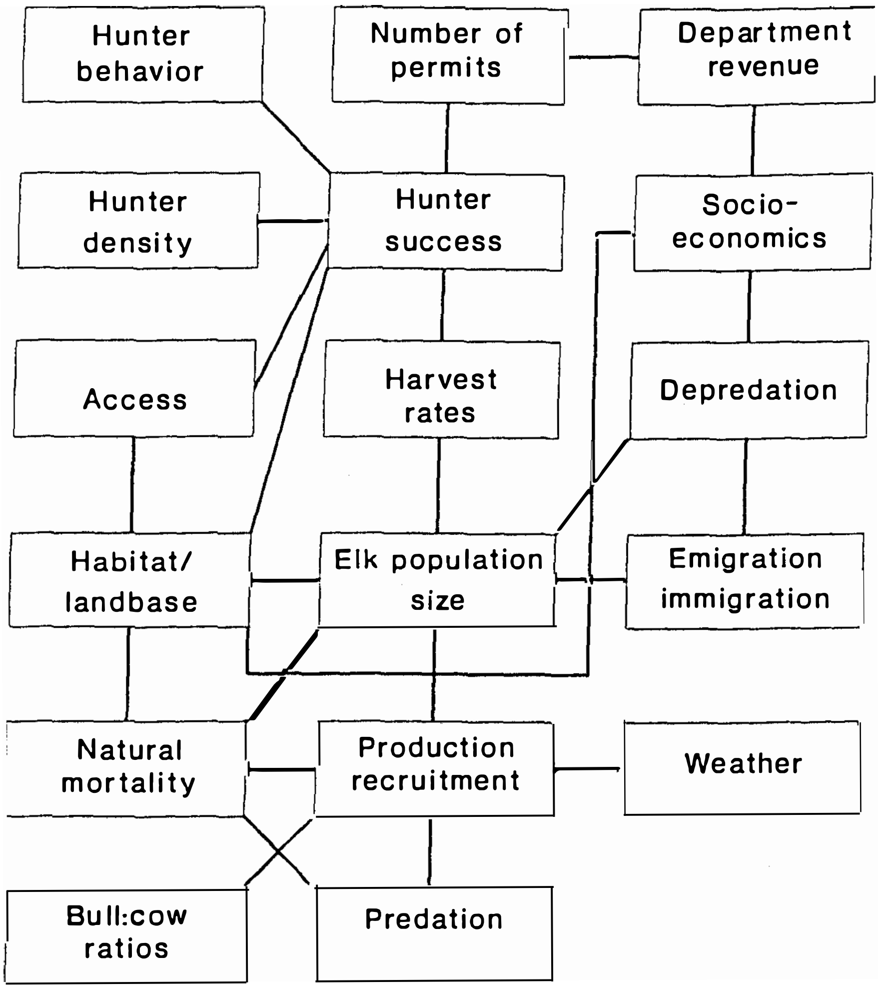

Figure 1. Functional relationships in our elk management system that influence appropriate antlerless elk harvest rates and permit numbers.

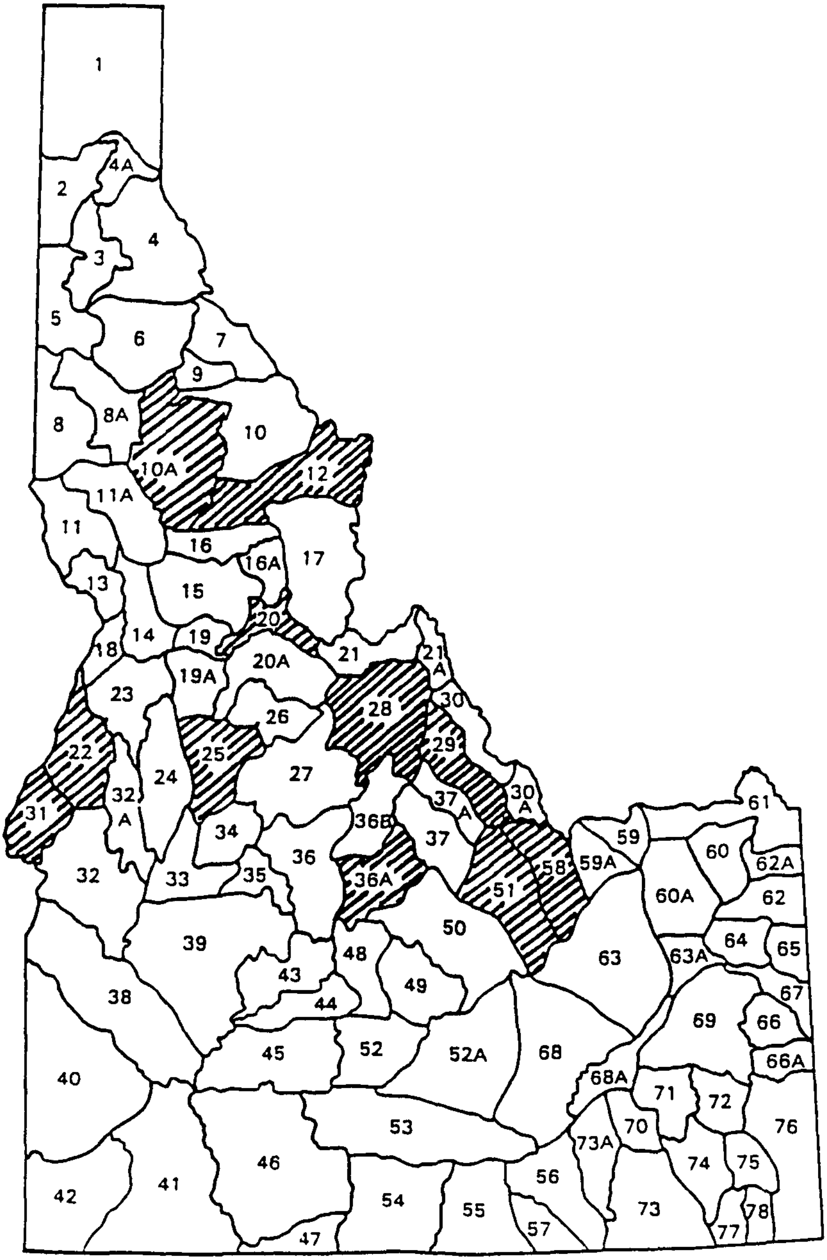

Figure 2. Game Management Units included in our antlerless elk management experiment (diagonally lined units).

from 1992–1996. This may necessitate changing the numbers of permits available to hunters.

We are estimating harvest rates by telephone survey (Nelson 1992). This survey samples controlled hunt permit holders to obtain estimates of hunter harvest, success and effort. We increased sampling effort for the units included in the study in an attempt to provide harvest estimates with 90 percent bounds of ±10 percent or less.

Results and Discussion

We are taking a different approach to managing antlerless elk harvest than is perhaps typical. We are doing this because we are uncertain of the precise effects of our current harvest rates. The usual lack of adequate controls and replicates in the past precludes unambiguous conclusions about the effectiveness of much of our antlerless elk management program. We want to change this and start systematically acquiring knowledge about the system as we manage it.

Our approach also is a bit different than the typical research study. However, we want a general predictive model that can be used statewide, which necessitates its development under the full range of environmental and socioeconomic conditions in which elk management will be conducted. We do not feel that a detailed research study of one or two areas could provide this. We hope our approach, an attempt to use some of the recommendations of Romesburg (1981) and MacNab (1983) and principles of Adaptive Resource Management (Waters 1986), allows us at once both to meet general management goals and acquire more reliable knowledge of our elk management system.

Is Management by Experiment a Paradox?

One major challenge we encountered early on is the quite understandable reluctance of wildlife managers to allow complete randomization in assigning treatment levels (har-

Table 1. Antlerless elk management by experiment on 11 Game Management Units in Idaho, 1992–1996.

Unit	Estimated adult female population	Adult females per square mile (km^2)	Attempted percentage harvest each year	Number permits 1992
Control units				
28	2054	1.53 (0.59)	2	150
20	876	1.84 (0.71)	3	150
25	780	0.83 (0.32)	3	100
Low harvest units				
12	2539	2.10 (0.81)	7	150
51	588	0.62 (0.24)	7	100
36A	1384	1.97 (0.76)	7	300
10A	3757	2.74 (1.06)	10	950
High harvest units				
31	1313	2.18 (0.84)	17	400
58	738	1.19 (0.46)	21	250
29	469	0.62 (0.24)	23	200
22	1164	1.35 (0.52)	28	650

vest) to Game Management Units. In some cases, obtaining randomized treatment levels became an exercise in negotiation with managers, and for some units included in our sample, randomization lost out! However, randomization is crucial to experimental and statistical procedures; without it, all sorts of difficulties, particularly with respect to treatment bias and uncertain Type I and II probabilities, are created.

We examined a number of potential treatment biases by investigating the pre-treatment relationships between attempted harvest rate and adult cow elk density, and between attempted harvest rate and calf:cow ratios. Neither correlation was significant ($P > 0.10$). After the 1992 hunting season harvest estimates were available, we again looked at potential bias between treatment level and cow density, and calf/cow ratios. Again, neither correlation was significant ($P > 0.10$). Thus, treatment bias appears at first glance reasonably small, probably because managers operate rather independently. Other potential biases are under investigation.

Our tentative conclusion from this initial experience is that, in all likelihood, investigating and dealing with pre-treatment bias will be an important part of applied management by experiment. After all, management, by definition, operates nonrandomly. We are looking for methods to both avoid bias and deal with it once it has been recognized, without losing the structure of our experiments. We hope that as our adaptive management proceeds, managers will be more likely to appreciate the necessity of randomized treatment, and in the interest of confidence in management effects and inevitably better management, insist on it. This will take education.

Getting the Required Harvest

A problem directly related to treatment bias, because of nonrandomization, is our ability (or inability) to obtain target harvest rates. Key uncertainties in the controlled-hunt harvesting process include the number of permits that sell and hunter success. Uncertain hunter success influences our ability to obtain unbiased treatments and thus, implement appropriate harvest rates. It also ultimately affects our ability to predict future elk herd behavior.

Historical variation in hunter success appears high. In 1992, hunter success rates across all antlerless controlled hunts in Idaho averaged 0.46 (range = 0.20–1.00). In 1991, success rates averaged 0.51 (range = 0.12–1.00). For 8 of the 11 units included in our management experiment, the difference in hunter success between 1991 and 1992 averaged 0.16 (SD = 0.15, range = 0.03–0.41). We hope this high variability will work to our advantage in learning what major factors contribute to hunter success rates.

Our initial inability to obtain harvest rates close to targets is particularly disquieting. The mean difference between target harvest rates and 1992 actual estimates was 0.05 (SD = 0.03; range = 0.02–0.13). Now we are left with the problem of deciding whether to continue our attempt to obtain initial targets or alter target harvest rates to reflect our first hunting season.

Monitoring for Management versus Research

Although Idaho now has the methodology to obtain relatively accurate and precise estimates of elk harvest (Nelson 1992), and elk population size and composition (Samuel et al. 1987, Kuck and Nelson 1992), obtaining frequent estimates is costly.

Already, because of budget considerations, helicopter surveys in some of our experimental units are at risk. Statewide elk population surveys typically have been conducted every fourth rather than every third year in individual units. Monitoring elk populations more frequently is not a trivial effort. With our current design, population monitoring will require 25–46 percent more survey time than normally would be the case.

Thus, we have learned that it is, *perhaps*, better generally to live within the typical monitoring scheme (scale, frequency, etc.) of management than to expect that monitoring be either more precise or frequent, as for many traditional research purposes. This seems to us, in part, ultimately a financial question, but also an applied one. For if more intensive monitoring is obtained for the "learning" phases of our program, will it not then be necessary during the "management" phases? Because monitoring costs are large for the scale on which typical management operates, it is likely that if adaptive management programs do not live within these bounds, there will always be a breakdown in experimental design or sample sizes. We do not, however, want to give the impression that more precise and accurate methods of monitoring generally are not needed. Indeed, at the level of detail that our elk management is headed, we consider our current ability to accurately and precisely estimate populations and harvest a necessity. Our point simply is that for effective adaptive management programs we often do not need the level of detail found in many intensive basic research efforts.

Limitation on Mechanisms

Although we should be able to detect if compensation is occurring in our experimental elk units in relation to harvest rate, and at what threshold, it is unlikely with our current design that we will be able to say, for example, that compensation is associated with decreased natural cow mortality. Determining what mechanisms are responsible for compensation would require estimating productivity or recruitment, natural mortality, and immigration/emigration simultaneously. This is one possible direction we may take in the future in our adaptive management process. For our initial purposes, however, it is enough to know what level of compensation may occur under a particular set of environmental circumstances (e.g., weather, habitat, etc.). Thus, we think it initially will be sufficient to understand what factors covary with compensation in order to predict how much will occur.

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Registered Attendance

ALABAMA

Jim Armstrong, Shaliah Armstrong, Frank Boyd, Wayne Goble, David C. Hayden, Gena Latham, Jeff Lathan, H. Lee Stribling, Leigh Ann Stribling

ALASKA

Raymond C. Altop, Michael A. Barton, David Benton, Jack Capp, Cleve Cowles, Rocky Holmes, Junior D. Kerns, Nicki McCabe, Thomas R. McCabe, Jerome Montague, John Payne, Wayne Regelin, John A. Sandor, John Schoen, James S. Sedinger, Christian A. Smith, Ronald J. Somerville, Ken Spiers, Walter Stieglitz, Dennis Tol, Lynn Wallen, Kenneth J. Wilson

ARIZONA

Christine G. Bates, Ted Cordery, Carolyn Engel-Wilson, Rich Etchberger, Deborah M. Finch, William F. Grossi, Natasha C. Kline, Carol L. Krausman, Paul R. Krausman, Bryan Morrill, Valerie Morrill, Jerome J. Pratt, Charles Pregler, Bill Radtkey, Duane L. Schroufe, Linda Schroufe, Bruce D. Taubert, A. H. Underhill, Elizabeth T. Woodin, D. D. Wyatt

ARKANSAS

Ron Byrns, Clyde P. Gates, Tony Melchiors, Clark Reames, Sharon Rushton, Milo J. Shult, Irene S. Vansandt, Robert J. Wilson, Steve N. Wilson

CALIFORNIA

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