TRANSACTIONS
of the
Forty-ninth North American
Wildlife and Natural Resources
Conference

Conference Theme:

Society's Responsibilities in Fish and Wildlife Management

March 23–28, 1984
The Boston Park Plaza Hotel
Boston, Massachusetts

Edited by
Kenneth Sabol

Published by the
Wildlife Management Institute
Washington, D.C.
1984

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

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

Printed in
U.S.A.

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Strengthening Natural Resource Stewardship and Management

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Opening Remarks

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

Good morning, ladies and gentlemen. Welcome to the 49th North American Wildlife and Natural Resources Conference.

It is fitting that we meet this year in this historic state and city. Every school child knows the story of Plymouth Rock and of the Pilgrims who sought and ultimately gained personal freedom to create and maintain a way of life unavailable to them in their native lands. By that initial step and others that followed, those colonists enlarged the course of world history. Even a rowdy tea party figured in their doings.

Then as now, opportunity is ever-present for those who will grasp it. And opportunity confronts conservation and environmental interests in a special way this year. In the United States, we have the quadrennial turmoil involved in electing a President, one-third of the Senate and all of the House of Representatives. There is much action at the state level, too. At no other time are those who seek to lead our nation so attentive to society's concerns. And a matter of grave national concern is the even-handed management of natural resources and the protection and maintenance of the environment that so adequately supported the nation's founders and their successors to this day.

At short range, there is urgent need to ease the funding restrictions placed selectively on already inadequately funded resource management programs. For programs of some resource agencies, next year's budget requests are partly fiction, because they are based on anticipated income from authorizations yet to be requested from or approved by Congress. Do away with those optimistic predictions, and the agencies end up with less money than they have now.

National policies and programs for timber harvest, grazing, mining, energy development, and water and wetlands must be protected where they are sound, and brought to heel where they are not. Wildlife refuges, parks and recreation areas, wild and scenic rivers, and other special properties in the national systems must be protected and propely maintained. Much remains to be done to round out the nation's wilderness system. And it is past time to move directly against the problems of air quality and acid precipitation.

In recent years, policy, regulatory, and budget emphasis clearly has favored resource use. Agencies charged with maintaining the productivity of this nation's lands have found it increasingly difficult to plan, guide and monitor resource development on anywhere near a balanced basis. Less funding, loss of manpower, and abrupt regulatory and policy realignment create formidable obstacles.

There can be a significant difference between an administration that is business-oriented and one that is businesslike. It is possible to blend the two, and sometimes with considerable benefit. But an administration that merely is business-oriented poses grave risk of overcommitting our nation's resource capital. Some resource areas—particularly soil, water, and air—are being sorely tested today.

But there have been some changes in recent months, and one only can hope that they are harbingers of a more sensitive and ready response to these serious environmental problems. They should be encouraged.

We have a full and interesting morning ahead of us. So it is with great pleasure that I turn this Opening Session over to David C. Knapp, the president of the University of Massachusetts. Assisting Dr. Knapp as vice chairman of the session is C. D. Besadny, secretary of the Wisconsin Department of Natural Resources and president of the International Association of Fish and Wildlife Agencies.

Canada's Natural Resource Management Programs and Needs

The Honorable Charles L. Caccia
Minister of the Environment
Environment Canada,
Ottawa, Ontario

All life depends upon ecological processes such as the nutrient cycle in soil, water, plants and animals, or in the fertilization and cleansing of water. Therefore, when careless human acttivity impedes these ecological processes, both wildlife *and* human life will be correspondingly limited. For example, summer fallowing, the practice of leaving fields bare of vegetation, is causing certain soils in the Canadian prairies to become so salty that they can no longer be used for crops and can only support a very few species of wild plants.

In a nation like Canada, whose whole economic future depends on sustained renewable development, environmental and economic issues cannot be separated. The maintenance of our wildlife species depends on the preservation of healthy ecosystems; so does the preservation of our forests. Thus, in Canada, the overriding environmental issues of our times—acid rain, managing toxic chemcials, maintaining the purity and integrity of our soil and water—are also wildlife and economic issues.

Let's consider other habitats under pressure in Canada today. Wetlands are among the most productive ecosystems in the world. They have great economic, recreational, scientific and aesthetic value. Canada is losing its southern wetlands at an alarming rate. For too long wetlands have been considered wastelands and have been drained, filled, dyked or dredged for the purposes of urban, agricultural, industrial and recreational development. Yet the factors that lead to the destruction of wetlands are complex, and are beyond the powers of the wildlife manager alone to address.

Forestry is Canada's most important economic activity. There is no doubt we need the raw materials, the jobs and the foreign exchange that our forests provide, yet intensive logging has resulted in changes to vast tracts of land. Clear cutting may well increase forage for deer. But imagine the effect it must have on birds and other wildlife species. Steep slope logging can destroy soils and ruin fish habitat through increased run-off.

Another example of habitat destruction is our prairie grain belt. While it is of great importance to North America and the world, no one will ever again see the ecosystem of the grassland that existed there before the white man's settlement.

Of great risk to all habitat in eastern Canada and the United States is the phenomenon known as acid rain. While studies are still at an early stage, links have been established between acid deposition and damage to many members of the animal kingdom.

Direct and strong effects have been demonstrated on many aquatic ecosystem species, mainly on fish and amphibians. The effects of acidification of surface waters on fish populations such as salmon, brook trout, lake trout and bass, have been well documented, especially in five areas of intensive research: the Adirondacks region of New York, the Lacloche Mountain region of Ontario, Nova Scotia, Southern Norway and Southern Sweden.

For example, in the Lacloche Mountain region 24 percent of 68 lakes surveyed contained no fish and 56 percent of these lakes are known or suspected to have had reductions in fish species composition. And, in Southern Norway, of almost 3,000 lakes surveyed since 1940, more than 50 percent of the original brown trout populations have been lost, and two-thirds of these cases have been correlated with acidity.

Embryos and larvae of amphibians are also very sensitive to acid deposition. Many species of frogs, toads, and salamanders breed in shallow hilltop ponds formed from a mixture of meltwater and spring rains, both of which can be very acidic. Toads, for example, are terrestrial as adults, but are affected by acidity during the larval and embryo stages in the ponds. In Sweden, the common toad was not found in areas where pH levels were below 4.2.

Acid deposition is also affecting birds by altering the availability and quality of their food. Disruption of the normal food chain may in turn change traditional nesting or breeding patterns and modify distribution of aquatic bird populations. In Scandinavia, it has been reported that fish-eating birds such as mergansers and loons no longer frequent acidified lakes where fish stocks have decreased. Swedish researchers have found a negative correlation between the acidity of water bodies and the diversity of the bird species that depend on open waters.

The diet of the common loon is approximately 80 percent fish. The range of the loon includes areas of Canada's precambrian shield and the Adirondack Mountains which are sensitive to acidic deposition.

If acid rain goes unchecked, it could become one of the greatest threats to wildlife in North America and other industrialized regions of the world. By causing damage to our lakes, rivers, and forests, acid rain not only threatens our wildlife, but our fishing, forestry, and tourism industries as well.

That is why, last week I met in Ottawa with Ministers of Environment from nine European countries and signed with them an agreement to reduce sulphur emissions by 30 percent by 1993.

Canada is prepared to go even further. Earlier this month the provincial Ministers of Environment and I agreed to reduce Canada's sulphur emissions by 50 percent by 1994.

We fully realize, however, that our efforts alone are insufficient. Over half of the acid rain falling in my country has its origins in your country. And conversely, a significant proportion of the acid rain which falls here comes from Canada. So our interests are intertwined. Clearly, only an effort by both Canada and the United States has any hope of removing the threat that acid rain poses to our environment, our economy, and our society.

Contemporary interest in wildlife goes far beyond the preoccupations of government agencies in the past: hunting and trapping, or the enjoyment of wildlife in parks. Today, wildlife managers, environmentalists, businessmen, government officials and everyday people increasingly recognize the importance of linking environmental, economic, and social issues. We are beginning to recognize and to act upon the basis of the interdependence of living resources and the elements of the environment.

The ultimate goal of wildlife policy is, it seems to me, to maintain the health of ecosystems upon which both wildlife and people depend. The Canadian Wildlife Service is working to attain this ultimate goal, through the maintenance and protection of wildlife habitats across our country.

In addition to Canada's extensive system of national and provincial parks, there are now 39 sites known specifically as national wildlife areas. Initially, the emphasis was on preserving migratory bird habitats. Now, however, the focus has shifted to better protect the habitat of *all* wildlife in these areas. But ecosystem preservation and management is beyond the capabilities of government alone, given that almost every conceivable human social and economic activity can have an impact upon the biosphere.

Canada is trying to address the need for an overall and cooperative approach, one which is capable of harnessing the skills and energies of people outside government. The Wildlife Habitat Canada Foundation, established in February 1984, will bring government and non-government groups together in a common initiative with a common goal. The Foundation will be a new tool to help complement traditional wildlife management programs. It will provide expertise and planning to bring together all those who can contribute to preserving habitat. Canadians hope that this new approach will help fill the gaps between traditional fragmented conservation efforts.

It is also encouraging to see increasing activities at the international level. Wildlife managers from different countries are beginning to work closely together, since wildlife does not respect national boundaries any more than pollutants do. Canada and the United States are working toward the resolution of three items of priority on our mutual agenda:

1. agreement on the management of the Porcupine caribou herd,
2. a North American waterfowl management plan, and
3. completion of the subsistence hunting protocol to the migratory birds convention.

On the Porcupine caribou herd, we are close to an agreement in Canada between three native groups and the three governments involved. With this Canadian agreement in place, we will reopen discussions with our American friends on an agreement between the two countries.

Preliminary discussions between officials of our two governments are already under way on the North American waterfowl management plan, with the intention of producing a first draft by September of this year. I am pleased with the positive approach being taken and am confident we will continue to show good progress. To complete action on the protocol to the migratory birds convention, both countries are developing the details of its interpretation and implementation, which will be incorporated into an agreement.

Canada and the United States have been cooperating in efforts to manage migratory birds since 1917. Canada has been painstakingly and at great expense carrying out a program to help re-establish the peregrine falcon, a magnificent bird of prey that has been devastated by modern pesticides.

Even as we nurture and release new stocks of peregrines, we find that they are still accumulating DDT—a substance whose use has been greatly reduced in Canada and the United States for many years. The reason seems to be that DDT is still used in many countries south of the United States, and on their migrations the falcons feed on prey that has been contaminated by the substance. The case of the peregrine falcon illustrates the need for hemispheric and even global wildlife cooperation.

The world conservation strategy is a pragmatic framework that applies to developed, as well as to developing nations. The strategies main goals are:

—maintenance of essential ecological processes and life-support systems;
—preservation of genetic diversity;
—sustainable use of species and ecosystems.

Canada has endorsed the strategy, and our Department of Environment has drawn up a list of twenty-two recommended actions to be taken in our country to carry it out. The world conservation strategy is a declaration of principle, of humanity's resolve to save its only biosphere. It is a national and international program for action on a variety of fronts:

1. stronger, more comprehensive international conservation law, and increased development assistance of living resource conservation;
2. international programs to promote the action necessary to conserve tropical forests and drylands, to protect areas essential for the preservation of genetic resources, and to conserve the global "commons"—the open ocean, the atmosphere, and the polar regions;
3. regional strategies to advance the conservation of shared living resources, particularly with respect to international river basins and seas.

If we are to continue to take practical steps to solve our environmental problems on a habitat and ecosystem basis, wildlife managers will have a bewildering amount of work to do, in the years to come, in areas far beyond the traditional.

The Wildlife Habitat Canada Foundation and the B.C. Forestry and Wildlife Management Symposium to be held at the University of British Columbia on May 7–10 this year, give strong hints of what this work might entail.

For example, wildlife managers will have to examine carefully the impact of various economic factors, such as municipal tax structures and government drainage grants, which lead landowners to destroy wildlife habitat. Methods will have to be found to minimize such undesirable, and sometimes unnecessary impacts.

Certainly there should be discussions between wildlife managers and the forest industry, and representatives of agriculture and fisheries. In the future, wildlife management will mean more than buying up acreage for preserves, or putting more game officers in the field. It will entail closer cooperation among all in society to prevent the damage to the environment caused by human activity.

And it is inescapable that in the future, wildlife management will have to come to grips with questions of increasing importance to the public . . . fundamental questions that strike at the very heart of our relationship with nature and the animals that share our environment.

For example, there are those who would question the advisability of mere mortals attempting to take over from nature the infinitely complex job of managing wildlife in the first place. Historically, we have dealt with what we would call an imbalance by reducing the numbers of one species or another. We increase game herds by reducing the number of animals that would be predators.

This radical surgery approach to treating the symptoms of an unhealthy, imbalanced wildlife population is clearly insufficient. It has led to grave mistakes including, for example, the disappearance altogether of wolves from regions of Europe. If we are to be in the wildlife management business at all, we will have to learn from nature's holistic approach.

And if we are to manage wildlife and their environments, with what goals should we do so? Should our society endeavour to protect endangered species, from the blue whale to the snail darter? In what numbers should animal populations be maintained? Enough to ensure survival of the species in its natural environment, or should we also allow for recreational hunting, in addition to the established need for commercial hunting?

What is the future of consumptive use of wildlife? Are we witnessing a trend towards non-consumptive use? Or is it a trend towards non-use of wildlife, in other words, a view of wildlife as being more than just a resource for benefit of humans? Is the ethic of man's dominance over the environment changing? Having abolished slavery only in the last century, having entered the age of acceptance of the idea of equal opportunity between man and woman only recently, have we reached a stage in our development when we are ready to question man's right to manage and control the species inhabiting the earth?

The changes posed to wildlife managers by these and other questions under discussion at this conference are great. The responsibility, enormous. For in the hands of wildlife managers is the stewardship of not just a dozen species of game animals, but as you well know, entire ecosystems. And not just in one country, or even in one continent, but around the world.

All of us here today are all too familiar with the quantity, variety and intensity of human activities that threaten those ecosystems we seek to protect. It gives one cause to wonder if it is not man, instead of wildlife, who is in need of management.

It is true that, if man were not present, the ecosystem and the wildlife would take care of themselves. But we are present. And we are dominant. And we must ask ourselves how we can best apply the brain that has put us in this advantaged position for the benefit of all life on this planet.

Address by the Secretary of the Interior

The Honorable William Clark
Secretary of the Interior
Washington, D.C.

It's a pleasure for me to be with you this morning and to have a part in the longest-running and probably most distinguished series of conservation meetings in America. And I'm especially pleased to join you for a conference that's headlined "Society's Responsibilities in Fish and Wildlife Management."

I can't think of a more appropriate theme for this kind of meeting. And I know the President agrees. In fact, he asked me to bring you his warmest greetings and his regrets that a schedule conflict made it impossible for him to be here himself. He also asked me to remind you that he shares your concern about fish and wildlife. As he put it in the State of the Union Address back in January, conservation "is not a liberal or a conservative issue, it's common sense."

That happens to be my view as well, and I'm sure it's also your view. Most importantly, it's the view of the American people. There's no question that the preservation of natural resources and their careful use are issues that transcend political, economic, or regional differences. We all value the natural treasures of this land.

That's not to say we have no differences about how those resources might best be managed. But it does suggest that we can resolve our differences through cooperation and genuine bipartisanship, so that everyone who is interested can be involved.

I have followed that basic approach since taking my desk at the Department just a few months ago. Obviously, I don't expect that everyone will agree with every decision we make. But I can promise that decisions will be made openly and in consultation with the States, with the Congress, with interested groups, with industry, with science, and with individuals. The conservation issues we're facing as a society do not lend themselves to one-sided solutions. And I don't intend to try resolving them on my own. I need your help and the help of other concerned and informed Americans.

But by the same token, let's remember that cooperation is a two-way street. Goodwill must be met by goodwill; nonpartisanship in the Department, by nonpartisanship in the private sector; a policy of openness, by a sense of responsibility on the part of our critics.

A policy of cooperation also requires that people resort to litigation only as a last resort. That hasn't been the case in recent years. In fact, as a lawyer and as a judge with twelve years on the bench, I'm deeply concerned over the tendency these days to litigate so many issues. The judicial system was simply not designed, nor is it presently equipped, to handle the volume of cases or the kind of conflicting demands that are being placed upon it. Litigation is expensive for everyone, including society as a whole. It's time-consuming. And the very nature of the judicial process frequently creates an "either/or" situation, limiting executive discretion, and preventing us from reaching solutions that could benefit all parties at a much earlier stage.

It appears that Alexis de Tocqueville was right when he predicted 150 years ago that the law in America would become a "secular religion," and that "sooner or later every important political question would be turned into a matter for law and litigation." Wouldn't it be better to have the Executive Branch of Government bring competing interests together more often, to develop policies and procedures that could satisfy the legitimate concerns of everyone involved? I think the United States Supreme Court would agree. In a recent case on offshore leasing, the Court stated: "Collaboration among State and Federal agencies is certainly preferable to confrontation in or out of the courts."

At Interior, we've found that negotiation can be helpful in resolving all kinds of difficult problems, ranging from land exchanges in Washington State, to fishing rights in Michigan, and complex questions on Indian water rights. In fact, on this last issue, we have something like 50 major cases pending, one of them, believe it or not, dating back to 1915! Through negotiation, we're trying to get this backlog cleared up.

Of course, mediation is not our only answer to disagreement. Certainly, I'm not going to allow the Department to back away from litigation where I think principle is at issue. But I intend to see negotiation and mediation used to their utmost at Interior.

As you may know, the Department's Solicitor, Bill Coldiron, heavily involved in negotiation, has resigned to return to private life. As replacement, I'm bringing in a colleague of many, many years on the California State Supreme Court, Frank Richardson. Two months ago, Frank thought he had retired from public life. But instead, thanks to his tremendous sense of public duty, he'll soon be joining us in Washington. And when he arrives, his most important priority will be to review the 4,000 cases that we have at Interior. In the process, I think he'll find himself playing the judge again, as I have done myself on a number of occasions since becoming Secretary. In any event, it's my hope that we'll be able to get the caseload down.

Of course, that will still leave those policy issues within the Department that are not so much matters of formal debate and litigation as they are questions of good judgment and the common sense that President Reagan emphasizes. Take the management of open lands, for example. No one disputes their value to our society. There is universal agreement that open space, wildlife, and natural habitat are an important part of our national heritage. But their management must be considered, as always, in light of budgetary constraints, alternative uses, competing needs, and again that commodity called common sense.

To a large extent, these conflicting concerns are addressed by the budget that the Department recommends each year to Congress. It's a policy paper, really. And I'm satisfied that the budget that we've just proposed for 1985 does just that. We've asked Congress for a budget that's responsible, yet which will allow us to maintain important progress in our efforts to improve our parks, expand our wildlife lands, and protect the environment.

For example, our budget for the Fish and Wildlife Service includes nearly $58 million for new acquisitions. That would include $30 million for wildlife refuges, $20 million for additional wetlands that will also become National Wildlife Refuges, and $7.5 million in matching grants to support State wetland programs. Altogether, that's $15 million more than was appropriated for 1984, and it will add roughly 66,000 acres to our refuge system, with a special emphasis on salvaging critical wetland areas.

At the same time, we've asked Congress for $100 million for acquisitions by the Park Service, not to add new units to the existing system, but to continue rounding out existing units and to purchase private inholdings within the parks. The emphasis is on improving the parks we already have. With regard to parks, I recently made a decision that should put many minds at rest about plans for Grand Canyon National Park. I'm talking about proposals to build a high dam and hydroelectric plant at Bridge Canyon. Those ideas have been around for 40 years, and I thought it was about time we made it clear that there would be no projects that would threaten the Grand Canyon. As a result, 350,000 acres have now been returned to the Park Service and another 130,000 acres to the Hualapai Indians.

As part of the '85 budget request, we've also asked Congress to appropriate $257 million for the Park Restoration and Improvement Program. PRIP, as it's called, is a five-year, one-billion-dollar program to perform badly needed repairs and improvements in our national parks. For too long, we've neglected the maintenance of our parks, and if Congress goes along with our request, we'll have the job essentially done, a year ahead of schedule!

Our '85 budget also recommends immediate action to neutralize the effects of acid rain on fish and wildlife habitats. The Fish and Wildlife Service will work with States to restore surface waters that have been damaged. We've asked Congress to appropriate $6 million for this effort in fiscal 1985.

We also requested an increase of $1.2 million to support monitoring and research activities to measure effects of other contaminants. If appropriated, that will enable the Fish and Wildlife Service to identify some of the geographical areas and contaminants with the greatest potential for harm.

The '85 budget request also calls for further progress on the protection of endangered species, with particular emphasis on recovery. By the close of the fiscal year that ended last October, there were 293 U.S. species on the Endangered Species List. Recovery plans have been developed for some 220 of those species. We will accelerate this program. So we've asked Congress to increase this budget item by another $3.3 million.

Overall, the Department's budget is $105 million less than last year's. It calls for 72,833 employees, down from 90,000 employees at the Department just three years ago. Yet even with such a reduction, there have been no allegations—at least, none that I'm aware of—of any drop in the level of quality of service provided by the Department.

In addition to our spending plans for next year, we're also moving ahead with efforts to place greater reliance on the private sector and the States. This is a valid, proven way to bring additional resources to bear on our many conservation needs.

Here in New England, it was precisely that kind of cooperation—between the Federal Government, the States, and private industry—that lead to the return of Atlantic salmon in the Connecticut and Merrimack Rivers. Later this spring, a new fish passageway will be opened on the Connecticut at Bellows Falls, Vermont, that will enable salmon and shad to reach spawning grounds above that city—in the case of salmon, for the first time in this century; in the case of shad, for the first time ever. In June, we'll dedicate a new salmon hatchery also in Vermont.

These are tremendously positive accomplishments. They have been achieved with the combined support of government, private companies, and individuals. And it's a model that we intend to see duplicated in other conservation areas.

Take the Year of the Wetlands, for example. As you know, 1984 marks the golden anniversary of the Migratory Bird Hunting and Conservation Stamps, the oldest Federal conservation program for wetlands. Since they were conceived by Ding Darling and were first introduced in 1934, Duck Stamps have raised $285 million, allowing us to add nearly 4 million acres in wetlands and wildlife habitat. Those areas are now part of 186 different wildlife refuges. And we hope to add another 31,000 acres this year.

As part of our anniversary observance, the Department is undertaking an aggressive program to promote the sale of Duck Stamps to photographers, fishermen, and other non-hunters who enjoy wildlife-related recreation. More than 50 corporations and organizations—many of them represented here today—are actively supporting this effort. I understand that later in the conference, you will have an opportunity to preview a new film that has been produced by the Fish and Wildlife Service as a way of introducing people to the Duck Stamp effort. I think that will give you an idea of what we're trying to accomplish.

Among other cooperative efforts to promote wetlands and waterfowl, we have inaugurated a program to reverse the decline of black duck populations. As you're aware, the black duck is one of the most important species of duck in the Eastern United States. Unfortunately, for a variety of reasons, black ducks have been declining in numbers for several decades. To halt the trend, new hunting restrictions went into effect last fall, developed jointly by State and Federal wildlife authorities. In addition, with the help of sportsmen's groups, a public education campaign has been mounted to generate public support for the effort.

Recently we also signed a formal Memorandum of Understanding with Ducks Unlimited. Under the terms of that agreement, DU will finance projects to restore wetland areas and to increase waterfowl production on lands owned or leased by the Fish and Wildlife Service, the Bureau of Land Management, and the Forest Service. A number of proposals are now being considered, but the emphasis will be on high-priority projects the agencies themselves are not able to fund. Ducks Unlimited will devote up to $2 million to this effort in 1984 and even greater amounts in the future.

The day after we signed the agreement with Ducks Unlimited, the Department also received one of the largest corporate conservation gifts ever. Prudential Insurance Company of America donated 120,000 acres of prime wetlands in North Carolina to the Wildlife Refuge System. That acquisition will become the Refuge System's newest unit. It's an exceptional tract. It's heavily used by waterfowl. And it includes habitat for bear, deer, and bobcat. It also marks the northernmost limit of the American alligator. This gift is an outstanding example of public and private cooperation, true partnership, that has made this country great in the past and is now on the rise again. We thank Prudential. I also want to thank The Nature Conservancy for its role in helping to bring it about.

The Department has also been striving to develop that kind of productive relationship with State and local governments and with the Indian Nations. For example, we recently transferred 350 acres of public coastal lands to the Florida Department of Natural Resources, to enhance the existing estuary preserve at Rookery Bay. Earlier this year, the Park Service ceded 821 acres of unneeded land near Glacier National Park to the Blackfeet Tribe. And we're presently considering an application by the town of Nantucket, here in Massachusetts, to make a local recreation area out of 142 acres of surplus Federal property on the island. The decision hasn't yet been made, but let me say that it appears to be consistent with our policy and with the letter and spirit of the law, to place surplus lands in the hands of local people, so thay can make a higher, better use of what has become obsolete to the Federal Government.

Of course, ceding surplus Federal lands is an easy way to work with the States and local governments. It's sometimes another matter, however, when we're talking about leasing of the Continental Shelf for exploration and understanding and assistance in this time of national need.

Offshore leasing and development is not new. The first offshore well was drilled nearly a century ago, off my native California, near Santa Barbara. Since then there have been more than 30,000 wells drilled in Federal and State waters. Over the years, production from those wells has amounted to more than 10 billion barrels of oil and about 72 trillion cubic feet of natural gas.

Today the Department of the Interior is under a Congressional mandate to promote the careful development of resources on the Outer Continental Shelf. The basic law was passed in 1978, at a time—I might add—when the President, the Congress, and the Secretary of the Interior were all from the same political party. That law says, in effect, "Go out and find it and produce it, in light of our national needs." And that's what we've been doing, sometimes in the face of bitter resistance, frequently fueled by a lack of understanding, particularly within the Coastal States. Yet ironically, many of those States already have their own successful development programs in State waters!

Rest assured, we're aware of the environmental issues. We have to be and we want to be. I'll never forget, standing on the Santa Barbara coast with my five children in 1969, watching the terrible blowout. That accident took its toll. But it also had its benefits. Since then, over $340 million has been spent on environmental studies to protect against this type of thing in the future. New environmental controls were established in 1970. And industry has taken the lead on its own to prevent another spill or other environmental damage from offshore drilling. The result has been years of activity without any recurrence of the Santa Barbara blowout. In fact, since 1970 more than four billion barrels of oil have been produced from Federal offshore waters, while only 791 barrels have been lost because of blowouts.

We cannot afford to ignore these technical advances. Our needs are clear. The mandate to the Department is also clear. Offshore leasing of Federal lands now accounts for about 10 percent of our oil and 25 percent of our natural gas, at a time—and this is critical—when we are still dependent on imports for 30 percent of our oil. That's about where we were 10 years ago at the height of the OPEC crisis. But today we're paying 10 times as much for the same oil. In the last decade, we've spent roughly half a trillion dollars for imported oil. And with the Iran-Iraq situation threatening the entire Persian Gulf, things could change for the worse at any moment. We're better prepared today than we were in 1973. But that's no reason to sit back and wait for another crisis to develop before we take further action.

All the same, recognizing the legitimate concerns of many people, we've changed our leasing process substantially in the last 90 days. We're working with the States at a much earlier point in the process, taking cognizance of consistency requirements. We're into heavy consultation with local governments and with conservation organizations that are concerned, as they should be, with all aspects of offshore leasing and production. We're also talking to industry. We've said, Gentlemen, would you please come forward, and tell us what you're really interested in out there. And tell us early on, so we can narrow the area of consideration."

As a result of such dialogue with the Governor of Alaska and the Alaskan Congressional delegation, we reduced our planned lease sale offshore Alaska by a third. We dropped plans to lease several tracts in an area that's important to the Alaskan fishing industry. And we're advising potential bidders on the lease sale scheduled for next month that under the consistency review provisions of the Coastal Zone Management Act, the State of Alaska will be involved in approving their operating plans.

Likewise, in Southern California I've deferred leasing until I am satisfied that all environmental issues have been adequately resolved and that the Defense Department is pleased with the final designations.

Our policy is similar with regard to other kinds of economic activity in the Exclusive Economic Zone declared by President Reagan a year ago. For example, we just reached an agreement with Governor Atiyeh of Oregon concerning possible mineral exploration of Gorda Ridge in Federal waters off the Oregon coast. As a result of our decision, the Department reduced the original size of the lease offering from 40 million acres to four million acres. At the same time, we also deferred leasing until a joint Federal-State review panel can examine the environmental, economic, and technical aspects of the lease sale. I'm delighted to add that the review panel has since been joined by California. And we have reached a similar agreement with the State of Hawaii. So where the Exclusive Economic Zone is concerned I think we've established a precedent for this kind of positive, constructive cooperative agreement.

I would hope that as we work to resolve issues in other areas, you will all be working with us. I realize, of course, that many of you have interests that go far beyond the subjects I've mentioned this morning. I don't think I could cover all of them if I spoke all day! But above all I want to give you a general understanding of how we are approaching controversial questions at the Department. Before closing, however, I would like to mention two additional issues that I know concern many of you.

First, concerning expanded use of the National Wildlife Refuges. As I've said many times, refuges are primarily that. They're for wildlife. Additonal use is allowed by law only when the secondary use is compatible with the primary purpose. We are not considering applications for oil and gas leases on wildlife refuges. There may be exceptions, of course, where there are valid rights that preceded our responsibility in that area. But none of those have been issues lately.

As a result, we've asked Congress to strike the half million dollars appropriated last year for environmental impact studies, imposed by Congress as a condition for oil and gas leasing. If we're not even going to lease, as I stated, there's no reason to study the environmental impact further. Instead the money is being reprogramed for habitat study in Alaska.

Finally, let me say a few words about the lead shot-steel shot controversy. It's a critical issue, involving an unacceptable mortality rate for waterfowl. The issue has been with us for years, as I know and you know. And there's been too little progress toward an answer.

What we do not need at this point, however—and I think you will agree—is another lengthy study. We already have truckloads of data, data that I myself will never have time to study personally.

On the other hand, realizing the divisiveness of the issue, and the fact that the Stevens Amendment requires State concurrence in enforcing steel shot regulations, I think it would be inappropriate for me to attempt to resolve that issue, either way, on my own, at the Federal level.

As I announced recently: For all these reasons, I've asked my staff to organize a broadly representative review panel on the issue, comprised of State, Federal, industry, scientific, and environmental representatives. This panel will meet at the Department very soon, under the chairmanship of Under Secretary Ann McLaughlin. Let me emphasize that I do not mean for this to be just another study effort. It's my hope that, in this collegial atmosphere, a meeting will help us come to a greater understanding, greater options, and maybe resolution of the issue.

It's the kind of issue that really cannot be solved without cooperation, openness, candor, and discussion. It's also an example of an issue that our judicial system is not equipped to resolve by litigation, and that I hope can be resolved without further legislation.

Finally, I wish to repeat that whatever the issue, our doors are open. First, they're open among ourselves at Interior. I discovered in my review, requested by President Reagan, that too often in the past a certain autonomy existed among our 10 bureaus at Interior, sometimes with one bureau refusing to speak to another. So, in openness, we have a full board of directors meeting, you may call it, at 8 a.m. each morning. Each Assistant Secretary is there, and each bureau is represented. Our Public Affairs and Congressional Affairs Officers are also there, with the Under Secretary and myself. We go on for about an hour, discussing all issues and not limiting discussion by anyone to his or her particular issue.

We're striving for the same kind of openness with the Congress, not in a formal way, but as more of an informal get together, whether by phone, staff to staff, or whatever, and I believe we're making a lot of progress.

We're working towards openness with the press and with other agencies. Nancy Maloley, who is with us here today, is formerly of CEQ, and she's coordinating the interagency and White House communications, so we'll be in step with every other agency of government.

And lastly, but perhaps most importantly, we want to have openness and continued cooperation and communication with a man I worked closely with for about 20 years now, the President himself.

Now, as you might guess, I've been asked a time or two recently, to list all changes we've made in what we call the three P's—Process, Personnel, Policy. "Tell me, is it campaign-year appeasement, or do you really mean it?" Well, ladies and gentlemen, I'm not going to answer that. I would rather leave that up to the people who watch our progress—and hopefully it is progress—now and through the year.

But I do want to know your thinking. And if there are times that we disagree, you'll have my full explanation and quick return. I'm confident that, in that kind of atmosphere, we can continue our efforts to make our country truly a better place in which to live.

New Directions in Resource Management

The Honorable John H. Chafee
Chairman
Subcommittee on Environmental Pollution
U.S. Senate
Washington, D.C.

Thank you for that fine introduction. It is indeed a pleasure to be here this morning at the 49th North American Wildlife and Natural Resources Conference. Those individuals and organizations who have put together this impressive forum are to be congratulated. Exchange of views and information between the many diverse groups represented here furthers our national effort to conserve our nation's priceless wildlife resources.

Many of you have been involved in shaping wildlife conservation programs of the federal government over the years. The Dingell-Johnson and Pittman-Robertson programs—to name just two—have been essential building blocks in the nation's wildlife conservation policy. These programs have served us well, but I think it is becoming clear they no longer meet all of our wildlife conservation needs.

One area where we need to take a fresh look is land acquisition. The increasing Federal deficit has put a crimp in our ability to use federal funds to acquire new wildlife habitat areas and has forced us to look at new alternatives to protect the land.

One new approach is reflected in the Coastal Barrier Resources Act which was enacted by the 97th Congress. "COBRA"—that is the sinister acronym Washington has given this benign law—reaffirmed the Federal government's role in conserving and protecting undeveloped coastal barrier islands and beaches along the Atlantic and Gulf coasts because they are important habitat for fish and wildlife. At the same time, we recognized the other side of the coin—namely that the Federal government has been undermining fish and wildlife conservation by subsidizing coastal development through various projects and programs.

To resolve this obvious conflict, the Act established a Coastal Barrier Resources System which delineates the remaining undeveloped coastal barrier beaches and islands on maps and prohibits new federal financial assistance or expenditures to help develop them.

Now, for the first time, the Federal government is not underwriting the destruction of the valuable fish and wildlife resources it is seeking to conserve. This legislation also paves the way for State and local governments to take similar action. A logical extension of this law is for other government bodies to piggyback on the work we have done and cut off their subsidies as well. A bill to do this has already been introduced in the Rhode Island legislature.

The simple, comon sense—and less costly—approach to conservation reflected in this new law can be easily applied to other areas where fish and wildlife conservation and protection is important.

That is the thrust of new legislation I introduced in the Senate last week—the Wildlife and the Parks Act. This legislation is designed to head off conflicts between wildlife resources that reside in our National Parks and incompatible activities that occur within the park boundaries or on contiguous federally managed areas.

Like barrier islands, we have a situation where, on the one hand, the Federal government is responsible for conserving the fish and wildlife that live within the borders of our

National Parks while, on the other hand, the government sometimes spends money on projects and programs which are threatening to destroy the habitat of those very wildlife resources. For example: Timber harvesting in the Flathead National Forest to the west of Glacier National Park threatens to bring roads into an area which is important to the park's wildlife. On Forest Service land southeast of the park, proposed oil and gas leasing will intrude upon the winter range and calving area important to the park's elk and moose populations.

Similarly, in Yellowstone National Park the government is spending money to construct a visitor complex in what many people believe is prime habitat for the grizzly bear. The Federal government's right hand doesn't always know what its left hand is doing when it comes to wildlife conservation.

The bill is fairly straightforward. It would, for example, allow the Secretary of the Interior to bar government financing of roads in parks and neighboring forests, or to bar federal assistance for new sewer and water services to privately owned property within the management areas if such projects were found to threaten wildlife.

Even though we would not bar privately financed projects, this bill will be controversial. Any time you start to fiddle with the rules governing multiple use lands such as BLM and Forest Service lands, you can expect to hear some screams. But this bill makes sense. It is environmentally sound and it is fiscally responsible.

Although we are facing a short session this election year, I am hopeful we can hold hearings on this legislation and—schedule permitting—report it from the Committee in late Spring or early Summer. During the hearing process, I would certainly want to receive the views of the many organizations that are represented here today.

The success of the barrier islands legislation and the promise of the Wildlife and the Parks Act stems, in large part, from the fact that they address easily identifiable, discrete areas. Turning from the parks and barrier beaches to another category of important wildlife habitat—wetlands—we can see that the elimination of harmful federal expenditures is an appealing conservation tool, but it has limitations.

There is no question that some Federal expenditures, grants, and financial assistance have a significant adverse impact by contributing to the destruction and degradation of wetlands throughout the United States. Construction projects and income tax provisions which provide for rapid depreciation of capital costs associated with clearing or draining wetlands for agricultural purposes are two examples of harmful federal expenditures.

But how do we delineate the affected areas? The Fish and Wildlife Service's wetlands inventory and mapping process is making progress, but we have a long way to go before we can identify the wetland areas where a funding cutoff should apply. Unlike coastal barrier islands or national parks, wetlands can be found in all parts of the country in all shapes and sizes.

Unfortunately, our wetlands are disappearing. The U.S. Fish and Wildlife Service has recently completed a detailed, scientific study on the status and trends of our nation's wetlands. It was found that the average loss of wetlands in the lower 48 states from the 1950s to the 1970s was 458,000 acres per year. *Over 9 million acres of wetlands were lost in that 20-year period.* Agricultural development such as clearing and draining was responsible for 87 percent of these losses while urban development and other activities caused 8 percent and 5 percent of the loss, respectively.

The Fish and Wildlife Service estimates that, at present rates, there will be virtually no waterfowl breeding habitat left in the contiguous states 100 years from now.

It was statistics like these that led me to introduce the Emergency Wetlands Resources

Act. An important component in efforts to resolve the problem of wetlands loss must be increased funding for state and federal acquisition programs. While wetlands have numerous values in addition to their crucial importance to wildlife, let me concentrate on just the waterfowl habitat issue for a moment.

In 1959, the Department of the Interior, the States, and the International Association of Fish and Wildlife Agencies jointly determined that conservation of 12.5 million acres of waterfowl habitat was necessary to maintain existing waterfowl populations. To achieve this goal, the U.S. Fish and Wildlife Service needed to acquire an additional 3.8 million acres and the states an additional 2.5 million acres. Since that time, only about 17 percent of the state wetlands acquisition goal has been achieved.

In 1976, the Service adopted a ten-year plan to acquire 1.9 million acres of wetlands. But at the end of fiscal year 1984, approximately 1.5 million acres will still need to be acquired. Thus, at the end of the eighth year of the ten-year plan, only about 20 percent of the goal set in 1978 will have been achieved. Clearly, we need to do a better job of meeting our goals.

As approved by the Committee on Environment and Public Works, the Emergency Wetlands Resources Act will provide, for an emergency 10-year period, approximately $50 million per year for Federal acquisition and an additional $50 million per year for State conservation projects. Of this, approximately $25 million per year will be raised from user fees, such as refuge admission fees and sales of Migratory Bird Conservation Stamps, and $75 million per year will come from the existing Land and Water Conservation Fund which contains $900 million each year, collected primarily from offshore oil and gas revenues.

Make no mistake about it: it will be an uphill fight to pass this bill in its current form. After the Environment Committee approved it, the bill was sent to the Energy Committee, where the provisions affecting the Land and Water Conservation Fund are being examined. I expect the Appropriations Committee will also want to examine the bill's pricetag.

But all is not lost. Anticipating passage of our bill in one form or another, Secretary Clark was able to convince the President to request in his 1985 budget proposal, an appropriation of $27.5 million for federal and state wetlands acquistion programs. This is clearly a step in the right direction and the Secretary deserves the credit for it.

The need for new direction in resource management goes beyond the need for new habitat conservation tools. Our experience with the management of migratory fish teaches us that we need new management tools as well.

Many of our coastal fisheries have undergone a precipitous decline during the last decade. The best example of this decline, perhaps more accurately referred to as the "worst example", is the striped bass.

In 1979, I decided that we needed a scientific study to determine the causes and extent of the problems facing the striped bass. We are now in the final year of the Emergency Striped Bass study and recent reports from the study group confirm the calamitous trend of the Atlantic coastal stocks of striped bass.

Obviously, action must be taken to reverse this trend. It is beyond dispute that a reduction in fishing mortality would alleviate a major threat to the striper's survival. The Atlantic States Marine Fisheries Commission Interstate Plan for striped bass was designed to do this. The plan has not, however, been implemented by all affected states and a call to implement even *further* reductions in catch has recently gone out to the states. Unfortunately, it appears that uniform implementation is not likely to occur this year. The most effective method for reducing fishing mortality is to impose a temporary moratorium on the taking of striped bass along the Atlantic Coast. My home state of Rhode Island has imposed such a measure for its waters. A moratorium in one or two states, however, will do little to benefit the fishery. If a moratorium is to be effective, it must be imposed on an interstate basis. Migratory fish such as the striped bass do not recognize the jurisdictional limits of the several states. That is why uniform, interstate measures must be used. The time has come for a new management approach. For the past several months, I have been working to develop a bill with a two-fold purpose: (1) to establish a workable mechanism for interstate management and protection of migratory species of fish; and (2) to initiate emergency action for the protection of Atlantic Striped Bass.

The bill which I will be introducing shortly would impose an immediate moratorium on fishing for striped bass within all state and Federal waters of the Atlantic Coast. This ban would be lifted upon implementation, on a state by state basis, of a fishery management plan for striped bass.

A moratorium, however, is a temporary action which cannot assure the viability of the striped bass stock. Factors other than fishing mortality are contributing to the decline of the striper and these, too, require uniform, interstate response. The quality of breeding and spawning habitats, improvement of water quality, and the reduction of contaminants in the striper's food supply must also be considered in an attempt to restore the fishery.

To address these factors for the striper as well as other migratory species, the bill will enhance the role of the Interstate Fisheries Commissions and coordination of fishery plans. The states would still be responsible for regulating the fisheries within their waters, however, as members of a compact, they would be obligated to meet the minimum standards set out in the plan.

The Federal role is to assist the Commissions and states through existing grant programs (Anadromous Fish Conservation Act and Commercial Fisheries Research and Development Act), to publish plans and schedules, to intervene when a state or states are negligent in exercising their responsibilities, and to invoke emergency action when necessary.

The bill recognizes an old problem and proposes a new solution. As always I look forward to working with all of you on this important issue. Not only are you the experts, you are dedicated professionals and I salute you.

As decision makers in the field, you are often on the firing line. You may not hear it often, but I for one want to thank you. Too often we hear that environmental issues are passe; that the national concern for a healthy environment has been replaced by concerns over nuclear arms or the federal deficit. Well, I'm here to tell you that protecting our environment is still good politics. Citizens—voters—appreciate those who care for what they care for and what their children care for. What more exciting, satisfying, and indeed noble effort could you be engaged in than managing and conserving the wonders of nature, our natural resouces.

Thank you for inviting me to address your conference. I hope in your committee meetings and informal gatherings you will discuss new and different approaches to conservation. Yes, we must continue to support the time-tested programs we have already developed, but we must look beyond those programs to develop new and effective alternatives to resource management.

U.S. Federal Farm Programs

The Honorable Roger W. Jepsen
Chairman
Subcommittee on Soil and Water Conservation
U.S. Senate
Washington, D.C.

Last month, in Denver, I had the honor of receiving the National Association of Conservation Districts annual award for distinguished service for my work in the Senate on soil and water conservation issues. At that time, in my keynote address, I mentioned President Reagan's observations in the State of the Union address. He encouraged us as Americans to carry on our traditional American pioneer spirit and develop the next frontier—outer space. However, at the same time the President was looking to the future, asking Americans to develop the use of space as a resource—he was reminding us of our responsibilities to preserve our natural resources here on earth.

As Americans we have always been looking toward the next frontier—knowing that each exploration may yield multiple discoveries . . . and with that . . . expand our capabilities and create new horizons. Yet, new discoveries and the changes they bring to our lives and values often cause us to reexamine our heritage—to question the need to advance as we must. We look to space to provide the next frontier of promise. But at the same time, we must also look back to our heritage and reexamine agriculture.

We must weigh how we in Congress, and you as individuals and members of organizations, are preparing to embark on the next agricultural frontier. This is a linkage of agricultural resource conservation policy with our nation's natural resource and environmental policies, goals, and objectives . . . to form a cohesive resource conservation policy in the United States.

As nationally recognized leaders and active participants in fish and wildlife, natural resources, and conservation organizations, and as individuals, you know that agriculture in the United States is as much an obligation to preserve as it is an oppportunity to advance. Future generations will judge whether we have lived up to our heritage, and to our obligations.

I am excited that you have recognized this responsibility by having as the theme of your conference "Society's Responsibility in Fish and Wildlife Management." It is also encouraging to see that you have included federal farm policies and programs as part of that responsibility.

For some time now I have been trying to formalize this link between our national farm soil and water conservation program goals and our national fish and wildlife program goals. As you may be aware, in early April of 1983, I formed a wildlife advisory council. The purpose of the council was to get together with fish and wildlife interests . . . to meet, collectively review, and analyze legislative proposals on integrating wildlife concerns with agricultural conservation policy. This initiative was taken primarily because of what I saw, early on, happening in the Payment-in-Kind Program. Farmers were idling large tracts of land and, as a requirement of the program, keeping the crops on the field until the pre-harvest mowing deadlines.

About this time, I had a visit from two Minnesota state senators and representatives from the Department of the Interior. That meeting was eye-opening. We discussed the benefits of leaving this cover on the fields past the mowing deadline. From my perspective, leaving the fields covered for a longer period of time would help keep soil moisture in and would reduce erosion that would occur if the crops were plowed under. From a fish and wildlife perspective, additional benefits could be gained. Cover would remain on the fields through the wildlife season, generating increased wildlife habitats in the farming areas. I moved swiftly to convince Secretary Block to allow cover to remain on the fields through the nesting season.

Within one month of my visit with the senators from Minnesota and representatives of the Interior Department, a letter was sent to the Secretary . . . a decision was made . . . and the Agricultural Stabilization and Conservation Service made a nationwide announcement to allow cover to remain on the fields, through the early fall. This announcement was followed by a detailed two-page memorandum to all state and field offices on how to proceed with this program change.

It occurred to me that the U.S. Department of Agriculture had not really thought out additional conservation and wildlife benefits that could be brought by sustained field cover. There was a missing link in forming a new, responsive agricultural program—the Payment-in-Kind (PIK) Program—to what at the time was becoming a very serious agricultural economic situation. I recognized this was a great opportunity for some creative and new initiatives in the conservation area.

Too often, conservation and environmental interests have not joined hands. Agriculture in the past has not been able to align the common goals of conservation with other environmental policy goals set by the Congress in response to public desires. I decided a formal working council would be the most effective means of joining this link and making it active and workable in my daily decision making as chairman of the Senate Agriculture Committee's Soil and Water Conservation, Forestry, and Environment Subcommittee.

Initially, I started meeting with the fish and wildlife groups and the environmental groups. Then I arranged to have representatives from the Department of Agriculture, the Department of Interior, and the Environmental Protection Agency join us. The first few meetings involved exchange of expertise on how programs worked . . . what our different objectives were . . . and what our institutional constraints were. It became clear to me, and to many of the council members, that the integration of fish and wildlife concerns with agricultural policy could only occur by including other soil and water conservation groups. The council is now referred to as the Wildlife/Conservation Advisory Council.

As I stated earlier, the ad hoc chairman of the group is Larry Jahn, vice-president of the Wildlife Management Institute. Again, I would really like to compliment Larry and the Institute on all the fine work they have done . . . meeting informally with council members . . . and keeping in touch with my office on a regular basis. It is only through this constant communication, exchange of ideas, and generation of support, that we can effectively move legislation through the Congress.

One particularly effective way of keeping the communications going has been the development of a newsletter entitled "Linking Agriculture and Resource Conservation Programs." The newsletter is funded through the Wildlife Management Institute, the International Association of Fish and Wildlife Agencies, the Association of Midwest Fish and Wildlife Agencies, and the Southeastern Association of Fish and Wildlife Agencies. Together, the members of the associations finance, prepare, and distribute the newsletter, which is prepared as issues arise, or as policy developments or decisions occur. The newsletter carries discussions or comments on recent council meetings, as well as information about agricultural conditions that may be useful to you in your decision making on fish and wildlife programs and policies.

The Council has been extremely effective in assisting me with designing a long term program for agriculture. And it is to this item that I would like to focus my remaining comments.

Sadly, farm policy has become a hurried reaction to an endless series of dramatic events. 1983 epitomized the kinds of unpredictable and extreme circumstances that farm policy makers must face. In the last twelve months, we have had two record crop surpluses, record production controls, a record drought, and record costs for farm programs. The inevitable result is that soil and water conservation and fish and wildlife concerns get lost in the frantic shuffle.

The people who formulate the most important farm policies—policies for the major farm price support and commodity programs—tell us again and again that there isn't time, or a proper method, or enough federal financing to incorporate natural resource goals and objectives with other federal farm program objectives. It is going to be difficult to turn the situation around and get resource conservation and commodity programs pulling in the same direction. But that is what we must attempt to do, and I know it can be done.

Recently, the Senate passed the sodbuster bill. This legislation prohibits farmers from receiving federal price and income supports for crops produced on newly plowed, highly erodible lands. The bill is significant because it has been almost *thirty years* since federal commodity program objectives have been linked with conservation objectives, legislatively.

Additionally, the bill was supported not only by the traditional farm and conservation groups that represent farmers in Washington, D.C., but also by fish and wildlife and other natural resource and environmental groups across the nation which have not been active previously in farm policy. This type of coalition building will help bring agricultural resource issues into the mainstream of the nation's environmental policy. And it is this link with the mainstream of the nation's environmental policies that agriculture needs to build more effectively public awareness and support for agricultural resource problems.

From the beginning of my tenure in the Senate, I have been a member of the Senate Agriculture Committee's Subcommittee on Soil and Water Conservation. I became a member because I believed an economically sound and profitable agriculture required my input, not just for the traditional farm programs, but also for an environmentally sound farm policy. That included not only farm resource goals, but wildlife management concerns too.

During this past year, I have concentrated on fostering the debate about how we should proceed in this next generation of farm programs. Resource conservation and fish and wildlife goals must be recognized as a fundamental principle underlying our farm policy. And just as important, this is a practical component and an integral part of implementing farm programs.

We cannot ignore the problems we have today with excessive wind and water erosion and related resource problems. From where we sit today, I warn you very bluntly, that our current agricultural land management practices cannot continue. Abusive farm practices must change. Conservation tillage has been tried and successfully practiced on many farms in recent years. Changes in cropping patterns, new technology, new crop strains, and unlimited information sources exist. As farmers and conservationists we need to work harder to seek them out.

But at the same time we cannot lament the state of our resources—we have to recognize the few steps we have taken in recent years and continue to build. We cannot reach all our goals immediately, but we must continue to have goals—to initiate new ideas—to look beyond our traditional sources—to reach beyond the traditional groups—and see what we can accomplish. We already have the vision—that America's future agricultural policy must be long-term and must fully integrate resource preserving techniques.

As we progress on this path we will reach certain points along the way where we will have to make changes. There are many things wrong with American agriculture—but there are also many things right with American agriculture. The U.S. is the only country which has the science and the natural resource base to explore and commercialize the next agricultural frontier. We cannot and should not rely on the federal government to guide us along the road. The states, the counties, and you as scientists and policy makers contributing to this debate, must also decide to design economically viable agriculture policies that are in concert with the environment. For example, in my home state of Iowa, the Legislature appropriates money for agricultural market development and conservation and for fish and wildlife habitat proliferation and maintenance.

Introducing and moving legislation through the Congress—holding hearings and participating in public forums—and building a network of communication and a coalition of support are the steps I have taken to forge a comprehensive agricultural resource policy.

More important, soil and water conservation problems must be brought to the attention of the individual farmer—that's where the ultimate responsibility lies for proper land management and a commitment to preserve our natural resources. A landowner's commitment to stewardship cuts straight to the heart of what we in Congress have been grappling with for some time. It deserves some thoughtful consideration. Is the commitment there? What kind of incentives do farmers need? What kind of options can the federal government offer? And equally important, what is the farmers' or landowners' obligation to search for their own initiative?

How can the independent resource groups and research scientists help? The federal government's commitment can only go so far. The real drive, the real strength, of any nationwide commitment to achieving specific goals must be felt within those who are immediately concerned. In this case it is the farmers of America. They must renew their commitment to achieving the goal of increased soil and water conservation for better overall land management, and a better environment.

Over the coming years, perhaps our greatest challenge as a society may be to devise new methods to grow more and different foods without exploiting our unique agricultural land and water resources. We need to expand our efforts to develop new crops which minimize negative environmental impacts and foster fish and wildlife habitat developments. And we need to expand our efforts to develop more efficient planting, harvesting, processing, and storage methods to assure maximum nutritional payout from our limited soil and water resources.

Years ago, Iowa conservationist Aldo Leopold wrote: "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

Slowly, I think the American public is beginning to understand that feeling of community with the soil. All of you have played a substantial part in bringing about that new understanding. You are creating the new frontier of American agriculture—but you are also creating the American heritage upon which future generations will reflect.

Fisheries and Wildlife Management in an Urbanizing State

The Honorable James S. Hoyte
Secretary
Massachusetts Executive Office of Environmental Affairs
Boston

Delighted to welcome you all here today. I understand this is the first meeting of the North American Wildlife Conference in Boston. Needless to say, we're proud of our city and what we've done in Massachusetts in the wildlife and natural resources area and are glad to show it off.

We feel we have a very special environment here in Massachusetts and hope you have a chance to experience some piece of it while you're here. We have a very beautiful and extensive coastline some of which you no doubt noticed when you came into Logan Airport—if you traveled by air—and we have a wonderful group of islands out there known as the Boston Harbor Islands State Park which we have made accessible to the public by developing a water taxi system from island to island.

You'll also be interested and perhaps surprised to know that Massachusetts has the sixth largest state forest and parks system in the country even though we are the sixth smallest state in the nation in terms of size. So there are a lot of places in this state for fish and other wildlife to flourish.

As I talk with you this morning I'll take some time to describe our state, its wildlife and the opportunities available for those who want to hunt or fish—for those who want to watch it all and for those who just want to learn more about it. I'd also like to fill you in a bit on some of our history and heritage around the wildlife and natural resources issues. It's quite interesting. But I primarily want to talk with you this morning about three programs we've initiated that very much affect the future of wildlife in our state.

One is a program designed to inventory plants and wildlife of Massachusetts. We call this the Natural Heritage Program.

Another is our so-called nongame tax check off which is raising funds to support programs to preserve and protect nongame wildlife and their habitats.

And we have developed a very significant program to purchase open space, wildlife habitat, and recreation land. This one has a high price tag of more than $160 million which will be funded through a bond issue that was signed in January by Governor Dukakis.

And before I leave you this morning I want to address two important national environmental issues that I believe can and should be addressed in a more bi-partisan manner than has happened to date. One is the serious problem of acid rain, which as you know poses a very real threat to our water and of course to our fish, wildlife, plants, and trees. The acid rain also threatens the health of our people and is presently in this state causing some significant damage to our historical monuments.

The other important national issue is that of conservation and preservation of special land that invariably serves as home for special wildlife. We need to take care of special land and special life. This is an issue which all of us in this room can agree on I'm sure. And agreeing on this issue should have nothing to do with whether we're Republicans or Democrats. We can agree that the environment is important to preserve and protect.

Well, let's get on with the history first and then get back to some of these other issues.

In the beginning, newcomers to North America thought that there would be no end to the abundant game and plentiful forests they found when they got here. The first environmentalists here, however, were the native Americans who know this was not so. And by the beginning of the 19th century it was becoming clear to others that there was a limit to the game and the lumber in the Northeast. In 1818 the Massachusetts Legislature passed a bill protecting larks and robins at certain seasons—perhaps the first nongame legislation in the nation. Henry David Thoreau staked out his solitary vigil in Concord and published *Walden* in 1854. His observations there, on Cape Cod, and elsewhere have been a model and inspiration for generations.

By 1859 both Atlantic salmon and shad—once so plentiful that a law was passed prohibiting colonists from feeding it to their servants more than three times a week—were all but eliminated. It was this loss, in fact, that prompted the establishment of the Massachusetts Fish Commission in 1865, to determine why the shad and salmon were gone and what could be done about it. The remainder of the 19th century saw the extirpation of much of the animal population originally present in the Commonwealth.

But the opening of the West and the mass exodus to the fertile soils of the Great Plains which led to abandonment of New England farms and reforestation of the countryside coupled with a growing awareness of the value and the limits of our national resources—which gave rise to the national park and forest movement—had a profound effect in Massachusetts. The Massachusetts State Park and Forest System, inaugurated in 1898, provides some 250,000 acres of open space and wildlife habitat. Frederick Law Olmsted, who worked from an office in Brookline, next door to Boston, created in and around Boston using the hills and the valleys of the Mystic, Charles and Neponset Rivers, the first metropolitan park system in the nation—one that today provides habitat and a pathway for wildlife to enter the city. And by the way, these Olmsted Parks will be restored and revitalized as a part of our open space program; $13 million will be put into this effort.

The Audubon movement which was heavily involved in the passage of the Migratory Bird Treaty Act of 1916 had its initial organization in a livingroom a few blocks from here. In the early 20th century, Edward Howe Forbush, the state ornithologist wrote, Fuertes illustrated, and the Commonwealth published what has become a classic and a choice find for rare book collectors, the three-volume *The Birds of Massachusetts*.

The rest of the 20th century has seen the construction of Quabbin Reservoir—providing 300,000,000 gallons of water daily to eastern Massachusetts and now surrounded with 100,000 acres of largely undisturbed wildlife habitat. Part of it is a limited access laboratory for wildlife research. The reforestation of the state, coupled with careful management and reintroduction has set the stage for the return of the beaver, fisher, bear, deer, turkey and other woodland and edge dwellers. Fishlifts on the Merrimack and Connecticut Rivers now allow salmon beyond the Massachusetts-Vermont border on the Connecticut River and above the Essex Dam on the Merrimack. That's a real capsule history—with much omitted—but what I want to stress is that we've been concerned about natural resources and wildlife for a long time.

Now, let me review briefly aspects of the wildlife situation in Massachusetts today. Our state is small, about 5 million acres, and dense—about five-and-one-half million people—but two-thirds of the people are within 10 miles of the shore. We are richly endowed with wildlife—of the 1619 species in the U.S., we have 565—35 percent. My biologists tell me there are several reasons for this. Four major regions provide different habitat: Coastal Plain, Piedmont (Worcester Plateau), Connecticut River Valley, and Berkshire Hills. We're at the transition between oak/chestnut forest of the south and hemlock/hardwood forest of the north. The Gulf Stream moderates coastal climate. So, we have coyotes reappearing here, a large healthy deer herd, and arctic terns and mocking birds nesting in the same county. Our fish and wildlife are varied and enjoyed by hundreds of thousands of people.

The programs now functioning in the Division of Fisheries and Wildlife will add considerably to our capacity to protect and manage our wildlife. The Natural Heritage Program, now in its sixth year, has provided us with a complete inventory of rare and endangered species in Massachusetts. Its inventory enables developers or others who are proposing changes for various parcels of land to check out the plant and animal species which may be found there and to use this early warning system to modify or appropriately plan for their projects so they won't need to make expensive changes down the road. It will also enable us to locate and possibly acquire parcels of land which provide habitat for rare or endangered species.

We are in the process of coordinating this program with the one that will be funded by revenues designated from the Massachusetts income tax form. It's simple—if you're getting a refund this year on your Massachusetts tax, you simply check off yes to contribute to this nongame wildlife fund. And of course even if you don't get a refund, you could make a contribution. We anticipate between $300–$400 thousand in revenues this year from the check off and plan to use it for inventory, management, habitat acquisition, and public education about nongame species.

What are we doing about the future? It holds some real challenges for us—ranging from how will we continue to provide open space, habitat, and public access to what we'll do about acid rain. Let me talk first about acid rain. The Reagan Administration's position is one that is of serious concern to us here in Massachusetts. Last Monday, Massachusetts, along with other New England states, New York, and environmental organizations announced that we were filing suit against the EPA for their failure to take action to stop acid rain. The President and the EPA have responded to our concerns about acid rain by saying we have to study the problem even more. The facts are already in, and we believe they are dragging their feet and simply not being responsible to those of us who are suffering from the disruptive effects of acid rain. We simply cannot stand by while our lakes and forests are slowly strangled and the federal government studies the problem further.

We've chosen to bring this lawsuit to press the Reagan Administration into responsible action at the federal level. Meanwhile, we will continue to work with our congressional delegation to enact legislation mandating SO_2 reductions. And in fact our public concerns in this state, coupled with our tough regulatory decisions, have already led Boston Edison, a Metropolitan Boston Electric Utility Company, to recently announce that it will voluntarily install scrubbers at its South Boston facility to reduce sulfur emissions.

We're doing what we can here to deal with the problem of acid rain. But since the overwhelming majority of sulfur dioxide emissions come from factories in other parts of the country, federal action is essential. Acid rain is a national problem requiring a national solution—the scientific facts are in on this one to support legislation. A recent survey has shown that more than 80 percent of Massachusetts' water bodies are threatened by acid rain. Our Division of Fisheries and Wildlife, by the way, has been monitoring acid levels in water bodies since 1957. For 20 percent of these water bodies, including the Quabbin Reservoir, which supplies water to 2.3 million people in metropolitan Boston, the situation is critical.

The cost of materials damage in the eastern United States is estimated to be over $2 billion annually. In Boston alone it will take $1.4 million for repair and preservation of bronze statues.

Acid particles and sulfate aerosols are adversely affecting health throughout the United States. A 1980 study by Harvard and MIT researchers estimated that 53,000 people die prematurely each year from sulfur dioxide pollution.

Massachusetts Lt. Governor John Kerry and Department of Environmental Quality Engineering Commissioner Anthony Cortese, meeting recently with officials from Norway, Sweden, West Germany, Belgium and the United Kingdom, saw first hand some of the visible damage to the Black Forest. Between 1981 and 1983, damage to spruce trees had increased from 10 percent to over 90 percent of the tree stands. The Europeans waited until the evidence was clear and now their precious natural and cultural resources are threatened and, in some cases, irreparably damaged. We cannot continue to wait!

There is another national issue of concern before us as environmentalists. And that is in the area of land conservation. The federal government has of late been selling some of its so-called surplus land to the highest bidder. Their general policy does not seem to be one that is supportive of land conservation and preservation of open spaces. Such an approach is not responsive to the whole issue of preserving natural habitats for wildlife and for protecting rare and endangered species from abuse.

In Massachusetts there has been a recent case in point on the island of Nantucket. And it is, by the way, an issue that is not yet resolved. The federal government owns 142 acres of land on a beautiful parcel on the south side of Nantucket. They've owned it for 40 years or so and recently announced they would like to sell it to the highest bidder for development. We were immediately concerned about that for a number of reasons. This is special open land that is a home for rare and endangered species of both plants and wildlife. In fact, our State Department of Fisheries and Wildlife would designate it as one of the top ten parcels of land statewide to be held in public trust and protected from abuse. It has a shoreline that is eroding at a rate of 10 feet per year—such private development usually exacerbates the problem and often transfers it elsewhere on the coast line. The General Services Administration (known as the GSA) proposed this sale without regard for our Coastal Zone Management Regulations. There is a specific process for them to follow in such a case to determine whether the environmental letter of the law is being met. . . . We insist that this process be followed!

I've asked Secretary of the Interior Clark and the Acting Director of the GSA to assign this land to the Park Service for conservation and recreation. So far I believe they are willing to assign only part of it. We are most anxious to preserve this land. And we want to encourage one public agency to support another public agency to mutually act in the citizens' best interest.

Finally, I want to tell you about our new program to acquire public open space in the Commonwealth because I believe that it has the potential to provide a legacy for future generations that will continue Massachusetts' heritage of environmental concern.

Early in 1984, the Massachusetts Legislature authorized and Governor Dukakis signed a special capital outlay budget. Over $160 million of that budget is for open space land acquisition.

We are committed to protecting those lands in our state of special scenic beauty, which provide habitat for rare wildlife, public access to salt and fresh water, buffers for existing public lands and trail links from one area to another. Particularly in a state as urban as Massachusetts where wildlife management and enhancement is concerned, we feel that habitat preservation, whether by acquisition or other means, is absolutely essential.

Highlights of the program include:

—$30,800,000 to complete work on the state's eight existing Heritage State Parks and establish six more. These parks are located in cities throughout Massachusetts and celebrate the specific cultural heritage for which the city is known.

—$7,000,000 to restore Boston's Long Wharf as a gateway to the Harbor Islands State Park and to complete a pedestrian mall with a new visitor center between the aquarium and wharf.

—$12,000,000 for the acquisition of land for new state parks.

—$14,000,000 to buy buffer land and inholdings to protect existing state parks, state forests, and wildlife management areas.

—$28,000,000 to acquire river corridors, cold water streams and greenways.

While virtually all of our land acquisitions will provide some benefit to wildlife, the portions of the bond authorization which deal specifically with that include:

—$4 million for endangered species habitat;

—$4 million for a wilderness corridor along the Farmington River, located in southwestern Massachusetts and tying together existing state parks and wildlife management areas in a wide swath from central Massachusetts to the Connecticut border;

—$4 million for the acquisition of cold water streams—to protect them and their access for all time;

—$3 million to expand and better protect the wilderness surrounding the Quabbin;

—$2 million for acquisition of land along the Connecticut River; and

—$7 million I already mentioned to acquire inholdings and buffers around wildlife management areas.

So you can see where wildlife is concerned we are not letting any grass form under our feet.

True to our heritage, we are continuing a variety of programs which will keep Massachusetts in the forefront of enlightened wildlife and natural history policy—we will continue to identify and manage the wildlife here, to spend substantial portions of our state budget on it, to educate the public about it, and to protect habitat—whether from acid rain or human encroachment. Because of that policy, we trust Massachusetts will be just as good a place for our children to live as it has been for us.

Current Water Management Policies and Procedures

Alvin L. Alm
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Washington, D.C.

I am pleased to be here with you this morning to discuss the Environmental Protection Agency and its approach to water pollution control. We at EPA are always happy to get together with the Wildlife Management Institute to share ideas and further cement the close relationship we need if we are to achieve our common goal: a clean and healthy environment for the American public and for one of our greatest national treasures, our wildlife.

Today I want to outline some of the progress the United States has made toward that goal, particularly over the past 13 years spanning the life of EPA. Alongside those achievements I will lay out some of the challenges ahead, with particular emphasis on matters of particular interest to you, such as our approach to protecting estuaries, wetlands, and the ocean.

Water quality improvements are, of course, a direct result of reductions in the amounts of pollutants released to receiving waters. As you know, under the Clean Water Act we limit the amounts of pollutants entering the nation's waterways through permits based on water quality standards. Currently, all States and jurisdictions have approved water quality standards. For most waters these standards include a fish and wildlife protection use, commonly refered to as a "fishable" use. Only eight States have any waters that are not assigned "fishable" uses. Beyond this, many streams are afforded additional degrees of protection designed to make them "swimmable" as well as "fishable."

Permits issued under these standards require that industries discharging wastes into navigable waterways install pollution control technology. Over the past ten years, EPA and States have been requiring firms to install Best Practicable Technology (BPT). This technology ordinarily removes enough conventional pollutants to restore a stream to its designated use. As of now, the overwhelming majority of industrial facilities on navigable waterways have BPT controls in place. This step has resulted in load reductions of 71 percent for biological oxygen demand; 80 percent for suspended solids; 71 percent for oil and grease; 52 percent for dissolved solids; and 74 percent for phosphate. Beyond this, BPT permits now in effect are controlling a significant amount of the potential discharge of heavy metals and toxic organic chemicals.

While we are not doing as well in dealing with water pollution from cities, we are making headway. In 1968, over 44 million people were poorly served by municipal sewage treatment plants that provided only primary treatment. The wastes of another ten million people received no treatment at all, and were discharged raw into the nation's waters. The Clean Water Act set out to change this by requiring secondary treatment, a far more sophisticated—and, needless to say, expensive—form of waste disposal. By 1977 we had 37 percent of the needed plants in operation, but by 1983 the proportion was 69 percent. Part of this progress is only apparent, since 1981 amendments to the Act reduced the number of facilities considered necessary. But the numbers reflect real progress as well, since facilities planned as long as ten years ago have finally begun operation, and many more are nearing that point.

These sewage treatment plants are removing about 13,600 tons per day of the two principal conventional pollutants, biological oxygen demand (BOD) and suspended solids—an improvement of 65 percent over 1973 levels. Thanks largely to this program of treatment facility construction, the total amount of pollutants entering the nation's waters in the form of municipal sewage has stayed roughly constant in the last decade, even though the population served has increased by 18 million, and municipal wastewater flow has grown by almost 7 billion gallons a day.

What, then, is the result of all this investment in technology to control water pollution? Recently, we reviewed State reports on water quality trends required under Section 305(b) of the Clean Water Act. Nationwide, the trend is good. In 1982, most streams surveyed were meeting the "fishable, swimmable" goal of the Clean Water Act. Twenty-one of 35 States reporting cite gradually improving water quality, with the other 14 showing water quality holding steady. No State is finding broad-scale water degradation.

Now that's a lot of progress to report. But it is the way of the world that once we have one problem nearly under control, new problems present themselves. In other words, our 13 years' experience has taught us how much there is left to do.

Among the most vexing problems remaining is that involving toxic organic chemicals and metals. As you know, removing these poisonous contaminants is that expensive "last mile" of environmental protection that the Nation has chosen to purchase. Setting requirements for these controls—for the best available technology economically achievable (BAT)—has not come easy. As a process, it has been a technically complex, administratively frustrating, and litigiously replete. Still, by the end of this year, EPA will have promulgated effluent guidelines defining BAT for all but one of the major industrial categories we are concerned with. The guideline for the last category, organic chemicals, is scheduled to be promulgated in 1986. When these guidelines are fully translated into action—through compliance with the permits to be issued under them—we will have reduced the amount of toxics reaching the Nation's waters by 660 million tons per year—more than 90 percent of the tonnage that would otherwise be discharged. We at EPA expect to issue the permits within our responsibility by the end of 1985, and we have beefed up our permitting staff by 30 percent to do it.

As for municipal sewage treatment, these plants are designed to remove conventional pollutants, not toxics. Nevertheless, a survey of wastewater entering and leaving municipal sewage treatment facilities reveals that well-operated plants meeting standard treatment requirements remove substantial amounts of toxics and heavy metals as well as the conventional substances they are designed to remove. While we still need to ensure adequate pretreatment of industrial wastes discharged through municipal sewage works, our job is made a bit easier by the knowledge that these plants provide a real "backstop" for toxic removal.

To guarantee that firms making use of municipal facilities for waste treatment are not interferring with municipal facilities, we are moving ahead with the National Pretreatment Program. Under this program, localities that allow industry to use the municipal treatment system must ensure that individual dischargers remove excess toxics from their waste water before it enters the municipal works.

A continuing debate over the pretreatment program has slowed its implementation since it was legislated in 1977. As of January 1984, only about 450—out of 1675 local programs required nationwide—had been approved, while only 19 States had been designated to administer the program.

Admittedly, the debate over pretreatment has been grounded in legitimate concerns on all sides. Those of you who have followed the Clean Water Act reauthorization process know that there have been several proposals to change the statutory language. But after much review, EPA has come down squarely behind the existing provisions as being the best way to go.

Let me assure you that we are deadly serious about our legal obligation to mount an effective industrial pretreatment program. For one thing, in accordance with the Clean Water Act we are now facing impending compliance deadlines. Some 10,000 electroplaters and metal finishers nationally have deadlines of either April or June of this year to meet pretreatment requirements. The requirements are not new. In fact, the standards for this industrial category have been in place for three years, and neither EPA, States, nor approved municipal facilities have the authority to extend this statutory deadline.

In some respects the situation is reminiscent of an unwritten rule of baseball: don't ever stop to argue while the ball is still in play. Firms who hoped to avoid their responsibilities under the pretreatment program have nevertheless remained under legal responsibility to install controls. Now that they have lost the argument, those who have delayed are in danger of being called "out." In other words, you can expect to see some enforcement activity in this area. Meanwhile, an EPA task force is continuing to explore administrative improvements to speed up implementation of the program.

As for another difficult area, municipal enforcement, the Administrator recently signed a policy that enunciates our approach. Some municipalities seem to think they may wait until they receive a Federal grant before they commence contruction of needed municipal facilities. The law is quite clear on the matter: all communities are to achieve secondary treatment or better by July 1, 1988. It is EPA's responsibility to enforce the law, regardless of who has received a grant and who has not.

For municipalities that have received a grant but are now in non-compliance, our enforcement will be vigorous but realistic. Rather than apply for fines or even more draconian sanctions, EPA will request the court in such cases to require the municipality to prepare what we call a "composite correction plan." This plan requires a diagnosis of the compliance problem, a statement of planned remedies, and a schedule for attaining compliance—all at community expense. We will also concentrate on setting compliance schedules for two other priority categories—other major facilities and minor facilities that are contributing to water quality problems. We think this approach concentrates on the bottom line, which is municipal compliance in support of water quality.

In the case of municipalities that will not have facilities complete by July 1, 1988, we will ask that they be required to develop a municipal compliance plan, which lays out plans, resources, and a schedule for the design and construction of needed facilities as soon as possible after the legal deadline.

So far, I have discussed control of point sources of pollution. We have found in the Chesapeake Bay and in the Great Lakes, and in other drainage basins, however, that the control of point sources is not enough to prevent environmental degradation, and that we must now turn our attention more fully to the control of nonpoint sources.

There is general agreement about the significance of nonpoint source pollution, though there has been little enthusiasm for instituting the broad-based management practices needed to deal with the problem. Chesterton once overheard a speaker say of Christianity that it had been tried and found wanting; he replied "No, rather it has been tried and found difficult." The same might be said of nonpoint source control. The Department of Agriculture has had some success with its program of soil conservation, flood control, and water conservation. However, we need to help focus their network of technical assistance and support on agricultural and silvicultural activities directly aimed at water pollution control. We must establish the ethic of using best management practices to derive benefits both on the farm and in the stream.

Moving from the theory to the practice of nonpoint source control will require strong environmental leadership, and EPA is prepared to provide it. To promote creativity and cooperation between the States and Federal Government in this area, I have formed a Task Force to forge a strategy for improved implementation of nonpoint source controls. We will involve representatives from the States and the Department of Agriculture, as well as EPA, in this effort. This is a major step forward in bringing a coordinated, common sense approach to an area that heretofore has been marked more by promise than by progress.

One place where nonpoint source controls will have a great impact is in the Chesapeake Bay, a magnificent estuary that provides a unique natural environment as the nurturing ground for many marine creatures. As you know, the Bay, like many estuaries, is threatened by eutrophication caused by excessive discharge of nutrients, as well as toxification from industrial discharges. Our studies show that the major unchecked source of nutrients reaching the Bay is agricultural runoff into the major tributary estuaries. The challenge to control such pollution is not an idle one, as those of you who have hunted and fished on the Eastern Shore must surely know. Continued sacrifice of the Bay's vitality would cost us our fisheries, our sport, and our sheer enjoyment of one of nature's greatest gifts to America.

I'd like to turn for a moment to another concern of yours related to nonpoint source control: wetlands protection under Section 404 of the Clean Water Act—the so-called dredge and fill program that EPA runs in conjunction with the Army Corps of Engineers. Although the pressures to convert wetlands to agriculture or other development make 404 a very controversial program, EPA remains steadfastly committed to its importance.

Once regarded as wastelands, wetlands are now understood to provide irreplaceable benefits not only to wildlife, but to people as well. As for wild creatures, it may be enough to point out that one-third of all endangered species depend on wetlands for some part of their life cycle. As for the American public, wetlands provide natural flood prevention and pollutant filtering systems, and contribute greatly to ground-water recharge. Right here in the Boston area, wetlands in the Charles River Basin absorb floods that would otherwise cause millions of dollars in annual damage.

To be sure that we do not give in to mindless development of this essential resource, we are working on a number of fronts to strengthen our 404 program. We are negotiating with the Corps of Engineers to clarify jurisdictional authority, especially in areas where development pressures are greatest. We are conducting studies to evaluate the effects of wetland conversion to agricultural use in such diverse areas as bottomland hardwoods, Alaskan tundra, and Atlantic Coast swamps. These studies will lead to regional guidance for defining 404 jurisdiction over wetland conversion.

We are also exploring general permits as one method of program administration. In doing so, EPA will ensure that dredged or fill material does not significantly impair municipal water supplies; wildlife; shellfish beds; and spawning, breeding, or other fishery and recreational areas. We are especially concerned to find more effective ways to protect small inland wetlands. These are typically small bogs, marshes, and swamps that have been filled casually in the past.

Finally, you may know of EPA's renewed emphasis on ocean protection. In line with this we are establishing a single Office of Marine and Estuarine Protection to manage the ocean dumping program; the ocean sewage discharge waiver program under Section 301(h); and national oversight of the Great Lakes and Chesapeake Bay renewal programs.

To make you familiar with our thinking on this matter, let me share with you some recent debate we have had on marine policy at EPA.

We are currently engaged in discussions with other Federal agencies on this policy, but I expect the general thrust will be similar to this discussion. EPA believes that ocean disposal must be approached carefully because there is still substantial scientific uncertainty about the potential impact of the ocean disposal of different wastes, and because of the difficulty in monitoring and our limited capability for recovering materials in the ocean. Hence, the Agency will continue to regard the ocean as a unique resource to be protected. Thus, the Agency's general approach to ocean dumping may be summarized as follows:

1. We will, as an overall principle, protect the oceans from significant adverse effects of waste disposal. We will particularly assure that they are not used for "cheap" waste disposal as a matter of short-run economic considerations alone.
2. In any specific case we will allow ocean disposal of a waste only if it is judged environmentally preferable to other practicable waste management alternatives.
3. For the long run, we will actively encourage environmentally beneficial approaches such as waste minimization, recycling, or reuse.

This morning I have tried to give you an indication of our priorities and progress in protecting the nation's waters for people and wildlife alike. Long before Europeans arrived, this nation was blessed with a fabulous abundance of natural resources; our wildlife is among the richest and most varied in the world. Until recently, human activity threatened the very existence of our wildlife. If we are not careful, that threat will continue to arise in years to come.

If human activity is the source of the threat, then human activity can be the means to remove it. At EPA, it is our duty to shape the activities needed to protect this magnificent natural resource. We are fortunate to have such an ally in this endeavor as the Wildlife Management Institute. I trust we can continue to work together on the important task of restoring and protecting the quality of our environment.

International Cooperation for Wetland Conservation: The Ramsar Convention

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Introduction

Wetland preservation is essential for the conservation and management of numerous species, especially of waterfowl, fish, herpetofauna and invertebrates. In addition, economic benefits from fisheries, agriculture, water storage and flood control, as well as tourism and recreation are all directly related to the health of wetland areas. Nonetheless, wetlands are also among the world's most threatened habitats due to accelerating drainage, reclamation, pollution and other factors.

Cooperation among countries is a prerequisite for effective wetland management measures given the international "linkages" peculiar to these habitats. Wetlands, being dependent upon their water supply, are affected, for example, by impacts upon streams and rivers occurring at considerable distances and in many cases beyond national boundaries; wetlands are seriously degraded by transboundary air and water pollution; and much of the wetland fauna are migratory species whose conservation and management require international cooperation. Therefore, it should not be surprising that there is an international agreement which specifically focusses upon wetland conservation.

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, sometimes also known as the Ramsar Convention from its place of adoption in 1971 in Iran, provides the framework for this necessary cooperation. It was the first of the modern global nature conservation conventions and is unique in being the only convention dedicated to the preservation of selected ecosystem types along with the species dependent upon them. Of course, it cannot serve to control all the deleterious factors mentioned above, but through its provisions States do have opportunities to consult, to adopt agreed upon management measures, and to indicate to the world at large that special attention will be devoted to conserving selected wetland sites of "International Importance."

However, the Wetlands Convention suffers from a number of weaknesses. It has been criticized for its lack of stringency as well as for inadequate administrative provisions. Both of these factors have led to the Convention having fewer Contracting Parties and less impact than other global conservation conventions (e.g., the Convention on International Trade in Endangered Species of Wild Fauna and Flora or the World Heritage Convention). Nonetheless, there is ample evidence that the Ramsar Contracting Parties find the Convention to be a useful conservation instrument. More important, they are currently taking steps to remedy its most glaring deficiencies.

This paper will provide an overview of the provisions of the Wetlands Convention, of the efforts underway to strengthen its coverage, and the requirements for the future.

General Background on the Convention

The Wetlands Convention was adopted following a series of international conferences and technical meetings mainly held under the auspices of the International Waterfowl Research Bureau (IWRB). It entered into force in late 1975 upon the deposit of an instrument of ratification by Greece, the seventh State to do so. As of 1 February 1984, the Convention has 35 Contracting Parties throughout the world[1].

The Secretariat, or Bureau as it is referred to in Article 8 of the Convention, is provided by my organization, the International Union for Conservation of Nature and Natural Resources (IUCN). We are assisted in this task by the IWRB as Scientific Advisor. However, as will be discussed below, provisions do not exist within the Convention to finance this work.

The board objectives of the Convention are to stem the loss of wetlands and to ensure their conservation in view of their importance for ecological processes as well as their rich fauna and flora. To meet these objectives, the Convention provides for general obligations relating to the conservation of wetlands throughout the territory of the Contracting Parties and for special obligations pertaining to those wetlands which have been designated in a "List of Wetlands of International Importance."

Specific Provisions of the Convention

Scope

The Convention takes an extremely broad approach in defining "wetlands" to be covered under its ambit. Wetlands, as defined in Article 1, are "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters the depth of which at low tide does not exceed six metres." In addition, Article 2 provides that wetlands covered "may incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies or marine water deeper than six metres at low tide lying within the wetlands."

As a result of these provisions, the coverage of the Convention extends to a wide variety of habitat types including rivers, coastal areas, and even coral reefs!

Main Obligations

There is a general obligation, as noted above, for the Contracting Parties to include wetland conservation considerations within their national planning. Article 3, para. 1 provides: "The Contracting Parties shall formulate and implement their planning so as to promote. . . as far as possible the wise use of wetlands in their territory." The Contracting Parties have interpreted this requirement to concern the maintenance of the ecological character of wetlands (Recommendation 1.5 of the First Conference of the Contracting Parties, Cagliari, 1980), which has significant implications for wetland conservation measures.

A second obligation under the Convention is the designation of wetlands for inclusion in a "List of Wetlands of International Importance" maintained by IUCN as the Convention Secretariat. Specific conservation duties pertain to the listed sites. At least one site must

[1] Algeria, Australia, Austria, Bulgaria, Canada, Chile, Denmark, Finland, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Iceland, India, Iran, Italy, Japan, Jordan, Mauritania, Morocco, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Senegal, South Africa, Spain, Sweden, Switzerland, Tunisia, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, Yugoslavia.

be designated by each Contracting Party (Article 2, para. 4) with selection based on "international significance in terms of ecology, botany, zoology, limnology or hydrology" (Article 2, para. 2). Criteria for selection, with greatest relevance to importance for waterfowl, were adopted by the Contracting Parties at their 1980 Conference.

Finally, Contracting Parties are obliged to promote the conservation of wetlands in their territory through the establishment of nature reserves. This applies to wetlands whether or not included on the "List".

The List of Wetlands of International Importance

In practice, the Contracting Parties have gone far beyond the mandatory designation of only one site; as of 1 February 1984 some 285 sites covering in excess of 18,764,967 ha have been designated for the List. Furthermore, no site has been deleted from the List and replaced by another, despite the possibility that this might be done, by "a Contracting Party in its urgent national interest" (Article 4, para. 2).

An analysis of the ecological coverage of Ramsar sites was provided for the First Conference of the Contracting Parties[2]. Therein it was noted that as of 1980 most Contracting Parties had designated wetland sites on the basis of their importance for waterfowl, although other faunal and floral interests had obviously been taken into consideration. To illustrate this point, examples were given of designated sites in Italy and the United Kingdom of relatively minor importance for waterfowl but included on the basis of their botanical/limnological interest. This broadening trend has continued, and presently a rather comprehensive selection of major wetland types is included in the Ramsar List, especially for the Western Palearctic region. A Directory to sites on the Ramsar List is maintained by IUCN's Protected Areas Data Unit, which details both biological and physical features of interest for each site. Furthermore, efforts are underway by IUCN and IWRB to develop a comprehensive Directory to wetland areas in Latin America as well as by IUCN and UNEP for Africa. It is also planned that a similar project be carried out in the near future for Asia. The data from these works will be used to spotlight areas for future coverage under the Convention, in "shadow list" publications.

It should finally be noted that Ramsar sites may encompass very large areas. Although on accession in January 1981 Canada designated a relatively small site covering 2200 ha, it later announced the addition of 14 more sites covering some 10 million ha. Mauritania, upon its accession in October 1982, designated a site of 1,173,000 ha. A third example can be seen with Australia recently adding 20 sites totalling 271,043 ha in two of its states.

Values of the Convention Perceived by the Contracting Parties

National reports on the implementation of the Convention are submitted to Conferences of the Contracting Parties. These provide an interesting overview of the values that the Contracting Parties have attached to the Convention. Italy has indicated that its general national policy on wetland conservation has been based on the elements of the Convention and that the Convention has stimulated active conservation collaboration between its Central Government and Regions. Hungary has noted that the Convention provides important impetus for States to cooperate for wetland conservation and as a result has urged

[2] IUCN/IWRB, (1980), "The Ramsar Convention: A Technical Review", Conference on the Convention of Wetlands of International Importance Especially as Waterfowl Habitat, CONF/4, Cagliari, Italy, 24–29 November 1980.

that efforts be made to encourage its neighbor, Romania, to accede to the Convention and designate the Danube Delta for the List, in order to facilitate its own national wetland conservation efforts. Norway has also said that the Convention has provided the basis for its national wetland conservation policy, with particular attention being given to preparing wetland inventories, ensuring the protection of a network of wetland reserves, and the prevention of degradation of wetland habitats. The Swedish Government has commented that the Wetlands Convention has increased national interest in wetlands, spotlighted their importance both nationally and internationally and promoted the concept that migratory waterfowl are an international asset.

Reports from the Contracting Parties have also stressed the value of the Convention in helping to prevent detrimental changes to sites included in the List. Examples include a reduction in the area to be affected by harbor extensions in the Wadden Sea between the Federal Republic of Germany and the Netherlands due to the designation of Ramsar sites in the region; the reversal of drainage orders within the Colfiorito Marsh, a Ramsar site in Italy; the cessation of commercial fisheries in Lake Haleje, a Ramsar site in Pakistan; and the rejection of proposed plans to sink a stricken oil tanker close to the Minsmere-Walberswick Ramsar site in the United Kingdom.

Deficiencies in the Convention—and Steps to Overcome Them

Despite the positive examples given above, it must be realized that the Wetlands Convention has not been fully effective due to several inherent weaknesses. In the first place, as has been noted in a national report of the Federal Republic of Germany, due to the imprecise terms of the Convention the implementation of its measures are dependent more upon moral than legal commitments. However, given the sustained goodwill of the Contracting Parties, this lack of stringent legal obligations has not been an absolute hinderance to the successful operation of the Convention. More significant has been the absence of administrative provisions. Indeed, in 1980 the World Conservation Strategy assessed the Wetlands Convention by noting, "Experience has shown that an international Convention must have a (permanent, secure) secretariat and financial mechanism to be effective, but the Wetlands Convention lacks both"[3]. Furthermore, the Convention does not have an amendment procedure, which has frustrated efforts to address its deficiencies. Another problem has been the presence of an unfortunate final clause establishing English as the only authentic language, thereby posing a serious political difficulty for participation by certain States, French and Spanish-speaking countries in particular. An expert paper prepared for the First Conference of the Contracting Parties discussed these problem areas in detail[4].

Against this background, the First Conference of the Contracting Parties was called by IUCN in November 1980 with the assistance of IWRB and at the invitation of the Italian Government. Conference purposes were to assess the implementation of the Convention five years after its entry into force, to discuss its deficiencies and to chart a course to overcome its most serious problems.

The Cagliari Conference was eminently successful. Following a review of national experience, the Contracting Parties adopted ten recommendations aimed at improving the

[3] IUCN/UNEP/WWF, (1980), "The World Conservation Strategy", Morges, Switzerland.
[4] IUCN, (1980), "The Ramsar Convention: A Legal Review", Conference on the Convention of Wetlands of International Importance Especially as Waterfowl Habitat, CONF/5, Cagliari, Italy, 24–29 November 1980.

functioning of the Convention. These included calls to arrange for the necessary amendment of the Convention and for the immediate provision of voluntary funding to the Secretariat until such time as an amendment providing for a sound financial base might become operative. Contributions have been forthcoming from several of the Contracting Parties in this way. However, due to legal and constitutional impediments to voluntary financing in many other Contracting Parties, it has become clear that adequate financial support can only be ensured following the formal amendment of the Convention.

Since the Cagliari Conference, IUCN has devoted renewed attention to servicing the Convention and in December 1982 organized an Extraordinary Conference of the Contracting Parties in Paris wherein a Protocol was adopted providing for an amendment procedure and additional official language versions of the Convention. At that time the Netherlands Government offered to host the next regular Conference of the Contracting Parties at Groningen in May 1984 to consider specific amendment proposals and to review further implementation requirements.

Preparations for the Second Conference of the Contracting Parties

The Host Government of the Netherlands, along with IUCN and IWRB, have devoted extensive efforts to ensure that the Groningen Conference provides an important impetus for the implementation of the Wetlands Convention. In addition to a review of national reports, amendments to the Convention will be discussed, four expert presentations will be made on "The Ecological Importance of Wetlands", "The Interdependence of Wetlands", "Land-Use Approaches to Wetland Areas Throughout the World", and "Conservation of Wetlands: Legal and Planning Mechanisms." Finally, a draft entitled "Framework for Implementing the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar, 1971)" will be reviewed. It is intended that detailed project Action Points pursuant to specific items in the "Framework" might be adopted by the Contracting Parties for priority attention in the period immediately after the Conference.

Draft "Framework" for Implementing the Convention

The "Framework" document, based upon the text of the Convention and the Recommendations of the Cagliari Conference, has been developed by the Secretariat to help guide the Contracting Parties in the achievement of the Convention's objectives. The "Framework" is comprised of four sections: "National Wetland Policies," "List of Wetlands of International Importance," "International Action," and "Secretariat Functions."

National Wetland Policies

The draft "Framework" suggests that national measures dealing with the following points should be considered in order to give full effect to the Convention:

1.1 Development of a nationwide inventory of wetlands, covering all habitats listed in Article 1.1 to the Convention;
1.2 review of impediments, particularly legal and fiscal, to conservation of wetlands;
1.3 adoption of policies and legal instruments to ensure wetland conservation by both public and private parties;
1.4 development of land-use planning within the framework of geophysical units to take account of wetland conservation requirements;
1.5 adoption of measures to guarantee quality and quantity of water supplies to wetlands;

1.6 evaluation of environmental effects before decisions are taken which would significantly transform wetlands;
1.7 provision of measures to mitigate adverse effects of wetland transformation, if decided upon;
1.8 establishment, management, and monitoring of wetland reserves, including marine parks;
1.9 management of man-made wetlands where original natural sites have been destroyed and if possible rehabilitation of degraded wetlands;
1.10 preservation of external natural features essential to maintain the integrity of wetlands;
1.11 prevention of over-exploitation of wetland resources;
1.12 prevention of exotic species introduction to wetlands, and, where appropriate, eradication of introduced species;
1.13 data collection, monitoring, and research related to species dependent on wetlands, for the purpose of management and as a contribution to international actions to sustain wetland management efforts;
1.14 review of status of wetland species, identification of endemic, rare, or endangered species and their critical habitat areas;
1.15 development of management plans to maintain the populations of wetland species and of recovery plans for endangered species;
1.16 promotion of public education and awareness with regard to the value of wetlands.

List of Wetlands of International Importance

The "Framework" document includes the following proposals as a means to increase the number of listed wetlands and to ensure their conservation:

2.1 Further development of the criteria adopted at the Cagliari Conference for the selection of wetlands for the List, with special reference to wetland types and species habitat insufficiently represented on the List;
2.2 designation of additional appropriate wetlands in the light of agreed criteria, national inventories and of international "shadow" lists;
2.3 effective conservation of listed wetlands, including wardening, development of buffer zones, and other land-use control mechanisms;
2.4 monitoring of any changes in the ecological character of listed sites, and reporting such changes to the Secretariat.

International Action

As the purpose of the Convention is to promote wetland conservation through international cooperation, the "Framework" proposes that the Contracting Parties may wish to consider the following measures:

3.1 Cooperation in wetland management for migratory species conservation, control of extended harmful influences, and conservation of trans-frontier wetlands through mutual consultation and coordination of policies;
3.2 special attention should be paid to promoting adherence to the Convention by developing countries, where many wetlands are still in pristine condition and where the major opportunities for wetland conservation are likely to occur in the next 20 years;
3.3 provision of special assistance to developing countries in the elaboration of their national wetland policies, in conservation and management of listed wetlands and

other aspects of wetland conservation including data collection, monitoring, research, public awareness, education, and training;

3.4 where bilateral or multilateral aid programs to developing countries affect wetlands, ensure that conservation measures are included in such development projects, especially through evaluation of environmental effects before any wetland transformation is carried out.

Secretariat Functions

Finally, the "Framework" document notes that in order to achieve the objectives of the Convention and the Recommendations of the Cagliari Conference, the Contracting Parties require the services of an active Secretariat adequately funded by the Contracting Parties. The "Framework" then elaborates the tasks which IUCN as a fully supported Secretariat should perform with the assistance of IWRB and other appropriate organizations:

4.1 Promotion of the Convention with States that are not yet Contracting Parties;

4.2 maintenance of the List of Wetlands of International Importance;

4.3 collection and dissemination of reports from Contracting Parties on wetland conservation and on changes in ecological conditions in listed wetlands;

4.4 organization and servicing of Conferences of the Contracting Parties;

4.5 assistance in the review of criteria for selection of wetlands for the List;

4.6 assistance in the development and maintenance of an international wetlands data base, including scientific, management, legal and planning aspects, and development and maintenance of international "shadow" lists and identification of priority research themes;

4.7 assistance in the preparation of scientific reports and technical studies and guidelines on the status of specific wetland types and species protection measures, planning and legal methods, management techniques, and management or recovery plans for endemic, rare, or endangered species, with the assistance of appropriate organizations and experts;

4.8 stimulation of public awareness by preparing and disseminating materials on the importance of wetland conservation;

4.9 provision of assistance in developing a curriculum for training personnel;

4.10 coordination of activities with the Secretariats of other relevant international Conventions and maintenance of cooperative links with concerned intergovernmental and non-governmental organizations.

Requirements for the Future

The future for the Wetlands Convention is considerably brighter than it was only a few years ago. A Protocol is in place which provides the basis to amend the Convention and draft amendments addressing its most serious problem areas have been prepared; the "authentic language" obstacle has been removed to foster increased participation especially by French and Spanish-speaking States; financial support, although in a limited amount, is being made available by the Contracting Parties on an interim voluntary basis for Secretariat servicing of the Convention; and the Netherlands Government has taken the initiative to host a major Conference in May 1984 to provide a strong boost for the Convention.

To take advantage of all these recent initiatives designed to enable the Wetlands

Convention to reach its full potential, three requirements need to be met in the near future: the formal amendment of the Convention, an increase in the number of Contracting Parties, and cooperation in agreed upon management projects. A few words should be said about each of these points.

Amendment of the Convention

In view of the goodwill of the Contracting Parties in applying stringently the spirit if not the letter of the Convention in their wetland conservation policies, Convention amendments are currently only being proposed for administrative rather than substantive issues. These include more structured arrangements for regular Conferences of the Contracting Parties, including improved opportunities for attendance by observers; the authority for Conferences of the Parties to adopt financial provisions to provide resources for the organization of meetings, the operation of the Secretariat, or for other purposes; the authority for Conferences of the Parties to create subsidiary bodies, in particular a Scientific Committee; the establishment of a permanent secure Secretariat to perform the range of functions as noted in the "Framework" document; and the insertion of improved final clauses, including a mechanism for the settlement of disputes.

The 1982 Protocol, which sets the amendment procedure, will enter into force by its terms upon the ratification or accession of two-thirds of the Contracting Parties as of the time of its adoption (December 1982). This means that action by 22 of the then 33 Contracting Parties are required. It is a top priority that this total be reached in the near future; about half of the necessary States have deposited their instruments of ratification or accession to date.

Increase in the Number of Contracting Parties

A cursory look at the current listing of the Contracting Parties is all that is needed to see that although coverage is excellent in the Western Palearctic region, it is spotty elsewhere in the world. In particular the Western Hemisphere is a problem, with only Canada and Chile involved. The adoption of an official Spanish language Convention text will help to remedy this situation it is hoped. Similarly, participation in the Convention by the United States would provide a major impetus to increased Western Hemisphere involvement and hence improved regional cooperation for wetland conservation.

IUCN has recently been in contact with many States which have indicated their intention to join the Convention. Overtures by Angola, Botswana, Central African Republic, Costa Rica, Czechoslovakia, Israel, Ivory Coast, Kiribati, Panama, St. Lucia, Sri Lanka, Sudan, and Venezuela are indicative of an increased interest in the Convention throughout the world.

Increased Cooperation in Management Projects

As noted above, it is intended that the Groningen Conference adopt a series of "Action Points" for cooperative project activities. In addition to financial support from Governments, it can be envisaged that funds from private bodies such as the World Wildlife Fund can be tapped for these purposes. What must also be arranged, however, is expert input for wetland conservation based on national experience. Assistance from States with special expertise in wetland conservation will be essential and thus there is a further requirement for increased involvement in the Convention by key non-Party States. Primarily, given extensive wetland conservation experience at both state and federal level in the United States, it would be extremely significant if the U.S. might soon join the Convention to assist in the planned program for increased international cooperation for wetland conservation.

Conclusion

Following a difficult adolescence, the Wetlands Convention is coming of age. This first modern global conservation convention, and until now the weakest, has the potential to do what no other existing conservation convention can do—foster cooperation to ensure the conservation of particular extensive habitats and the species found therein. The Contracting Parties are demonstrating their determination to make the Convention a success. IUCN as Convention Bureau and IWRB as its Scientific Advisor are similarly committed to promote and envigorate the Convention. With continued goodwill from the Contracting Parties and with the involvement and assistance of other conservation minded States and organizations, the important objectives of the Convention can be achieved. The opportunity should be seized to expand the use of the Ramsar Convention to help conserve wetland areas. The time to act is now.

Using Socioeconomics in Resource Management

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Utility of Socio-Economic Research in Wildlife Management

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Socio-economic research in wildlife management has involved such diverse disciplines as educational psychology and criminal justice. The topics of research have been équally broad. Studies have been done on the profile of deer poachers, bio-politics of endangered species, attitudes of children toward wildlife, and a variety of other issues. This area of research also has the best and worst examples of how to apply research information to management. The finding that Americans spent $40 billion to hunt, fish, and appreciate wildlife in one year, 1980, has been the most quoted result of wildlife research in the twentieth century. This information from the *1980 National Survey of Hunting, Fishing, and Wildlife-Associated Recreation* has been used to support pending legislation, save budgets, protect positions, and defend management of wildlife resources throughout North America. A lot of socio-economic information, however, has not been used in wildlife management.

The purpose of this paper is to review the utility of socio-economic research in wildlife management. This paper will explain how socio-economic research has failed to be accountable, why it has not always been used, how it sometimes has been abused, and why it is often viewed as irrelevant. This paper will also discuss how socio-economic research has become part of the wildlife management process, where it fits, and how information has been used to benefit wildlife resources and people. Conditions leading to management use of information will be discussed. This paper will conclude that researchers and managers should develop a better understanding of the management process in order to plan for the use of information.

Failure to Produce and Use Socio-Economic Information Relevant to Wildlife Management

There are three types of information problems that relate to the production and use of socio-economic information in wildlife management: (1) relevant information is not available, (2) irrelevant information is produced, and (3) relevant information is not used.

Relevant Information is not Available

The purpose of wildlife management is to produce the most wildlife-associated benefits to the most people at the least cost. Since wildlife resources are managed for public benefit, we need information on both wildlife and people. Specifically, we need to know which publics are interested in wildlife, what benefits are desired, and what people are willing to pay for wildlife (Gottschalk 1966).

Several research studies (e.g., Lucas 1970) have shown that natural resource managers require objective information to develop a good understanding of public sentiment. Otherwise, managers are likely to assume that public needs and preferences are the same as their own. Decisions may then be based on the managers' preferences, thereby reducing benefits of resource management to other people.

This same process that makes socio-economic information so important in wildlife management also explains why data are not always available. At times, managers may think they already know what the public wants. Socio-economic information is not perceived to be necessary. Some individuals may make a conscious effort to avoid socio-economic information that would jeopardize an elitist value. For instance, Hay (1971) argued that some wildlife biologists have a "boondock syndrome", characterized by a preference for trophy species and pristine ecosystems. This attitude may result in contempt for the idea that wildlife management might be applied to improve the quality of living environments in urban and suburban ecosystems. Data that relate to these broader social needs may be actively avoided to the point where research studies are not funded. This situation almost occurred with the nonconsumptive portion of the proposed 1985 National Survey of Hunting, Fishing, and Wildlife-Associated Recreation. It was suggested that socio-economic research on nonconsumptive users be dropped because the studies were financed with funds from hunters and anglers. The suggestion was not adopted.

Socio-economic information may not be available because wildlife managers did not anticipate the need for these types of data. It takes time to establish specialized research positions, develop contract research programs, and to locate interested research personnel, even when the need for socio-economic information is clearly perceived. As government becomes more responsive to the will of the public and more conscious of costs, it is likely that the demand for socio-economic information will increase.

Irrelevant Information is Produced

A second type of information problem occurs when research produces socio-economic information for which there is no management need. Information, in this case, may block the attainment of wildlife management objectives by distracting and confusing managers with too many irrelevant numbers, graphs, tables, and statistics. The failure to produce relevant information may relate to differences in perception between researchers and managers. As discussed by Lyon (1963), researchers can become frustrated by the reluctance of management to admit that problems exist. Researchers can become upset that they are not consulted by management and disturbed by management's lack of attention to the future. Some researchers may withdraw from the management process and retreat into peer or hobby research (Bennett 1976).

Research may challenge dated management objectives. In these cases, researchers may attempt to manipulate programs, sell projects to management that may not be needed, and use experimental studies to introduce innovative management schemes. Obviously, socio-economic information that contradicts the objectives of a wildlife management program will not be used until program goals are changed. Socio-economic research may identify issues that are viewed as someone else's problem. For example, limited attention has been given to some of the results of Jackson et al. (1981), although other research findings from this group have been carefully evaluated and used. The article in question concluded that poor hunting ethics may sometimes be a by-product of wildlife management activities. Managers may assume that irresponsible hunter behavior is someone else's problem because human behavior has not yet been formally described as an objective of wildlife management programs.

There may be situations where this type of information problem can be worthwhile, even though facts may not be applied directly to management. Managers should be careful about discounting the value of pure research, since these studies may lead to major breakthroughs, offer important spin-offs, and have some public relations values. Holt and Talbot (1978) supported the need for some basic research as a responsibility of the profession to better understand ecosystems. Ideally, research studies should be structured to accomplish practical objectives while also providing some contribution to theory and knowledge. Good researchers can attain this mix of objectives without incurring much additional cost. Good managers can encourage the development of this ability among researchers, thereby limiting withdrawal from management.

Relevant Information is not Used

Socio-economic information may not be used because of differences in orientation between wildlife managers and social scientists. Clark (1974) thought that communication between wildlife managers and social scientists might be limited because of professional jargon and differences in orientation (i.e., resources versus people). This tension between resource and people orientations may explain the reluctance of wildlife managers to fully apply the multiple-satisfactions approach of Hendee (1974). Managers often accept recreational benefits to humans as by-products of resource management programs. Thus, they would prefer to establish management goals on the basis of resource needs. The multiple-satisfactions approach requires more than this; that resource management goals be based on needs of people.

Sometimes, a difference in orientation towards the future can result in a failure to look at new information. Lyon (1963) explained that wildlife administrators with immediate needs for information can become frustrated with the future-orientation of research. After repeated attempts to encourage short-range research, some administrators may stop going to research for consultation, resist recommendations made for action, and ignore information that was requested.

Burgoyne (pers. comm.; Michigan Department of Natural Resources) thinks that wildlife managers can sometimes be too scientific in their perspective. Until recently, many of our most influential wildlife managers considered themselves to be wildlife biologists. When faced with a problem, the biologist considers biological solutions. He or she has an ecological ethic and can do nothing that is not "biologically right." The wildlife biologist does not consider the demands of the public because these people are not professionally-trained biologists. Social and economic issues are not considered to be part of the job of the wildlife biologist. These are viewed as matters that should be considered by commissioners and legislators. This self-image of some wildlife managers may result in the failure to use socio-economic information.

In rare situations, research may not be applied because of suspected bias. Witter and Sheriff (1983) discussed how organized waterfowl hunters challenged the creation of a state waterfowl stamp in Missouri by presenting information to document opposition. Since the data were suspect, a scientific survey was conducted. This survey, in contrast to the initial data, showed that there was support for the state waterfowl stamp.

Even in cases where the values of managers are aligned with those of others and there is a cooperative spirit with research, socio-economic information may not be applied because of powerful political forces that diminish the importance of factual information. For example, a national tax to fund nongame wildlife programs has been authorized but there has yet to be an appropriation made. The appropriation was not politically feasible during a time of tax reduction and government deregulation, despite a vast amount of socio-economic information showing strong voter support for a federal nongame wildlife program.

Sometimes, socio-economic information is not used because research fails to package results to catch the attention of management. Results may be presented at the wrong time or place to have management impact. Researchers may not understand the political setting in which information is exchanged and provide data to the "wrong" people. Socio-economic information may not be used because researchers erroneously assume that it is someone else's job to apply the information that they produce.

Use of Available Information

The value of research depends on use. Information is not consumed, but can be used over and over again. Interest accrues each time a fact is used. This interest serves to reduce the cost of the initial investment. Due to the cumulative effect of using information, research investments in fact-finding can be especially profitable. It is not unusual for research investments to return over 1000 percent in recreational values (MacMullan 1953).

Significant environmental impacts can arise from the use of socio-economic information. Often, data are used to show public support for new programs, legislation, and administrative rules. Socio-economic data have been used in litigation to defend major environmental programs. Information on hunting accidents and outdoor ethics has been used to modify educational material reaching hundreds of thousands of youngsters in hunter safety programs. Socio-economic information on recreational demand has influenced timber rotation, facility development, and land management on millions of acres.

Role of Information in Wildlife Management

The preceding analysis of research utility showed that application of socio-economic data requires management appreciation for both resource and public service values. A cooperative spirit is needed between research and management, as well as a clear set of objectives for wildlife programs. A shared definition of the management process is required to describe the kinds of information needed at different stages of wildlife management.

Ritchie (1972) proposed that the kinds of information needed by management be described by six functional areas of activity (personnel, production, marketing, coordination, finance, and control), by three levels of management (strategic, tactical, and operational), and by four stages of management (analysis, planning, execution, and control). This model has value, but needs to be modified before it can be applied to wildlife management.

Functions of Wildlife Management

The six areas of corporate activity proposed by Ritchie (1972) seem too structural. Evaluating the role of research in wildlife management requires that activity be classified by function. It appears that all wildlife management activities can be reduced to four basic functions: (1) acquisition, maintenance, and improvement of wildlife habitat, (2) control and expansion of wildlife populations relative to habitat, (3) optimization of net public benefits derived from habitats and populations, and (4) integration of wildlife management with other governmental programs and commercial ventures.

Wildlife habitat management alters vegetation, water, soil nutrients, or other environmental factors affecting wildlife communities. Wildlife population management directly alters species diversity and population density. Examples of activities with direct impacts include control of diseases and parasites, removal of surplus animals through hunting or predator control, and the re-introduction of a native species to a vacant niche. Optimization of net public benefits requires that social benefits of wildlife and management minus social costs be the highest possible. This would mean that consumptive, educational, aesthetic, and other social benefits of wildlife be properly mixed. The last function of wildlife management—integration with other activities—attempts to influence land use programs in related areas that have impacts on wildlife (e.g., agriculture, forestry). Similarly, an attempt may be made to minimize adverse impacts of wildlife programs on other programs and to strengthen positive impacts of wildlife management that have beneficial influences elsewhere.

Structure of Wildlife Management

The process of wildlife management mobilizes human, natural, and organizational resources to meet specified objectives. The process itself appears to have four basic parts: (1) analyzing, (2) deciding, (3) acting, and (4) evaluating. Analyzing is comparing a current situation with an idealized goal state. This comparison results in recognizing problems present in the current situation and opportunities that might be developed. Analysis results in a list of alternative actions, along with costs, and the probable degree to which the goal situation will be approached for each alternative. Deciding is picking among these alternatives based on consensus about the probability of each alternative producing an outcome and the value of approximating the goal state. Acting to implement the selected alternative follows. This involves coordination and control of personnel, equipment, and organizational procedures. Evaluating is the process of comparing a resultant situation, after management action, to the situation that would have occurred without acting. The comparison is made to determine which attributes of the situation approach the goal state. There is an important distinction in this definition: evaluating does not compare situations before and after a management alternative has been implemented. Rather, comparison of resultant situations with and without action permits separation of impacts due exclusively to management intervention from changes due to extraneous factors, or those that would have occurred anyway. The degree of change due exclusively to management acts can then be related to costs. Evaluating also measures any side-effects of management action on other programs.

Information Needed for Wildlife Management

There are 16 combinations possible from the four stages of management that would occur within each of the four functions of wildlife management. The kinds of information needed by management would be different for each of these 16 activities. For example, the analyzing stage of wildlife habitat management would require information on the current quantity and quality of wildlife habitat by species, soil type, and land ownership. Benefits and costs of management alternatives to acquire, maintain, and develop habitat need to be assessed to reach some desired level of habitat. This type of information is very different from that needed at the acting stage of optimizing public benefits from wildlife resources. At that point, informaton would be needed on methods to coordinate personnel and equipment to reduce the costs of producing and distributing public benefits, to control operations to make sure that intended action is implemented, and to communicate accomplishments and failures to decision makers, publics, and management personnel.

Use of Socio-Economic Information by Function and Stage of Wildlife Management

The 4-by-4 classification system offers a good framework for discussing the use of socio-economic information in wildlife management. Specific case studies can be examined to show how this approach clarifies the utility of research.

Wildlife habitat management. Landowner surveys have often been used to analyze problems and opportunities. For example, Witter and Sheriff (1983) discussed the use of a survey of farm operators in Missouri done by Kirby et al. (1981). Results of this study showed that farmers were not interested in developing wildlife habitat on their land in return for cash payments. These findings, which differed from conventional thinking, were used with other results to develop a program for improving wildlife habitat on private lands. The resulting program emphasized demonstration areas to show the relationship between altered farming practices and game populations. Farmers were also offered seeds and other planting materials, as survey results suggested.

Socio-economic research has also been applied at the deciding stage of wildlife habitat management. A good example of this can be found in the development of the RARE II program by the U.S. Forest Service. The process of selecting undeveloped and roadless areas for wilderness designation included the extensive use of public hearings and formal opportunity for review and comment. This decision-making structure was based on careful work of social researchers. For instance, this process reflected the recommendation of Schweitzer et al. (1975) that land-use decisions favor alternatives that are flexible, demonstrate technical credibility, and minimize conflicts among special interest groups. This process of soliciting public input on wilderness designations also reflected the most advanced system for obtaining, storing, and analyzing public comment (Hendee et al. 1974).

Kennedy's (1974) research on deer hunters in a Maryland forest has been used at the acting stage of wildlife habitat management. This study recommended that some habitat development funds be used to influence the social environment in which deer hunting occurs. Hunter satisfaction may be influenced more by campsite development, availability of maps, and distribution of trails than by increases in deer density. This notion, that human behavior can be regulated indirectly by modifying the environment of recreation, has been used in many areas and situations at the acting stage of management.

Bennett et al. (1980) measured the biological, social, and economic impacts of deer range improvement in northern lower Michigan. Continued research on economic impacts (Carlson, Michigan Department of Natural Resources: pers. comm.) has shown that deer range improvement increased site values for deer hunting by $292.20/mi^2/year (in 1974 dollars). This information will later be compared to the costs of residual forest treatment to improve deer habitat.

Wildlife population management. Wildlife population management has commonly involved the application of socio-economic research. The analysis stage of this process is often concerned with establishing specific season dates and bag limits for hunting regulations. In some situations, the social component of management alternatives is just as important as the biological. For instance, many special hunts have a "buddy system" or "partner permit" so that hunters can be together. Regulations concerning bag limits and hunter quotas are often modified to include this social component of comradeship in hunting.

Llewellyn's (1978) research on public attitudes toward the timber wolf illustrates the use of social research at the deciding stage of population management. This study involved a content analysis of 1,083 letters received by the Office of Endangered Species, U.S. Fish and Wildlife Service. The results, showing Minnesota residents had problems because of wolf numbers, were used to emphasize the idea that locals should have some input in decisions made at the national level. Local sentiment, along with biological data provided by the Wolf Recovery Team, resulted in the declassification of timber wolves in certain areas from endangered to threatened.

The acting stage of population management must consider efficiency of implementation. Human dimensions research can be useful at this point, as evidenced by Little's (1980) work on turkey populations in Iowa. This research showed that human activity may have a detrimental impact on turkey nesting and poult survival. As a result, guidelines for the translocation of turkeys for expanded distribution often include social conditions of proposed locations. Criteria for site selection to maximize the success of reintroduced birds often specify areas with low amounts of spring recreation and protectionist attitudes among local landowners.

Evaluative information on the social impacts of population control and expansion is common, although there are few studies comparing impacts with and without hunting, predator control, or species introduction. There is much informal information about this topic gathered from discussions with recreationists, landowners, and local business people. For example, the impact of coyote control in a ranching community can quickly be assessed.

Optimization of public benefits. Socio-economic studies used at the analysis stage of optimizing benefits are numerous. Brown and Decker (1979) determined the ideal deer population size that would accommodate demands of both hunters and needs of property owners to control deer damage. A specific deer density index was derived to accomplish this optimization, which was then applied by the New York State Department of Environmental Conservation. Resultant impacts are currently being monitored and an evaluation of this optimization strategy will be forthcoming. Wildlife management is not this advanced in the analysis of most optimization problems and opportunities. In most situations, the profession is still defining the many values of wildlife that need to be optimized. Symposium transactions on this topic (Shaw and Zube 1980) reflect a broad set of values for wildlife populations and habitats, ranging from the meat value of a harvested deer to the existential value of just knowing an endangered species is being protected. Charbonneau and Hay (1978) have led the way in attempting to quantify the value of wildlife in economic terms. Experimental work involving cash offers to purchase goose hunting permits in the Horicon Marsh (Bishop and Heberlein 1979) has supported the validity of the travel-cost method used by other economists. Advances in economic research will probably prod management to request more information to optimize benefits from wildlife resources.

Socio-economic studies have also contributed substantially to establishing decision structures and defining participants in designing solutions to optimize public benefits of wildlife. Shaw (1980) stressed the importance of considering the attitudes and views of non-hunters and the values of anti-hunters (Shaw 1977). Lyons (1982) reviewed the demand for participation in nonconsumptive activities among Americans in 1980. Similarly, Kellert (1978) has consistently argued that an emphasis on game in wildlife management will alienate segments of the public that do not hunt. Rolfing (1978) has argued that attempts to even communicate with anti-hunters will not work until hunters have policed their own ranks and improved the level of hunting ethics. Thus, social research has consistently shown that the decision process for optimizing public benefits of wildlife resources needs to involve a broad range of participants, as well as a broad range of benefits. Many of these views have been applied in the daily operations of wildlife management. Commissions and advisory committees have been broadened, nongame management has been expanded, and definitive programs have been established to improve hunter responsibility.

Some specific techniques to optimize benefits from wildlife resources have been developed with information from socio-economic studies. For example, Applegate (1974) suggested zoning nonconsumptive and consumptive users in time and space to increase their enjoyment of wildlife areas. Thomas et al. (1976) discussed the importance of forest trails to increase hunter benefits, and Kennedy (1974) stressed the need for a balance of providing hunters with game and other factors promoting quality. Similarly, Hautoloma and Brown (1979) found that different types of hunters defined quality of hunting differently with regard to access, game, hunting pressure, and other dimensions of the experience. Their suggestion, to diversify the types of hunting conditions based on demand by geographic site, has been incorporated with biological needs in designing areas and quotas for deer hunting in Colorado.

There has been little research on the biological or social impacts of procedures designed to optimize public benefits. This is because formal optimization procedures await more information on values to be considered and market segments of the public affected. Management often struggles with questions about how much effort should be devoted to game species, nongame species, urban wildlife, different regions, and various habitats. However, few management goals have been derived on the basis of producing the most benefits to the most people. These decisions are often based on the financial contribution of different publics and the biological need for habitat and population management. This situation may change as the amount of nontraditional funding for wildlife management increases and as the demands of wildlife enthusiasts become louder and articulated more clearly through the political system.

Program integration. The integration of wildlife management with other programs has required increased attention in recent years. This has partly occurred because of rapid development of other land-use programs in the 1970s and because of an emphasis on economic development of natural resources in the 1980s. Integration has been most successful for traditional programs with related objectives. Likewise, most of the socio-economic research has concentrated on integration with closely related programs. For example, Applegate's research on public attitudes toward deer (1973) and deer hunting (1975), along with other social and biological information, was used to develop a comprehensive information and education program for states in the Northeast (McDowell 1979). Similarly, hunter education programs have been developed to improve responsibility, based on the research of Jackson et al. (1979) and Applegate and Otto (1982). Research on the human dimensions of problems and opportunities in integrating programs is limited. Management is just beginning to work on analysis for this function of wildlife administration.

The desire to integrate wildlife with conflicting programs has been limited because of the anticipated compromises needed. Attempts to avoid integration have been most extreme for commercial activities like mining, oil and gas development, range management, and the dredging and filling of wetlands. In some ways, wildlife managers have decided to first fight developments that compromise wildlife values. Although this may be the correct stand of the wildlife profession, there may be opportunities to consider integration of wildlife with some agricultural (Cutler and Plunkett 1983) and forest management programs (Feltus and Langenau 1984). As in the case of optimizing public benefits from wildlife, we might expect the need for information on program integration to expand as management moves from accepting the importance of integration into the analysis stage.

Increasing the Utility of Socio-Economic Information

Some of the factors related to utility of wildlife research can be experimented with and modified. Better integration of research and management may be accomplished by reorganization. University relationships may be strengthened to take advantage of available talent and interest. Procedures can be developed to increase field and staff participation in defining problems and relevant research objectives. Reward systems may be initiated to recognize managers who seek research consultation and researchers who have applied interests. Assignment of non-research personnel to data collection, analysis, and interpretation processes may increase application of findings. Temporary assignments may be given to managers in research and vice versa to increase understanding.

The greatest contribution to increased utility of socio-economic research would come from a basic reorganization of thinking. Nearly all reviews of wildlife research categorize output by species and academic discipline. As a result, there is a science of waterfowl reproduction and deer nutrition, but no science of wildlife management. Movement towards such an integrated science would require classification of research by function and stage of management. This would increase communication across disciplines working together on a management mission, prevent any one science from studying tangential topics, and encourage a catalytic exchange of ideas. Such an approach to classification would also help to point out research needs not being addressed and show where more information is being produced than really necessary. As a consequence, the utility of available information would be increased. Proposals for future research would also be more productive and understandable.

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Developing Human Dimensions in New York's Wildlife Research Program

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Overview

The systematic study of people as an integral part of wildlife management has lagged behind other aspects of wildlife management research. This is understandable. Early on, agencies directed their scarce resources to the fundamentals of learning about the wildlife resource they were given the mandate to manage. Identification of hunters' goals, needs, etc. were left largely to managers' observations and intuition. Human surveys were conducted during the early years of management, but most of these were concerned with game take and effort. People were used chiefly as sources of biological information. From about 1950 to the mid-1960s, human surveys expanded to obtain basic socioeconomic information, user-characteristics and use-related expenditures. These data were needed to demonstrate program impact and values and in some cases to justify continued financial support. During the mid-1960s through the mid-1970s interest in human dimensions research grew rapidly. Research focused on specific "people" management problems. More detailed economic analyses occurred. Behavioral and social-psychological inquiries began. Many efforts were undertaken in response to new emphasis on program accountability. Others were developed to support an increasingly apparent responsiveness to public concerns and resultant public relations efforts. Since the mid-1970s we have been in a period of refinement and increased sophistication in human dimensions research. Studies of the behavioral and social-psychological aspects of the human dimensions of wildlife management have deepened. Much of the data currently generated are used in formative program evaluations and planning at both the specific activity and broad agency program levels. We are now at the beginning of an era of integration and synthesis which should lead to more concerted efforts at theory development and, consequently, better planning. The level of planning that this type of integrated conceptual organization and related data permits will result in fundamental changes in program orientation, changes that will yield greater predictability of outcomes.

Our concept of the evolutionary process of human dimensions inquiry is outlined in the categories on the left side of Table 1. Different levels of information needs exist within each category of information. These range from the general to the specific. The three general levels of human dimensions information needed by wildlife management

[1] A contribution of Federal Aid in Wildlife Restoration Project W-146-R:NY.

Table 1. Matrix of types of agency decisions and concomitant human dimensions information needs by categories of human dimensions inquiry.

Categories of human dimensions inquiry	Types of agency decisions and concomitant human dimensions information needs		
	Broad	Comprehensive	Focused
Surrogate biology	a] Statewide annual small game take surveys are used to determine trends in hunting activity and harvests.	b] Statewide annual small game take surveys are used to set following year's season length and bag limits. Regional stratifications used to tailor season length and bag limits to regional situation.	c] Harvest and effort surveys at particular sites (e.g., Wildlife Management Areas) used to determine needs for limiting use, access, stocking, etc.
Basic audience profiles	d] Justification for multiple-use approach to management generally. Estimates of user types and interests (reflected in participation), as well as wildlife resource value.	e] Determine needs for shifts in program emphasis.	f] Tailor programs, especially I&E portions, to particular audiences based on their socioeconomic characteristics.
Administrative justification of programs	g] Department of Budget recognition of wildlife program. Justification of program to policymakers and elected officials (constituency support).	h] Shifts of program support by constituencies.	i] Initiation of activities to generate support for programs or projects, or to gain acceptance for dropping or diminishing programs or projects.
User satisfactions and management preferences	j] Used to refine long-range program objectives; e.g., degree of emphasis on appreciative as well as harvest management needs.	k] Information to evaluate why a program failed or succeeded. Also, data used to design or modify programs so they are acceptable to particular clientele.	l] Used to determine specific characteristics of area or species management, either for new program planning or for execution; and for formative evaluation of existing program.
Integrated human dimensions inquiry	m] Determine antecedents to wildlife recreation interests and participation so some predictions about future participation can be made to aid long-range planning.	n] Information to evaluate program potential.	o] Information used to modify education programs (message content, method of delivery, etc.).

agencies and the types of decisions they serve seem to be: (1) *broad*—for long-range planning decisions; (2) *comprehensive*—for short-range planning decisions, commitment of resources, and establishment of goals and objectives at the program level; and (3) *focused*—for immediate action decisions and implementation of activities at the execution level (Decker et al. 1984a).

New York's Experience

Evolution and Recognition of Need

New York's (i.e., Department of Environmental Conservation [DEC]) experience in recognizing, supporting, and applying human dimensions research depicts the evolution and use of this research component by an agency. This development occurred in response to the changing management information needs of the State's broadening wildlife management program. As the DEC accumulated biological information and management experience, management programs were refined.

Unfortunately, amidst this management proficiency it periodically became apparent that many wildlife management constituencies neither comprehended nor accepted innovative management programs, perhaps because they did not comprehend their development or their intended outcomes. This prompted managers to learn more about their clientele's understanding of management programs and acceptance or support of management recommendations. This knowledge was especially needed in situations where unaccepting clientele blocked management via the political process. Managers needed insights to the most effective ways to communicate with specific segments of their constituency on the subject of ecologically sound wildlife management and how it would provide or enhance benefits or reduce conflicts with other land or resource management activities.

Concurrently, having developed proven techniques to manage wildlife populations, managers could give more attention to providing for the specific recreational needs of their expanding clientele. Managers began to ask wildlife recreationists about the satisfactions they sought from their activities and about their preferences for various types of wildlife recreation. It was soon recognized that multiple satisfactions were sought and management preferences differed among subgroups of clientele. Furthermore, as the DEC broadened its programming to more effectively embrace nontraditional clientele, it often found constituency preferences were divergent to the point of being opposing. Opposing factions sometimes resorted to political activity to achieve their objectives, forcing the wildlife agency to defend its management actions or intentions by documenting the various positions of their clientele.

The foregoing exemplifies the general changes in management perspective and trends in human dimensions information needs experienced by the DEC. Within this context a more detailed examination can be made of how specific human dimensions information needs were recognized and met in New York.

The New York example can be approached conceptually by constructing a matrix where categories of information needs reflected by the stages in the evolution of human dimensions inquiry are compared to types of management information needs (Table 1). Specific studies executed by a long-standing contract research program with Cornell University (W–146–R:NY) are assigned to the matrix cells, demonstrating how information ranging from the conceptual to the directly applicable enhances the total contribution to the management effort. These illustrate how information generated by several human dimensions studies helped shape immediate and delayed decisions and allowed implementation of sound actions at each of the three aforementioned levels. Successful applications of human dimensions information are discussed to provide a better picture of the value of human dimensions research input to a state wildlife management agency. Hopefully they illustrate a pathway successfully used to shape management we believe is more responsive to the full range of management constituencies.

Surrogate Biology

Game take and harvest surveys have been conducted routinely by the DEC for decades to meet broad, comprehensive, and focused information needs. There is an annual statewide small game hunter telephone survey and specific mail surveys regarding species or activities, regional surveys of hunters and trappers, and occasional surveys of hunters using particular wildlife management areas. These types of surveys are the least difficult to design, implement, and analyze because they do not involve attitude or other conceptual measurement. Simple numerical responses to straightforward questions are the norm. The human dimensions research expertise (i.e., Project 146 staff at Cornell University) available to DEC has been used in two basic ways to support such surveys.

Training—Project 146 staff held a workshop and developed a training manual for DEC field staff on human dimensions survey methods. After completion of the workshop, participants were able to design, implement, and analyze simple user surveys.

Advisement—Project 146 staff serve as advisors to regional and state program unit staff in developing simple surveys. This assistance spans sampling procedures, instrument design, implementation, analysis, and review of subsequent reports. Project staff also provide an outside review function at the request of DEC supervisors.

This combination of training and day-to-day consultation and assistance has proved to be a functional and productive arrangement. DEC staff have conducted excellent small-scale surveys of a variety of audiences—pheasant hunters using specific management areas, turkey hunters in multi-county regions, landowners in a particular deer management unit, and many more. This arrangement has raised awareness of administrators, regional managers, and biologists regarding the value of human surveys as well as the rigor involved to produce "good" surveys vs. "quick and dirty" versions (increasingly recognized as misleading or counterproductive, often leading to embarassment, tarnished image, and overall loss of credibility).

Basic Audience Profiles

A problem of long-standing interest to the DEC has been that of recreational access to private lands. The first major human dimensions study in New York (other than game take surveys) was on this topic. The DEC funded a study by the New York Cooperative Wildlife Research Unit at Cornell University to identify the level and location of private land posting problems (Waldbauer 1966). Landowners were the target of this "broad" study which obtained basic profile characteristics of New York's rural landowners. This first study reinforced the DEC's inclusion of hunting access as a major agency program thrust, including intensification of effort in the Fish and Wildlife Management Act (FWMA) land access program. Hunter education programs were modified, also placing new emphasis on hunter/landowner relations.

In the early 1970s another posting study was initiated through Cornell University. Landowners were surveyed to confirm observations suggesting an increased posting trend. The DEC also wanted to explore the causes of posting so their access and education programs could be made more effective. The study (Brown and Thompson 1976) documented a startling increase in posting and uncovered the major reason landowners posted—recreationist behavior. The DEC used these data to target hunting access efforts in high need areas and to intensify I&E efforts regarding hunting ethics and hunter/landowner relations. Thus, we have characterized this particular human dimensions research as "comprehensive."

After the full impact of the latest posting study had been analyzed, the DEC/Cornell University "partnership" recognized the need to look at the other side of the posting issue. That is, how were hunters being affected by posting? Consequently, a "broad" study of hunters was conducted to determine the characteristics of hunters for whom posting was a significant impediment to hunting activity and the locations in New York where problems were most severe (Decker and Brown 1979). Among the findings were two surprises: only about one-third of the hunters reported posting to be a problem (and seldom a serious impediment) and hunters residing in metropolitan areas did not report substantially more difficulty in finding a place to hunt than did their rural counterparts. The study also found that many people interpreted posting signs literally—they did not bother to ask the landowner for permission to hunt if land was posted. The previous study of landowners had revealed that many who posted would grant strangers permission to hunt if they were asked.

Consequently, the DEC made decisions at several levels regarding hunting access programs. Development of programs to meet the access needs of specific hunting publics (e.g., urban residents) was not deemed necessary (broad). And, in view of fiscal realities, creation of additional areas of access through the FWMA program was deemphasized (comprehensive). The DEC discouraged use of standard posters and increased efforts to get landowners to adopt new "hunting by permission only" signs that the DEC provided (focused).

A third posting study was finished in 1982 (Decker et al. 1982, Brown et al. 1984) to update posting trend data and examine a variety of land-use and wildlife interest/participation characteristics of landowners. This information helped to provide a more complete picture of landowner's motives for posting. Decisions regarding DEC programs based on these findings are pending, but will likely be at the comprehensive level.

Administrative Justification of Programs

Little research has been directed specifically at this area of inquiry in New York, although portions or aspects of many studies relate to it (e.g., "Return a Gift to Wildlife" promotion evaluation discussed later). Economic analyses for purposes of program justification have not been a top priority information need in New York; judgments on the economic feasibility of programs or projects have been made administratively.

User Satisfactions and Management Preferences

New York's study of metropolitan residents' wildlife interests and information needs (Brown and Dawson 1978, Brown et al. 1979a, Dawson et al. 1978) was designed to identify the interests and program preferences of a nontraditional wildlife management audience—metropolitan residents. At the beginning of a new program thrust in the urban wildlife area, the DEC needed data to aid in program development for the seven major metropolitan areas of New York. Information gathered in this study contributed to decisions to continue to broaden the scope of DEC wildlife programs (broad) and to commit resources to programs in urban areas (comprehensive). The study contributed to decisions in the focused category, including: wildlife park development in urban centers, establishment of an urban wildlife specialist, conducting an urban wildlife habitat inventory, greater involvement in nature education programs in cities (especially New York City), and production of an "urban wildlife packet" for teachers.

A series of five studies of farmers' attitudes toward deer, estimates of deer damage, and preferences for deer population management have been implemented and used as inputs to help set deer population management levels for deer management units, to defend management programs, to improve credibility with the farming community, and to help the DEC make choices regarding mitigation and herd management in various areas. The studies have given the DEC the ability to evaluate deer depredation problems beyond the individual, unsolicited complaint level. We will expand on these studies because they represent one of New York's most intensive areas of human dimensions research and one of the most effective uses of such research.

Deer management in agricultural areas of central and western New York has been approached very cautiously by the DEC. Since the inception of deer management in the region, a significant concern for cooperative land management with farming interests has been upheld. Prior to the mid 1970s, decisions on antlerless deer harvest quotas were based largely on the level of unsolicited deer damage complaints received from farmers. Deer populations were well within biological carrying capacity, indicating a potential for larger deer populations to inhabit the region. Managers recognized that if they were being overly conservative they were unnecessarily limiting benefits for many deer enthusiasts. It was assumed that deer hunters, and other deer enthusiasts generally, would like to harvest and see more deer in the region. Decisions would be guided by a compatability objective making farmer preferences a compelling factor. Consequently, there was a need for data to assess short-term range carrying capacity objectives (comprehensive) and for data to guide annual deer harvest quota decisions (focused).

To assess farmers' perceptions of deer populations and deer damage, and their preferences for future deer population levels, farmers in the region were surveyed (Brown et al. 1977, 1978, 1979b, 1980, Brown and Decker 1979, Decker et al. 1981a). the results showed that farmers enjoyed having deer in their area, were willing to tolerate considerable economic losses, and overall wanted the deer population to increase. In some towns, populations were considered high enough and some farmers were sustaining excessive damage—but such situations were exceptional.

With this knowledge of farmers' preferences, managers decide to allow a controlled increase in the deer population of many Deer Management Units in the central and western regions. These actions have resulted in increased opportunities for observing and hunting deer.

To check response to the new population levels (and some over runs due to recent mild winters), farmers were recently resurveyed (Decker et al. 1984c). As expected, estimated deer damage in the region increased and in most units a current "sociological" carrying capacity seems to have been reached. Farmers in most units want the population to remain at current levels; few want more deer. In addition, in some units slight population reductions may be appropriate. A systematic, integrated human dimensions research program can lead to focused management modifications responsive to public preferences at the local level. A continuing farmer preference monitoring effort is scheduled to assist in program assessment and planning and further work regarding mitigation and the relationship between preference and damage is being contemplated.

The example we are using for a comprehensive type human dimensions research effort in the user satisfaction area is the collection of studies preceding and planned as part of the Northern New York regional deer management program. The deer resource of the Northern Zone (NZ) of New York is not being managed optimally. Harvest is limited by legislative mandate to bucks only, a policy that can only be conceived as appropriate for specific purposes in small portions of the NZ. Unlike the previous example regarding farmers' preferences, we cannot yet point to Northern New York as a successful use of information generated by human dimensions research to meet program needs. But it is an excellent example of using such information to better define a problem and to devise an innovative, long-term plan to overcome it, paving the way for eventually achieving effective deer management. This example illustrates use of an extensive human dimensions research effort to address a problem and will also be covered in some detail. Some major elements of the investigation pertinent to this discussion include: illegal deer kill, the DEC's image in the NZ, and the Northern New York Strategic Plan for Deer Management.

The first element is illegal deer kill, one of the most persistent, identified problems in parts of the NZ, and believed to be associated with and partly responsible for the depressed deer population in more accessible portions of the region. Addressing this problem seemed to call for an effective educational communications effort. Wildlife managers were generally of the opinion that illegal deer kill was a socially acceptable practice in the area, but basing a communications campaign on this unproven assumption seemed tenuous. Consequently, prior to embarking on such a campaign, the DEC wanted to determine if illegal deer killing is indeed socially acceptable. Input was sought from several potential target audiences: opinion leaders on deer management, Conservation Officers, local magistrates, and landowners.

Conservation Officers and magistrates in the NZ were found to be no more lenient in their treatment of illegal deer kill offenses than their counterparts elsewhere in the state (Decker et al. 1980). In fact, more Conservation Officers and magistrates from this region than from downstate regions believed that the arrest and prosecution of deer hunting law violators were extremely important to protect deer in their area. As a result of these inputs the following recommendation was made: "Isolated trouble spots may exist, but none seems to be of sufficient magnitude regionally to warrant special regional attention, not even in the peripheral Adirondacks" (Decker et al. 1980:126). Opinion leaders (i.e., people the DEC most often are in communication with) on deer management believed illegal deer kill to be widespread, and over one-half felt this practice was socially acceptable (Decker et al. 1981b). This contention was not supported, however, by a survey of landowners in the area. These people recognized that illegal deer kill occurred, but clearly indicated that such activity was not generally acceptable (Decker et al. 1981b). Thus, the key target audience for a communications campaign to raise awareness of and decrease tolerance of illegal deer kill, were for the most part already aware of and disapproved of these violations. An awareness-building campaign would only reinforce their existing beliefs. Messages produced under the erroneous assumption that the publics condoned illegal deer killing could have had a negative effect. By systematic investigation, this potential pitfall was avoided and the posture of this public was better understood. These people needed, and perhaps still need, programs that facilitate taking actions to curb illegal deer kill, not sermons against poaching! Recognition of this fact in other states has resulted in SPORT or similar programs.

Concurrent with these other investigations was an effort to determine the causes of communications barriers perceived by the DEC to exist between it and NZ residents regarding deer management. DEC administrators were eager to evaluate if, or the extent to which, such a problem would preclude or inhibit acceptance of deer management proposals. Again, systematic effort unveiled valuable information (Brown and Decker 1976): (1) most area residents had no knowlege of existing deer management programs in the area, much less a defined image of it, and (2) hunters (who did have an image of the DEC) were more negative about the DEC than nonhunters. An important observation from this image study, from a communications standpoint, was the partitioning of overall agency image into three parts: personnel, function, and communications behavior. The agency personnel component was viewed most favorably, while agency communications behavior was most criticized. Typically, perceived lack of "responsiveness" to people's concerns is high on the list of problems in the communications behavior arena.

In response to these surveys and other information, DEC deer managers took an entirely new approach to the NZ problem. A team of managers developed the Northern New York Strategic Plan for Deer Management. The plan seeks to develop a sustainable long-range deer program in the region. It specifies three major short-term (10-year) goals; the one which initially holds the highest priority is to generate sustained public and governmental support for and participation in developing sound deer management programs. This calls for embarking on a communications campaign which seeks and uses goal-setting input from key publics and in turn provides those publics with information. This is to be a two-way communications process, an attempt to establish a dialogue between the agency and its constituencies. The agency's job is to explain the situation from a biological standpoint and offer sets of management alternatives that could achieve desired deer management objectives. The agency will solicit public input to help select the alternatives that will be both biologically and socially acceptable. Based on these inputs, sustainable management actions will be implemented. The underlying premise of the approach to reach this goal is that by demonstrating genuine responsiveness to public input and meeting real information needs of publics involved to achieve an *informed consent* status, as well as demonstrating on small scales the viability of controversial alternatives, the agency's credibility will be enhanced.

The Northern New York Strategic Plan for Deer Management was a landmark for human dimensions research in New York. The plan specified a series of human dimensions studies as an integral part of the deer management program development effort. One of the first activities called for under the communications development goal was a study to identify the degree of support existing among deer hunters for legislating greater deer management authority for the DEC in the NZ (Decker et al. 1984e). This information was to be placed in the context of a situation analysis for a communications effort and is an example of comprehensive information need. Hunters were placed into management support/opposition types based upon their opinions of NZ deer management and antlerless deer harvests. Hunters of each type then were described and compared on the following dimensions: standard socio-demographic characteristics, hunting experience in different management approaches in New York State, hunting motivations and satisfaction, opinions about deer management and the management agency, and organizational affiliation and wildlife-related communications characteristics. The results of this profiling analysis provided direct indications of potential management acceptability and identified characteristics of the opposition element. Furthermore, channels for reaching those not in full support of differential approaches to management were identified.

Another set of hunter characteristics that has a bearing on communications is their image of the DEC. Findings in this area demonstrate the need for enhanced communication on the part of the DEC. Of the three components of the DEC's image, that relating to communications behavior was rated the most negative by hunters in this study, consistent with the earlier study of the general population of the NZ. The image component toward which opinions currently are least formed is that regarding the competency of DEC personnel. Here lies considerable opportunity for building hunters' recognition of the DEC staff's management ability, which could lead to acceptance of management proposals. The process of building recognition of staff competency, which would necessitate increased or different forms of interaction between hunters and DEC staff, should simultaneously enhance hunters' perception of the DEC's communication behavior. This information is having a marked influence on communications programming in the NZ.

One of the major general findings of the NZ deer hunter study was that many hunters who are not now in full support of expanding the DEC's authority to manage the NZ deer resource seem to hold considerable potential for change. For example, some hunters expressed an array of conditions under which they would lend their support to deer management. The conditions mentioned by many of these people already exist, although they currently do not perceive them. Although the study findings did not show overwhelming support of the agency, the results are nevertheless encouraging considering that prior to this research effort some deer managers believed there was little or no hope of gaining public support for changes in deer management in the NZ. The study indicated that acceptance by hunters of new initiatives for NZ deer management, if preceded by communications that consider the characteristics and experiences of the hunters, may be possible. The results also verified the structure and priorities originally perceived for the program development plan.

Integrated Human Dimensions Inquiry

In an effort to become proactive moreso than reactive, an initial attempt has been made in New York to classify key constituent organizations by their interest in wildlife management and to understand how these organizations perceive and communicate with the DEC. A recent sudy obtained information of the broad type to enhance wildlife managers' understanding of the values, concerns, and attitudes of organizations regarding wildlife and wildlife management (Brown and Decker 1982). It produced wildlife values typologies placing key wildlife interest groups into types sharing similar values relative to four kinds of wildlife. The sets of organizations whose values clustered together differed considerably from species to species. This indicates that the common practice of stereotyping organizations based solely on their primary interest in either game or nongame species is erroneous and can be a serious mistake. It may lead to credibility problems with constituencies so categorized. Some organizations holding opposing attitudes toward the values of one or more species groups may share similar attitudes toward the values of others.

The information produced by this study has been used in a planning context as a pilot decision-making aid when contemplating a new or modified policy or goal for management. The typologies permit projections about the array of organizations most likely to support or express concern about a proposal.

This input from key publics has another application—identification of potential sources of communications problems between the DEC and its publics. Information about values and attitudes associated with deer and deer management practices held by organizations was asked of DEC staff as well as leaders of key wildlife organizations. Agency staff most knowledgeable of each organization indicated their perception of how the organization would respond. Analysis of these data allowed us to ascertain how closely DEC staff has understood the values and attitudes of each wildlife-related organization. We are now evaluating specific causes of agency misunderstanding of organizations' values and attitudes. Studies as described provide agencies with the kinds and breadth of information needed to achieve proactive planning and to prevent or eliminate schisms between game and nongame wildlife interests. In fact, "game" and "nongame" may be antiquated constructs which are counterproductive to comprehensive wildlife management.

A recent pilot study of the social-psychological antecedents to hunting initiation, continuation, and desertion (Decker et al. 1984b) exemplifies integrated human dimensions inquiry to meet comprehensive information needs. Earlier studies in this arena documented the size of the potential hunter and currently inactive hunter segments of New York's population (Brown et al. 1982) and the participatory characteristics of a cohort of hunter training course participants two years following course completion (Decker and Brown 1982a, b). These provided the background and demonstrated the need for the more basic research represented by the pilot study. The impetus for this study was agency concern about the pile-up of currently nonparticipating New York State residents who at one time hunted or intended to hunt. The DEC wanted some indication of whether the "benefits package" associated with hunting could be improved via innovative programming that considered peoples' expectations for and satisfactions from hunting. This exploratory investigation is providing valuable insights for program planning to influence hunting satisfaction, continued participation, and initiation by interested but unnecessarily inhibited persons. Furthermore, this study helped guide decisions concerning future research of hunting participation as a social activity, with predictable future demographic realities.

A recent survey of New York State taxpayers meets both broad and focused human dimensions information needs. The study evaluated the effectiveness of promotional efforts for the "Return a Gift to Wildlife" tax checkoff program. This was conducted in a formative evaluation context, where the wildlife interests, management program preferences, and wildlife values attributes of contributors and noncontributors were sought as well as basic socio-demographic and communications data. This breadth of data will serve program direction decisions (broad) and is serving immediate decisions regarding current year promotional efforts (focused).

The second of two studies regarding landowners' attitudes toward black bear management in the Catskill Region of New York is another example of an integrated human dimensions inquiry to meet focused information needs. The first study was a situation analysis following management decisions (Decker et al. 1981c). The second study (Decker et al. 1984d) evaluated the impacts of the previous management decision and identified communications strategies for reaching landowners reluctant to endorse management for a larger bear population. The two primary decisions served by data from this study were whether or not the bear population should be increased further (comprehensive) and which target audience, content, and channels to use to increase public acceptance of bear management (focused).

Summary

As management knowledge improves and experience with various management strategies accumulates, fine tuning of management programs occurs. These refinements require two types of human dimensions information inputs. One type relates to problem aversion or resolution, the other relates to program specification and development.

New York has found that the key to better understanding of wildlife constituency needs, interests, and management preferences is systematically acquiring public input for broad, comprehensive, and focused levels of application. The integration of human dimensions inquiry with the full spectrum of agency programming and planning activities can significantly influence those activities. Without such input, agencies work on an impoverished or biased information base where costly and sometimes irrevocable trial-and-error approaches occur. Responsible and responsive wildlife management requires appropriate human dimensions input. We maintain that the solicitation and application of such information is necessary if wildlife agencies are to grow and progress effectively.

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Human Research and New Jersey's Deer Management Program

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New Jersey deer managers have struggled for many years with the problem of obtaining reliable data on the number of deer killed during legal deer seasons. These data are essential in formulating strategies for managing deer populations and establishing deer seasons.

History

Various methods of recording deer killed during the hunting season have been utilized over the years. Prior to 1957, deer hunters reported their firearm buck season success to the local game warden via phone or personal contact. Starting in 1957, a postcard reporting system was utilized and remained in effect until 1972, when a mandatory deer checking station system was inaugurated. Both changes were efforts to obtain more accurate deer harvest data needed for more progressive programs of herd management through antlerless harvests. Associated with each reporting system has been the problem of legally killed deer that are not reported by the hunter. Between 1968 and 1971 the rate of non-reporting for firearm deer hunters was determined with field checks by state wildlife biologists. The license numbers on tagged deer were compared to hunter postcard reports. Howard and Lund (1970) reported that the average non-reporting rate for the entire state during those three years was 28.0 percent.

The only information on New Jersey bowhunter non-reporting came from a mail questionnaire conducted in 1970 by Toth. Toth reported that 11.0 percent of his survey bowhunters reported killing deer when only 4.8 percent of the bowhunters sent in deer harvest report cards. Due to the difficulty of finding a bowhunter with a deer, the small number of deer killed by bowhunters, and the long five week season, it was impossible to use the field check method to determine non-reporting rate for bowhunters.

The problem of non-reporting became especially acute in 1972 when the required deer checking station system went into effect. The deer checking station system was an important part of a deer management zone program that was designed to gather biological information on an ecological unit basis. This information would be used to develop deer harvest strategies that would produce a healthy deer herd, compatible with carrying capacity and various land use characteristics of a zone, and at the same time provide a maximum of hunter recreation days.

Accurate harvest data and information on non-reporting were critical to the success of the new zoning system. However, this information became more difficult to obtain. The new mandatory deer checking stations required nearly all of the field staff to properly man and manage the stations. This made any type of field checks impossible. However, the 1972 season showed an increase over 1971 of 42.0 percent in the firearm buck harvest, suggesting that the new checking station requirement may have increased the rate of reporting. There was no significant increase in the reported bow and arrow deer harvest in 1972, despite the same mandatory check station requirement. Either bowhunters were not responding to deer checking station requirements or they always had been reporting all the deer taken. Deer managers suspected that many deer were still going unreported.

In 1975 and 1976, telephone surveys were made of female heads of bowhunter and firearm hunter households to determine the utilization of harvested game in New Jersey. In addition to documenting substantial contributions to the diet of many New Jersey families, these studies provided an estimate of the number of game animals, including deer, being brought home by our hunters. In the 1975 survey (McDowell 1980) respondents reported that 11.0 percent of New Jersey's bowhunters were successful compared to the 5.5 percent who reported deer to the mandatory deer checking stations. Elicker's (1982) respondents reported that 11.0 percent of the state's 122,000 firearm deer hunters had been successful. Yet, only 6.2 percent of these hunters reported deer to the mandatory deer checking stations. The data in both studies suggested that large numbers of deer were still going unreported.

One of the goals of the New Jersey Deer Management Program is to maximize the recreational opportunities for people while obtaining deer harvests that are needed to achieve herd management goals. This philosophy is reflected in independent bag limits for various seasons through 1979. New Jersey deer hunters have been allowed to take a deer in each of the four season types. Hunters could participate in the fall bow season (30 days), firearm buck season (6 days), special either sex season (1 day), and winter bow season (13 days). Hunting success in any season did not eliminate participation in any other deer season. By 1979, then, New Jersey had a well-established mandatory check station system that was providing the biological data necessary for the management of 53 deer herds in ecologically distinct management zones. We also had evidence that substantial numbers of deer were still going unreported. Despite the opportunity to hunt in other seasons after killing a deer in one season, it appeared that many hunters were not reporting deer in the fall archery and firearm buck seasons so that they could continue to hunt within that season.

Deer managers considered several options in responding to this continuing problem. They could simply monitor rates of non-reporting through various techniques and add the results to reported harvest data. This possibility was discarded due to the cost in dollars and personnel time involved in these surveys and the continuing uncertainty of error involved in such estimates. A second option was to increase law enforcement and public relations in an effort to induce hunters to comply. This too was discarded because of expense and personnel requirements that would be needed to have a significant effect on compliance rates. The third strategy considered was to provide hunters with an incentive to report their deer. McDowell (1980) and Elicker (1982) reported that less than 1.0 percent of the bowhunters and 4.0 percent of firearm hunters actually took a second deer after not reporting their first. This suggested that allowing hunters to legally pursue a second deer would not have a significant effect on overall kill. It was decided to provide a free second deer tag in both the firearm buck season and the fall bow season. This tag was only available when the successful deer hunter took his first deer to the deer checking station. New Jersey deer managers felt that this system could prove to be a positive, economical means to obtain more reliable harvest data, with a minimal effect on the deer herd.

The Result

The "second deer" program was initiated in 1980, with results that were quite dramatic. The fall bow season harvest increased over 100.0 percent. The success rate had averaged about 6.5 percent for the three years prior to 1980 (Burke et.al. 1983). For the three years since the second deer was allowed the success rate has averaged 12.6 percent (Burke et.al. 1983). Only 9.8 percent of the bowhunters that reported a first deer were successful in bagging a second deer.

Firearm buck hunters also showed an increase in hunter success, but the rise was not as dramatic. During the three years prior to 1980, the success rate for the estimated 116,000 firearm buck hunters averaged 6.5 percent (Burke et.al. 1983). After the "second deer" program, the firearm buck season hunter success jumped to a three year average of 8.8 percent. Only 3.0 percent of the firearm hunters reported taking a second deer.

The surveys done in 1975 and 1976, and results obtained following implementation of the second deer program, served to provide New Jersey deer managers with increased confidence in their data base and deer management program (Howard, pers. comm.). The fine-tuning of deer management is extremely important in a state with rapidly changing deer habitat due to urban sprawl. This confidence has been supported by the sustained number of antlered bucks taken each year. Deer managers use the antlered buck harvest figures as an indication of herd productivity and health. In 1976, the antlered buck harvest in all seasons was 8,374; in 1979—10,084 and in 1982—13,527 (Burke et.al. 1983). The buck harvest has grown each year since the second deer program. The percentage of bucks older than 1.5 years harvested, another measure of harvest effects, has not changed significantly even in the most heavily hunted deer zones of the state (Person, pers. comm.).

Of equal importance to a biologically sound deer management program has been an expansion of recreational opportunity in low hunter density types of seasons. A prime example has been New Jersey's muzzleloader deer season. Since 1966 New Jersey deer managers have utilized a lottery permit one-day either-sex season to achieve herd management objectives. However, this season offered a low number of recreation days per deer harvested. In 1978, New Jersey instituted a special three-day muzzleloader season for either-sex deer. Permits were issued to 1,422 hunters who killed 249 deer (Burke et.al. 1979). In 1983, a nine-day season was allowed and 8,800 black powder hunters killed 1,119 deer. As the deer hunters have become more interested in hunting with muzzleloaders, permits for the one day either-sex hunt have been reallocated to the muzzleloader season. For every deer taken by muzzleloading, 23 man-days of recreation were obtained, compared to 5 man-days per deer killed by shotgun either-sex hunters.

Overall, the collective changes in New Jersey's deer harvest strategies have achieved large increases in recreational opportunity. In 1976 New Jersey deer hunters enjoyed 763,000 man-days of hunting (Burke 1977). In 1982 New Jersey deer hunters spent 1,055,299 days afield (Burke et.al. 1983). This is especially impressive considering that the estimated number of deer hunters has decreased from 135,000 in 1976 to 122,000 in 1982.

Conclusion

Surveys directed at hunters, their hunting activities and their characteristics have provided data that are essential to New Jersey's deer managers in formulating harvest strategies. In a state with an average of 1,000 people per square mile, with continually declining open space, it is a challenge to maintain quality deer herds and maximize human benefits. We believe that the integration of biological and people research has been important to meeting that challenge. We believe that the criterion of our success is the quality of our deer herd and the recreation provided to our citizens. In 1976, our total reported deer harvest was 12,688 animals. In 1983 that total had nearly doubled to 23,749. From 1976 to 1983, deer hunters enjoyed 292,000 more man-days in the field. These trends, in the face of declining habitat, testify to the successful utilization of research data in innovative management strategies.

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Hunter Surveys and Wildlife Management: Wisconsin's Experience

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Human Dimensions research in Wisconsin has been initiated and designed to answer specific policy questions, but its pay offs have been largely a result of the more basic information provided about human hunting populations. The Wisconsin experience involves close linkages between wildlife agency personnel and university researchers. The goal of this paper is to review this research program with specific attention to its influence on wildlife management. We wish to learn what kinds of social science data are most useful, and to identify the conditions that enhance the effectiveness of hunter surveys in wildlife management.

Goose Management and Hunter Surveys

Prior to the late 1960s most human dimensions research was conducted by wildlife biologists in the Wisconsin Conservation Department (after 1967, the Wisconsin Department of Natural Resources) and focused on goose management at the Horicon Marsh. This research was published in the *Wisconsin Conservation Bulletin* and described elements of the managed hunt and hunter success (e.g., Jahn et. al. 1954, Bell et. al. 1955, Stroebe 1955, Bell et. al. 1956, Wiita and Bell 1959). Studies included informal hunter surveys and reports of hunter satisfaction. Ten years of managed hunting at Horicon were described for a national audience in 1962 (Hunt et. al. 1962) and the effect of shell limits on hunter success and crippling loss was examined by Hunt (1972). A substantial study of the economic impact of goose hunting and goose viewing around the Horicon Marsh, including interviews with goose watchers and mailed surveys to goose hunters and local merchants, was conducted in the early 1960s by Lloyd Keith, then a post doctoral fellow in the Wildlife Ecology Department, in the University of Wisconsin-Madison (Keith 1964). The study was funded by the College of Agriculture.

With the exception of Keith (1964), these studies were really part of goose management programs. We may presume that modification of existing programs and retention of existing procedures were based largely on these reviews. Little general knowledge about goose hunter populations, motivations, satisfactions, migrations, and preferences were obtained by the researchers. While the impact on management may have been substantial, the contribution to basic knowledge was limited.

Waterfowl Management and the Beginnings of University Linkages

The focus of hunter surveys broadened some in the late 1960s when Clay Schoenfeld, Professor of Environmental Communications at the University of Wisconsin-Madison, interested three masters students in three separate departments in conducting human dimensions projects. All three studies involved waterfowl management. The issue facing the state at the time was the possibility of adopting species management for waterfowl hunting. For some types of species management to be effective it is necessary for hunters to identify waterfowl on the wing. Evrard (1970) examined the ability of hunters to make such identifications, and the effectiveness of training programs for improving such identification. His research involved field tests of experienced and novice hunters in blinds on Lake Mendota, both before and after a training program. He concluded "many hunters do not have the ability to identify waterfowl on wing at shot gun range to the degree assumed by present species management regulations. However, it appears that identification abilities of hunters can be improved" (p. 125). He called for expanded research in the area of "hunter attitudes toward selective shooting."

This hunter attitude research was initiated by Eisele, who surveyed a random sample of duck hunters (Eisele 1971), and Klessig in the Department of Rural Sociology, who obtained several samples of hunters (both from telephone interviews and license records). The telephone sample was unique because it included nonhunters as well as hunters (Klessig 1970). Eisele's work developed a profile of the Wisconsin waterfowl hunter (Eisele 1971), and Klessig, in collaboration with Biological Researcher James Hale in the Department of Natural Resources, published a demographic description of Wisconsin hunters providing separate statistics for big game gun and big game archery, small mammal, upland game, predator, and waterfowl hunters (Klessig and Hale 1972). Klessig specifically pursued waterfowl hunter acceptance of species management using a point system and found that 63 percent opposed such a system with only 32 percent favoring (the remainder were either neutral or did not answer the question). Out of seven proposed season changes, two were more popular than point system (Klessig and Hunt 1973).

Klessig's research represented the first introduction of basic social science theory into human dimensions research in Wisconsin. The majority of his 200-plus-page thesis and subsequent report dealt with the effects of social class and residence on hunter behavior, attitude, and preference. Fifty eight of the 84 references in his bibliography were to basic sociological studies.

University-Based Social Science Research

There was a brief gap in human dimensions research in Wisconsin until 1976, when three faculty members on two campuses became involved in separate research projects. Two were funded primarily by the Department of Natural Resources and the third by the College of Agriculture and other sources.

In 1976, faced with hunter opposition to proposed changes to the gun deer hunting season, the Bureau of Wildlife Management sought out the assistance of Thomas A. Heberlein and his associates in the Department of Rural Sociology at the University of

Wisconsin-Madison. Heberlein and Laybourne (1978) surveyed two samples of hunters in 1976—those who did and those who did not attend meetings reacting to the proposed season changes. A second survey was done in 1977 to see how hunters would react to a set of modified proposals including a proposal to replace the four hunter/party deer concept with a hunter's choice/any deer concept for selected big game license holders. Heberlein went on to initiate basic research on hunter density in a number of programs: deer hunting at the Sandhill Wildlife Area (Heberlein et. al. 1982), managed goose hunting at the Grand River Marsh, and managed pheasant hunting at the Bong Recreation Area. The later studies involved surveys of hunters in high and low density conditions, and hunter evaluations such as perceived crowding, satisfaction, and overall ratings of hunting quality. Data from Heberlein's hunter surveys were integrated with surveys of other recreationists (Vaske et. al. 1982, Shelby et. al. 1983) to examine the determinants of satisfaction and perceived crowding in recreation. In the 1980s, the Department of Natural Resources contracted with Heberlein for a study of hunter perception of hunting quality among deer, goose, and pheasant hunters.

Robert M. Jackson, a psychologist at the University of Wisconsin-La Crosse, was funded by Wisconsin's Hunter Education Program. He and his associates conducted hunter performance studies of waterfowl, gun deer hunters and archers. His initial studies of waterfowlers used the traditional spy blind method of observing hunter behavior coupled with field and at home interviews with the observed hunters. Rather than simply observing biologically related behaviors (i.e., shots taken, birds killed, and crippling loss), Jackson and his associates measured ethical behaviors such as sky busting, littering, crowding, etc. and correlated these behaviors with personal and demographic data. Jackson and Norton provided a number of reports to the agencies, and in 1979 presented data at the North American Wildlife and Natural Resources Conference that dispelled some major myths about ethical and legal violators (Jackson et. al. 1979). Rather than being the least experienced urban hunters, violators were highly committed local hunters who were more likely to hunt with dogs, have duck boats, have decoys, and be members of Ducks Unlimited. Jackson's work on hunters was innovative from a social science point of view because it went beyond survey methodology. Biologists have learned much about the species they study without benefit of the questionnaire, and Jackson's work showed that much could be learned about waterfowl hunters simply through careful observation. Unfortunately, it proved much more difficult to observe big game hunters in the field, so field and in home interviews were used without observation. Finally, his bow hunting research allowed comparisons among hunters who chose two differing hunting methods (Jackson and Anderson 1983).

Both Jackson and Heberlein have gone beyond the scientific journals to communicate the findings of their research to more general audiences. Jackson and his associates have published six articles in *Wisconsin Natural Resources* (Jackson 1978, Jackson and Norton 1979a, Jackson 1979b, Jackson and Norton 1980a, Jackson 1981b, Jackson 1983), two articles in *Archery World,* (Jackson 1984, in press) and three in the *Wisconsin Sportsman* (Jackson and Norton 1980a, Jackson 1981a, and Jackson and Anderson in press). Heberlein has published two articles in *Wisconsin Natural Resources* (Heberlein 1977, 1978) and one in the *Wisconsin Sportsman* (Heberlein and Trent 1982). In addition, Jackson has given presentations or run workshops in twenty two states and provinces, and both Heberlein and Jackson have organized human dimensions conferences in Wisconsin.

Resource Economist Richard C. Bishop at the University of Wisconsin-Madison began some basic research on economic issues related to goose management at the Horicon

National Wildlife Refuge. Along with Jeff Stier, he began looking at the effects of wildlife damage on farmers (Stier and Bishop 1981). This research grew into more basic research examining alternative methods for valuing wildlife. Working jointly with Heberlein, Bishop and his students began to test survey methodologies for determining hunter willingness to pay and sell hunting opportunities against a simulated market where permits were actually bought and sold (Bishop and Heberlein 1979, Bishop, Heberlein and Kealy 1983). Although the Department of Naural Resources initially opposed the original experiments on goose hunters, they have endorsed recent studies on valuation of deer hunting. Bishop's work has been funded by the College of Agriculture, Resources for the Future and the Electric Power Research Institute.

Very recently, other university faculty have begun human dimensions research in Wisconsin. Kirk H. Beattie at the University of Wisconsin-Stevens Point conducted a statistical analysis of Wisconsin hunting accidents for the Department of Natural Resources (Beattie and Winstead 1983) and Scott Craven in the Wildlife Ecology Department at the University of Wisconsin-Madison replicated the work of Brown and his associates on landowner tolerance for wildlife damage (Brown 1978). Craven's work was also partially funded by the Department of Natural Resources.

Influence on Management: A Pessimistic View

If one looks only at the most obvious direct implications of each research project, it is possible to argue that the research done by university social scientists since 1970 has had almost no direct impact on wildlife management in Wisconsin.

Klessig (1970) and Klessig and Hunt (1973) showed that hunters *did not* prefer a point system for establishing waterfowl bag limits. In spite of hunter preference, Wisconsin implemented a point system for waterfowl in 1973. Evrard (1970, 1976) showed that training was an effective mechanism for improving hunters' ability to identify ducks. No widespread or required training system has been implemented for waterfowl hunters.

In the fall of 1976, some 11,000 hunters appeared at public meetings overwhelmingly opposing the proposed 1977 changes in the Wisconsin gun deer hunting seasons. The survey conducted by Heberlein and Laybourne (1978) showed more than 80 percent of those who attended the meetings, and the same percentage of those who did not attend, opposed the proposed changes. The Department of Natural Resources dropped the proposals, which indeed was consistent with both the meeting and survey responses. In this regard, it is interesting to speculate on the necessity of the survey. After the public outcry against the proposals, would the Department have gone ahead with the plan if the survey had shown that a majority of the hunters who *did not* attend the meetings supported the plan? We think it unlikely that the Department would have gone against the wishes of the thousands of vocal sportsmen who attended the meetings.

The survey did provide insight into how to approach the problem in the future. A second survey in 1977 presented separate ideas for gun deer hunting season changes (Heberlein and Laybourne 1978) and of the eight ideas there was substantial support on only one modification, changing the four-person party permits to a one-person either sex permit. This change was adopted the next year. The survey here may have had an effect in speeding up the implementation of the hunters' choice permit system, but it's not clear if the survey provided any new information that could not have been acquired simply by meetings with hunters. In retrospect, policy implementation was consistent with the survey data, but it is not clear that the surveys influenced these actions.

Heberlein and his students also evaluated two managed hunts at the request of the Wisconsin Department of Natural Resources—one involving managed goose hunting at the Grand River Marsh Wildlife Area and the second involving pheasant hunting at the Bong Recreation Area. The study at the Grand River Marsh compared the managed hunt with a firing line situation on the same property, and the Bong hunt used the previous year's unmanaged hunt as a comparison. The results showed that the managed hunt at Grand River increased hunter satisfaction, perceived quality, success, and decreased crowding in comparison with the firing line (Table 1). At Bong, the managed hunt had only small effects on reducing crowding and increasing success, and hunters were no more satisfied, nor did they feel the hunt was of higher quality (Table 1). The managed hunt at Grand River Marsh was terminated, and the managed hunt at Bong was continued without major modification.

Major elements of Jackson's research also have been ignored. His research from spy blinds showed that 20 percent of the observed hunters violated the law, and that 30 percent committed a breach of ethics. It also identified the most committed hunter as the least ethical and most likely to violate. One implication for hunter education is to design, focus, encourage, and even require training for these highly committed groups. In spite of Jackson's findings, hunter education is still focused toward new hunters.

It is not surprising that Bishop's research has not found its way into management, since it was neither funded nor solicited by the management agency. His study of using cash to buy back free Canada Goose hunting permits from Horicon hunters, showed that the average hunter required $63.00 before selling. (Three out of fifteen hunters actually turned down $200.00 cash to give up a chance to shoot one Canada goose during a one week season at the Horicon Marsh.) If hunters were asked to purchase permits, Bishop's data showed that the average hunter would be likely to pay $11.00 for what is now a free permit. The research of Bishop and his associates demonstrated that goose hunting is valuable, and that hunters are willing to pay a reasonable amount in addition to their current expenses for the opportunity. Pricing permits at nominal levels would raise funds for the agency and could reduce crowding and competition among hunters. Horicon goose hunting permits are still free in Wisconsin.

It is probably still too early to assess the potential influence of the work of Beattie or Craven, since the former was just reported (Beattie and Winstead 1983) and the latter is not yet published. However, Beattie showed that accident reduction was not associated with hunter education programs, and that, if anything, those involved in hunter safety courses had more accidents. We doubt that such a finding will lead to a reduction or major change in hunter education efforts. Craven's work in Wisconsin largely replicated

Table 1. Comparing success rates and hunter evaluations of two managed hunts in Wisconsin.

Characteristic	Bong Recreation Area (pheasants)		Grand River Marsh (geese)	
	Managed hunt	Regular hunt	Managed hunt	Regular hunt
Success	32%	24%	48%	33%
Crowded	75	89	17	87
High quality	13	16	50	13
Excellent/perfect	9	13	33	9

the New York findings of Brown and his associates (1978), i.e., that farmers would tolerate some wildlife damage. In a post hoc sense, one could argue that his data only verified that the New York study conclusions could have applied to Wisconsin.

Perhaps we have overstated the argument, but the case can certainly be made that the specific data sought and paid for by the agency were not utilized. It should be pointed out that social science research is not unique in this regard. Discussions with biologists, both inside and outside the Department of Natural Resources, revealed many instances where the equally clear policy implications of biological research were also ignored. Our review of these cases suggests three important reasons why data did not influence policy.

First, there are always other constraints. Management agencies do not operate in a vacuum and science is but one of the many influences on management. In the case of waterfowl management, flyway councils and the federal government exert an extra-state influence on policy. Interest groups play a role and certainly the influence of the hunter interest groups was effective at maintaining the status quo at Grand River Marsh. Field managers have an influence and their decisions and preferences had an influence at both Grand River and Bong. And then there are the ever present budget constraints.

Second, social science data in an agency dominated by biologists, foresters, and engineers is naturally a little suspect. There is always a concern that a second survey would generate different results. Managers are well aware of the heterogeneity of human behavior and preferences. In addition, the complexities of field data collection and measurement tend to make managers skeptical of data collected on humans. Without social science training, it is difficult for them to put the data in context and to know when to trust and distrust data. When intuition and research disagree, there's a tendency by management to trust intuition.

Finally, there is no reason to expect the agency to act on the findings of social science research when they did not seek out or commission the research. Research can only expect to influence decision making when there is a decision to be made. If the data come in too early, or too late, or there is no decision pending, then it will not have an immediate or direct effect. There are, no doubt, additional reasons to document the lack of effect, but these three seem to dominate.

Influence on Management: An Optimistic View

In spite of the rather dismal review of specific impacts of human research presented in the last section, there is considerable enthusiasm among researchers, managers and the hunting community for human dimensions research in Wisconsin. Why the continued support and interest? It appears that the substantial contributions of the research have been in the basic advances in knowledge that were largely spin-offs from the initial goals of the managing agency in initiating the studies. In 1984, much is known about the Wisconsin hunting population, its behaviors, motivations, and preferences. The policy process is building on this basic grounding for new wildlife programs. Let's go back over the specific studies to discuss these contributions.

Klessig's research was important in that it surveyed nonhunters as well as hunters and suggested differences between the two groups. Its most significant impact, however, was in a technical bulletin published with James Hale, an agency researcher (Klessig and Hale 1972), which simply presented the demographic description of each type of hunter. Their work described the hunter and made this faceless mass more understandable to the manager. For the first time, the manager of a prey-predator relationship knew something systematic about the predator species. The first step in understanding is good description, and Klessig's research provided this.

Heberlein's work with Laybourne (1978) put together a few more pieces of the puzzle. Building on other recreation research, their survey showed an extremely high level of psychological commitment and social support among the Wisconsin deer gun hunters. This high level of commitment was seen as a major reason for resistance to change among hunters. Managers finally had some explanation other than simple ignorance or pig headedness to account for the negative reaction of hunters to any proposed hunting season changes.

The general hunter surveys also provided information about hunters' opinions concerning road hunting, which was used in legislative efforts, and information about group hunting, which also was used by sportsmen and the DNR Board to influence legislation in 1984, seven years after the second survey was completed. As discussed earlier, the quantitative evidence that hunters favored a hunters' choice system of doe harvest sped the implementation of this change. Furthermore, since the survey did not find overwhelming opposition to the idea of an earlier season in the north (about 50 percent opposition, in contrast to 70–86 percent opposition to other ideas such as split seasons, week day openings, and limiting license sales), this possibility was kept alive, and is under serious study at this time.

Finally, the deer hunter surveys provided clear evidence about the role of wildlife and social variables in hunter satisfaction. The data showed that hunters seeing deer, getting shots at deer, and bagging deer showed increased hunter satisfaction and higher levels of perceived quality. Interference with other hunters detracted from satisfaction and perceived quality. This finding disabused the common notions that "you can't measure quality" and that being close to nature is the primary motivation for hunting. Further research has amplified the notion of quality. In the post-1978 period, there is more agreement among managers about the components of a quality hunt and the obligation to provide quality recreation experiences.

All in all the deer hunter surveys of Heberlein and Laybourne (1978) had a substantial effect on changes in deer management and provided useful perspective for managers. The major objective of the study—to determine if the opinions of hunters who attended the meetings were representative—was probably one of the least useful outcomes of the research.

The remaining research conducted by Heberlein and his associates was to examine the effect of hunter density on hunter success, satisfaction, and perceived quality and other variables (see Heberlein et. al. 1982), which was part of more basic research he had been conducting on crowding in recreation settings (Heberlein 1978b). The program evaluation at Grand River Marsh and Bong were essentially density assessments, although the major research effort was done over several years at the Sandhill Experimental Wildlife Area, where deer hunters could be assigned at random to high and low density conditions. This basic research, which began in 1979 and continues through this writing, was not funded by the managing agency, since no deer hunter density questions appeared to be pending. Suddenly, in 1983–84 a study committee was established to consider changing the hunting season in the northwestern part of the state in a way which could increase hunter densities. The crucial question was the density level at which hunters feel crowded. And the Sandhill data gave some good guides, at least for initial planning. The point here is that basic research not funded by the management agency, but growing out of the disciplinary interests of the scientists, turned out to be useful for management, in fact, more useful than the specific information provided by the Grand River and Bong efforts.

Jackson's research efforts had both direct benefits tied to the objectives and spin-off benefits. Specifically, it has led to modifications and improvements in course material for hunter education programs. This was a major objective in all of his studies that were funded by the agency. Some of his findings have led to changes in field law enforcement efforts, as well.

The finding that illegal and unethical behavior occurred at a greater rate among hunter safety graduates than nongraduates led to a review and revision of the entire course. Black powder and archery segments were cut back and hunter responsibility segments were expanded. The instructor and student manuals were completely rewritten, utilizing many of Jackson's conclusions, and the course became one of hunter education rather than just hunter safety. Just recently a new manual containing 15 different Hunter Responsibility Curriculum Units has been published. This will be used not only as a supplement to the basic Hunter Education program, but will become the core of adult hunter education programs and specialized workshops or clinics.

The spin-off findings from Jackson's research have led to some changes in field law enforcement effort. The best example was the documentation that violations by local hunters occur more frequently on weekdays, particularly Fridays, rather than on weekends as had previously been assumed. Traditionally, warden efforts concentrated on weekends, and Fridays received very little effort. The findings led to a new focus on Fridays, resulting in an increase in arrests.

Another reason for the effectiveness of Jackson's research, in our opinion, is that he is an excellent educator and communicator. He has been able to communicate his findings well. His recent article in *Archery World* (1983) blends the data from waterfowl studies, gun deer hunter surveys, and bow deer hunter surveys into an insightful analysis of the bow hunter. Jackson goes beyond simple field studies, and as an educator actively helps managers improve training programs. He developed a set of innovative film clips that present complex social interactions while hunting (involving trespass, poaching, etc.). The situations presented in these films are left unresolved to "trigger" young hunters in hunter education courses to discuss these ethical issues, and allow instructors to avoid the often ineffective lecture method. Nothing in Jackson's field research about hunters pointed to the need for such films, yet they are seen by administrators as one of the major payoffs of Jackson's research.

Jackson's research illustrates one of the pay offs of working with social scientists outside the agency. Their basic disciplinary perspectives can add an important dimension to the wildlife research. Jackson's research on hunters, along with his training as a psychologist, yielded the notion of "phases"—the idea that hunters develop through a series of stages, from shooter to sportsman. While published in a popular journal (Jackson and Norton 1980b, Jackson 1981a) (the notion has yet to be documented empirically), the concept has received wide acceptance among hunters, managers, and human dimensions researchers. One of the pay offs of funding human dimensions research outside the agency is that basic researchers in the social science disciplines can add their own perspective, which may well enhance the broad applications of the research.

It is interesting to speculate on why social science research has had more effect in hunter education and law enforcement programs than in regulations. The strong commitment of hunters makes change extremely difficult in the regulation area. Hunting traditions are strongly held, requiring much more than a simple majority to effect a change. On the other hand, departmental law enforcement field efforts can be quickly modified to take advantage of findings. The hunter education program can likewise be modified (within budget constraints) with little if any adverse reaction. Change is not a condition that is even perceived by the user (i.e., students) since they take the basic course one time.

Bishop's research in Wisconsin is another example of how research has an indirect effect on policy. Its pay off in the state grew out of its utility *outside* the state. The research at the Horicon Marsh was not designed to establish fees; indeed neither the Department nor the sportsmen had any interest in establishing fees. Bishop was trying to test basic procedures for establishing values, to see how valid survey procedures were when tested against real dollar transactions. His research was of interest to those scientists developing the *National Survey of Fishing, Hunting and Wildlife-Associated Recreation* and other economists trying to value clear air and acid rain. One applied pay off of this research occurred outside Wisconsin, where these data were entered into testimony in a Virginia oil spill case, and, according to the economist who testified, were crucial in achieving a favorable settlement (Brown 1983). Moreover, in the years since the goose study, the conflict between foresters, who can show an economic benefit of red pine over aspen in dollar amounts, and wildlife managers, who cannot show the benefit of the improved aspen habitat for wildlife in dollar amounts, has sharpened. Enter here Bishop and his associates, who now can, and are, calibrating procedures for estimating the economic value of deer hunting in terms of willingness to buy and willingness to receive with real dollars. This is the first step in providing wildlife managers with data comparable to that used by foresters.

The conclusion of all this is the big pay off in hunter surveys and human dimensions research lies in providing a data base for management decisions. It is the broad perspective and extended findings that prove most useful in the long run, rather than the provision of specific data to solve the problem that motivated the research initially. Our conclusion, then, is that the research is very valuable, but not necessarily for the reasons it was intended.

Our conclusion here is not a rationalization to defend the last 15 years of research, but rather, as we reviewed each study and found it had either been unnecessary or ignored, we had to come to terms with the fact that something *had* changed in Wisconsin. In our judgement it is doubtful that any major change in wildlife programs could be accomplished today without the input of social science research. The managers want these data and so do the hunters. If each study had been largely a failure, then why the continued and increasing demand? Simply, in the aggregate, much more is known now about hunters than was known 15 years ago, and this is considered genuinely helpful to all involved.

Developing Agency-University Linkages

The most obvious lesson from the Wisconsin experience is that it is beneficial to develop agency linkages with basic social science researchers at nearby universities. While the agency-university relationship is not without frustration on both sides, the pay offs for management are substantial. The Wisconsin experience suggests how agencies in other states might establish such linkages.

1. *Initiate contact with the researchers*. The best researcher will often be too busy to reach your offices. Go to them. Visit with the department chairmen in sociology, economics and psychology at your nearby university and search for common ground and key individuals.
2. *Capitalize on scientist's motivations*. The great frustration to the scientist is that management questions are often formulated at the wrong level. Either they are

intellectually trivial (e.g., do hunters prefer a specific hunting season change?) or so broad as to be unanswerable (e.g., how can we get hunters to behave ethically?). Middle range, answerable questions (what are the dimensions of hunting quality or describe the type of hunting accidents and changes over time) are most interesting to the scientist. Even *more* interesting to the scientist are questions important to his or her discipline. Thus expenditure studies are dull for a resource economist, since there is little that they can contribute to the discipline. But expenditure data can be collected and analyzed as part of other surveys that provide informaton on more basic research.

The problem of publication and contributions to the discipline of human dimensions research has traditionally been a more serious problem for sociologists and psychologists than for economists, where the appropriate journals are well established. There is evidence that things are changing, however. Both the American Sociological Association, and the American Psychological Association have Environmental Sections. The Rural Sociological Society has had a Natural Resources Research Group and there recently has been a spurt of interest in human-animal research in Rural Sociology (Hummel 1983, Bryant 1984, Groth 1984). In addition, there is the Human Dimensions in Wildlife Study Group, an informal organization of social science researchers, which has a newsletter and has been meeting at the North American meetings. This support network is beginning to promote the kind of intellectual exchange that motivates the scientist. There is now a sufficient body of research in the human dimensions literature to generate its own interesting questions.

When hunting surveys are linked to the scientist's discipline and contribute to career development, this helps the agency research manager with his or her major problem: the timely provision of information. When the research is last on the scientist's agenda, reports are often delayed. When it is high on the agenda, stimulated by professional meetings and presentations (such as this paper, incidentally), reports are more timely.

Since disciplinary support is often lacking, the agency can attract scientist interest and involvement by capitalizing on avocational interest. It is no accident that the human dimensions researchers in Wisconsin are all avid hunters. In seeking out agency-university linkages, the first question the research administrator might ask the department chairman is: who on your staff hunts and fishes for recreation? Go for motivation over specialty. There are so many unknowns in the human dimensions area that input from a clinical psychologist could be just as useful as from a demographer or econometrician.

3. *Provide stable funding*. It doesn't have to be a lot of money, but the long term stability is important. In Wisconsin, agency funding for social science research has limped along from crisis to crisis. The funding has been unpredictable and often poorly timed. It is difficult to get good graduate students on short notice, or to provide long enough periods of funding to allow for doctoral training. Under these conditions, the research cannot build on itself. Long term funding of both Heberlein and Bishop, through the College of Agriculture, has provided a continuity that enhances productivity.
4. *Develop mechanisms for communication*. If university-based research is to have an effect in the agency, the researchers and managers must communicate well. In Wisconsin, social science researchers have been invited regularly to attend and make presentations at management conferences. They have served on study committees,

and have co-authored materials with agency personnel. This communication has been two way. Agency people have taken courses from university social scientists and have participated in research planning sessions on campus.

5. *Provide continuity and linkages.* The best way to do this is to have a social science specialist inside the agency. This could be a wildlife person with some social science training or a masters or Ph.D. level social scientist. This person can work on the human dimensions data collected by the agency. Most important, he or she should be aware of the findings of the university researchers and make sure these are presented in the internal policy formulation process. He or she should also be able to spot the social science implications of wildlife programs and seek out and inform the appropriate scientists. This sort of position would enhance the development and impact of social science research for wildlife management.

In conclusion, while sometimes ignored in specific cases, overall social science research has been important for wildlife management in the state of Wisconsin. We see an increasing demand for this sort of information in our state and encourage other agencies to develop linkages with university researchers, since the greatest pay off in Wisconsin has been on the general perspective rather than a specific finding. To do this it is necessary to initiate contact, capitalize on the scientist's motivation, provide stable funding and mechanisms for communication, and provide continuity and agency-university linkages. Fifty years ago, Aldo Leopold (1933) noted "that the attempt to control hunting has suffered from ignoring economic and psychological facts." In Wisconsin we are now making progress in providing those facts.

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Using Angler Preference Data in Defining Types of Sport Fisheries to Manage

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Purpose

Sport fishery managers are under considerable pressure to be responsive to the client groups they serve and to operate more efficiently as increasing demands are put on limited budgets. Although there is an obvious need to better integrate demand and supply, the means for doing so are far less clear. One problem is that the goods and services provided by fishery management are not always well defined.

This paper addresses that problem. The major objective is to describe how results of two studies of angler preferences helped improve classifications of sport fisheries in Wyoming and Colorado. The research was done at the request of managers in these states, who needed better angler demand data for fishery management planning.[1] Both studies were conducted in close cooperation with those managers.

Basic Concepts

Although the purpose of this paper is not to test hypotheses related to new theory or to describe new methods, the applied contributions of our research can be understood better if the two concepts on which that research was based are reviewed. One concept is that fishery management is a production process; the other is that the products of such management can most appropriately be defined by angler preferences.

Fishery Management As A Production Process

Fishery management as a production process proposes that the major goal is to produce fishery-related goods and services, which are considered to be the direct products of management. Those products are not fish or other things, but instead are *opportunities* to use a fishery in a particular way (Driver and Rosenthal 1982).

The production process concept recognizes the importance of the manager's knowing the technical "production-function" relationships between publicly supplied "inputs" (land,

[1] The word demand is used generically. It includes, but is not limited to, the concept of economic demand.

labor, capital, technology) and the products produced. In addition, it makes explicit the equally important need to consider user demands as inputs to the allocation decision, the role of user preferences in defining what the products are (as explained in the next section), and the on-site influence of the number of users, their behavior and their equipment on the quality of those products. For example, a "wild" catch-and-release fishery will not provide use opportunities related to that managerial classification if the number of users is excessive, if a user's noisy behavior conflicts with the values of other users, or if users fail to release their catch.

Also, a clear definition of products is needed to enable managers to know what to produce, to be able to inventory resources in terms of their potential to produce demanded goods and services, to set production targets, to measure use, and to determine the values of the products.

Role of User Preferences in Defining Products

Unlike the products of timber management (e.g., saw logs or pulpwood), which go through several intermediate stages of production, sport fishery products are used on-site (and by off-site appreciative users) directly as produced by the manager. Also, because these products are not physical things but opportunities to use the fishery in particular ways, they are not removed from the site, as are sawlogs or range cattle. Thus, fishery managers produce more than the fish, which might or might not be removed. The demand is for an experience that is provided by particular attributes of the product, such as the tranquility afforded by a wild, remote fishery or the opportunity for skill development and application when one is trying to outwit a smart lunker. More significantly, unlike users of most other resource commodities, the fishery user often transmits demands for specific types of experiences directly to the fishery manager, and frequently does so on-site. Many of these experiences directly depend on attributes of the setting in which the fishery is located and might have little to do with the types of fish present. Solitude is one example; it is influenced not only by the natural-physical setting but also by the social setting (e.g., number and behavior of other on-site users) and the managerial setting (e.g., rules, regulations, facilities, services, etc.).

To differentiate the products of fishery management, one must determine what attributes of those products are desired by the users—thus paralleling the market research done on product attributes for most goods and services offered by private industry. In addition, it is frequently necessary to obtain information on the users' fishery-related experience preferences. The value of this information is derived from understanding why particular experience-dependent attributes are desired and from being able to apply managerially useful names to fisheries that provide specific types of utility or satisfaction. For example, the concept of a wild type of fishery denotes preference not only for fish with specific attributes, but also preferences for particular types of settings and experiences. Or the label "trophy fishery" denotes types of satisfication, as well as of fish. Thus, the products of sport fishery management need to be defined by both the attributes of those products and by the types of experiences that are desired.

Only after the products have been clearly defined can the preferences of different types of anglers (e.g., market segments) for different types of fisheries be ascertained. Although any one fishery will receive different types of use, most fisheries might best be managed for particular types of use on the basis of the strongest demands of clearly defined types of anglers. The management of specific types of fisheries can thus be targeted to meet the demands of particular types of anglers.

Clarifying the Types of Fisheries Demanded in Wyoming and Colorado

The fundamental purpose of our research in Wyoming and Colorado was to determine angler preferences for several types of fisheries (e.g., wild, trophy, unique species) that managers believed to be workable managerial concepts in these states. Other objectives were to (1) identify and quantify preferences for other types of fisheries and describe the preferred attributes of these types; (2) describe managerially relevant characteristics of the different types of fishermen identified; (3) measure their use of different types of fisheries; and (4) determine their support for alternative management actions that could be taken to help resolve perceived problems.

Each study is presented separately to show how the Colorado study built on the results and applications of the Wyoming study. Such incremental building, by managers and researchers working together with mutual interests and respect, may be the best way to achieve more demand-oriented planning and management.

The Wyoming Study

In 1975, several related studies were conducted for the Wyoming Game and Fish Department, one of which was an exploratory "fishing attitudinal" study designed to meet the previously mentioned objectives (Phillips and Ferguson 1977). The methods are reviewed only briefly here.

Methods

The sample was taken from a total of about 247,200 1974 Wyoming license receipts for both resident (87,000) and nonresident (159,800) anglers. The nonresident category included nonresident annual (10,800) and 5-day tourist (149,000) licenses. A random stratified proportional sample of 2,000 anglers was drawn. A user preference questionnaire was developed and mailed in the spring of 1975, followed by a reminder to nonrespondents about 3 weeks after the initial mailing.

The questionnaire included a set of 23 questions designed to measure the importance of specific types of sport-fishery related experiences and attributes. These questions were selected to define types of fisheries that were judged to be preferred in Wyoming, even though the Game and Fish Department did not then formally identify some of those types in their fishery management plans and programs. Because this exploratory questionnaire was included as part of a larger research effort, the number of questions was restricted.

Respondents were asked to indicate how important the preference theme targeted by each question was to them when they fished at their favorite water in Wyoming. Preferences were reported on a 5-point response format that ranged from "Extremely Important" to "Not at All Important," which were coded 5 and 1 respectively, for quantification.

Data analysis consisted first of using cluster analysis to group logically and empirically related questions into distinct "preference clusters" that either defined different preferred characteristics of a fishery or of a fishing experience. Mean scores then were computed for each angler for each of the preference clusters and retained for further analysis. Different market segments, called "strong preference types" were defined using these mean scores and a decision rule explained later. Finally, percentage distributions were computed to show how the strong preference types differed across several characterizing variables, such as type of license bought or species of fish most favored.

Results

The 42 percent response to the questionnaire was typical of rates in hunter-angler surveys of this type that use license receipts as a sample frame. Although no tests were made, it is assumed that the more active and concerned fishermen responded, as has been disclosed in other studies (Bergersen et al. 1982).

The cluster analyses identified six distinct preference clusters, each of which had Cronbach alphas of at least 0.60. They were given identifying labels that reflect the preference questions, or statements that grouped empirically to define those clusters, as follows:

General Outdoors
- Just being outdoors
- Being able to relax
- Getting physical exercise
- Seeing wildlife

Social
- Showing fish to family and friends
- Being a well-equipped fisherman
- Developing or improving fishing skills

Yield
- Catching your limit
- Catching good eating fish
- Catching some fish

General Recreation
- Fishing at family-type areas
- Fishing near nice camping areas
- Getting out with family and friends
- Fishing water surrounded by pleasant scenery

Solitude
- Fishing wilderness-type areas
- Seeing few other fishermen
- Getting away from people

Trophy
- Catching large fish
- Chance to catch large fish

Wild (This one-item preference theme was added judgmentally)
- Catching native or wild fish rather than hatchery stock catchables

Some of these clusters, such as Trophy, Wild, and Yield, identified themes that defined types of fisheries that the managers expected to appear. Other clusters, such as Solitude, identified new concepts for fishery management in Wyoming.

For several reasons, the General Outdoors and Social clusters were dropped from further analysis. Each identified several preference themes rather than one central theme (as can be discerned from the above listed questions that defined those two themes). Also, about 95 percent of the respondents' average score (across the four questions) for the General Outdoors cluster was greater than 3.0. Thus, this common preference theme could not be used for market segmentation. Lastly, personnel with the Wyoming Game and Fish Department questioned the managerial utility of the Social cluster. The Wild "cluster," which contains only one question, was included as a market segmenter, because it differentiated the anglers by their preferences, and was viewed as managerially relevant.

Market segments were determined empirically to define the groups of fishermen who had both high and different mean scores for the preference clusters. Because statistical techniques for market segmentation, such as object-typing, were first being applied (Driver and Cooksey 1977, Hautaluoma and Brown 1978) to recreation experience preference data at that time, a decision rule was followed for assigning respondents to market segments. Each respondent was assigned to the market segment that reflected his/her highest score on the five preference clusters used as long as that score was at least 3.5. Each market segment was given the name of the preference cluster that defined it. This rigorous screening of respondents resulted in no assignment for the "less committed" respondents. Also, anglers having preferences of at least 3.5 for more than one preference theme, such as both Trophy and Wild, were not differentiated into separate multiple preference types; rather only the cluster with the highest score was used.

The results disclosed the specific types of fisheries that were strongly preferred, and the proportions of anglers that preferred them. Other types of analyses also provided useful demand information about the preferences of each of the strong preference types identified. Only a few examples are noted here: Ninety percent of the Trophy strong preference type showed a preference for brown trout, a much higher percentage than for any other segment; the Yield type showed the highest and the Solitude type the lowest preference for lowland lakes and reservoirs; the Wild type's mean score to the "Catching Native or wild fish" question was 4.6, whereas the scores for the other four strong preference types were all less than 3.0.

Applications

The results of this exploratory study were used to help support implementation of a more demand-oriented system for classifying the sport fisheries in Wyoming. After the report on the research was submitted, the Wyoming Game and Fish Department for the first time formally classified and then managed some of the state's fisheries to provide Trophy and Wild fishing opportunities. The concept of a Solitude type of fishery has not been added to that planning system, because the Wyoming Game and Fish Department does not have authority to manage for solitude per se. However, the preference dimensions of that type have been merged with the State's definition of a Wild fishery, which now is defined to mean both wild fish and remote, relatively undeveloped settings. A General Recreation type of fishery is not being provided as a distinct type of product, but the opportunities defined by that type are found at some Basic Yield and Put and Take fisheries—which, along with Unique Species, are the other types of fisheries being managed. In summary, the study provided empirical support for managerial concepts proposed by Wyoming managers and helped facilitate implementation of those concepts. In addition, new concepts were defined, which are partially being applied.

Further Refinement of Concepts

While the report by Phillips and Ferguson (1977) was being prepared, Bergersen and McConnell (1978) were developing a Fishery Operations Planning System (FOPS) for the State of Wyoming. That system is a comprehensive, computer-based, management planning system that integrates supply and demand data to classify the state's fisheries into "best use" categories and quantifies the potential contribution of each fishery to stated program objectives. On the basis of the results of the earlier Wyoming study, plus judgement of the authors and the managers with whom they worked, FOPS offered a refined classification of Wyoming's fisheries as follows:

Put and Take	*Wild*	*Basic Yield*
	Trophy	Trophy
	Unique Species	Unique Species
	Undesignated	Undesignated

The system provides further differentiation. For example, it proposes that a Trophy fishery can be either Wild or Basic Yield. The State of Wyoming has not yet implemented FOPS, but fishery managers in Colorado's Division of Wildlife became interested in its possible application in that state.

The Colorado Study

In 1982, a Colorado fishing preference study was conducted with a major objective of determining anglers' demands for the types of fisheries defined by FOPS, which was refined to include two additional types of fisheries called Urban and Plains (Bergersen et al. 1982).

Methods

The population sampled consisted of two groups of Colorado anglers. One group of 700,000 held regular resident or nonresident fee licenses in 1980. The other group of 70,000 held lifetime licenses issued first in 1976 to people aged 63 or older. A random sample of 8,700 anglers was drawn; sampling was disproportionally larger for the lifetime license group because of previous observations that their response rates were low. Necessary corrections were made later in the data analyses to correct for this inequality in the sampling procedure.

A 10-page questionnaire was developed and pretested twice before it was mailed during the first week of January 1982. A duplicate copy was mailed to nonresidents 4 weeks later, followed still later by a postal card reminder and request to participate.

Data analyses were similar to those made for the Wyoming study, but clustering was not done to define preference themes before the respondents were assigned to preference types. Instead, using results of the Wyoming study and personal judgement, we included several questions designed to measure preferences for each of the types of fishery defined by FOPS. Each respondent was assigned to one or more strong preference types if he scored each question, included to define a particular type, at 3.0 or more on a 4-point importance response format.

Results

The response rate was 53 percent for those in the sample who received the questionnaire. A test of nonresponse bias was made by a comparative telephone survey of 72 randomly selected nonrespondents. Most gave reasons for not responding that related to having little interest in fishing in Colorado. Nonresponse bias did not appear to be a problem.

A few of the empirical findings are reported here for illustrative purposes.

Only 35 percent of the anglers could be assigned to a market segment, as having a strong preference for a particular FOPS-defined type of fishery. These results parallel those of the Wyoming study, which had fewer strong preference types. Thus, it seems that strong differentiation of fishery products, as defined by the different types of fisheries used in these two studies, is primarily among about one-third of the licensed anglers.

For anglers who had strong preferences for one or more FOPS-defined types of fisheries, the percentage distributions were as follows:

Preference Type	*Percentage of All Strong Preference Types*
Put and Take	30
Wild (total)	(51)
Trophy	11
Unique Species	6
Undesignated	50
Basic Yield (total)	(8)
Trophy	0
Unique Species	0
Undesignated	8
Urban	1
Plains	26

The results do not total 100 percent because some anglers showed strong preference for more than one type of fishery. Also, it is apparent that some of the anglers preferred very different types of fisheries at different times. Furthermore, all of the Basic Yield preference was for Undesignated Basic Yield angling. These preference data could be interpreted as meaning that subcategories are probably unnecessary for Basic Yield. However, caution is needed, because it is shown later that actual use differs from preferred use for this type of fishery.

Data were presented that showed different distributions of the strong preference types by administrative regions of the Colorado Division of Wildlife. The report also showed the number of angler days spent in 1980 at each FOPS-defined type of fishery for all anglers and for the strong preference types. For the last group, there was considerable disparity between actual and preferred type of fishery used. For example, only 6.5 percent of the angler days in the total for all of the strong preference types were fished by members of the Basic Yield type; whereas 62 percent of the total angler days (for all the types) were at that type of fishery. Thus, many of the anglers who showed a strong preference for a particular type of fishery did not use that type, but instead fished at Basic Yield fisheries. This does not mean that the preference data are faulty; for many reasons, especially constraints that limit preferred choices, people choose to do things that are not always their first preference. It does mean that actual use data, preference data, and data on available supply all need to be considered when managers determine the amount of a particular type of fishing opportunity to provide.

The study also showed rather detailed data on how strongly the members of each strong preference type opposed or favored specific alternative management strategies; and it contrasted different positions between these segments. Not too surprisingly, each type tended to favor actions that would enhance the fishing opportunity indicated as being preferred.

Applications

The Colorado study provided a wide variety of systematically obtained angler demand data that are being used in sport fishery management planning in Colorado. For example, the differences in percentage distribution of strong preference types between administrative regions of the Colorado Division of Wildlife are being used to help guide decisions about where particular types of fisheries should be located.

The Division is also considering the implications of the findings that only slightly more than one-third of the Colorado anglers could be typed as having strong preferences for the specific types of fisheries defined. Given scarce resources not all angler preferences can be met, and allocation criteria must be established. The anglers making up the strong preference types are those to whom fishery management might most justifiably be targeted; they have differentiating preferences that should reflect benefits received. However, given that the other two-thirds of the anglers bought licenses and expended the travel costs and time to fish, their preferences are not irrelevant. Nor can it be said that they do not prefer particular types of fisheries; they just do so less strongly. It would seem that any targeting would meet their preferences, too, if all relevant concepts of management have been identified. The problem is determining how strong the preferences should be before targeting is done to meet that demand.

Finally, on applications, the results of the study are currently being considered to guide implementation of the FOPS systems by the Colorado Division of Wildlife. The recency of the report precludes further discussion now of specific applications of the results.

General Conclusions from The Two Studies

Because of increasing demands on finite resources, fishery managers have been obligated to develop programs that augment angling opportunities. As a result, new classifications of fishery resources have been made. Although intuitively sound, innovative, and based on useful feedback about angler preferences and satisfaction, these classifications frequently are not based on systematic research of angler preferences. As we have demonstrated here, such research can help support these management decisions—or refute them where necessary. In addition, these types of studies can systematically and objectively define new managerial options, show what proportions and types of actual and potential anglers desire such options, and thereby help facilitate definition of appropriate and possible public fishing opportunities—or products.

Future Directions

To be effective, applied research must have the support of the practitioners who use the results. Thus, future effort toward achieving more demand-oriented sport fishery management must proceed incrementally and not try to accomplish too much too quickly. Following that approach, teams of researchers and managers can make useful progress toward achieving more demand-oriented sports fishery management in the following types of inquiry.

More replications of the types of studies done in Wyoming and Colorado should be made. Researchers should attempt to quantify an expanded list of fishery-related experience and attribute preferences and thus refine existing management concepts and define additional ones. However, this research should be done only in conjunction with ongoing or emerging management systems that have mechanisms for direct application of the information generated. If this is not done, internal support for management planning will be weakened and the credibility of further applied demand studies will be reduced. Particular care must be taken not to propose managerial concepts that are too abstract to be useful. In these fishery classifying efforts, specification of too many types of fisheries would also be counterproductive. The proposed refinements in management planning must be easy to understand and rather simple to effect.

More systematic attention should also be given to determining how much and why expressed preferences for, and actual use of, different types of fisheries vary (Buchanan et al. 1982). To help explain these discrepancies, more research is needed of the type done by Wellman (1979), in Michigan, to relate anglers' behavior to the conditions they experience while not fishing. The preference studies should also define the types of fishing opportunities that are and are not substitutes for each other. This information is needed to obtain good estimates of economic demand and to help the managers cope with increasing demands.

Finally, as concerns grow about costs of managing public sport fisheries, more research is needed on the willingness of users to pay, and how programs to increase fees might be implemented. For example, the research by King (1980) showed that willingness to pay, and price elasticities of demand, varied considerably by different preference groups defined in his study of fishermen using the Fort Apache Indian Reservation in Arizona.

In these ways, both the state of the art and the state of practice of demand-oriented sport fishery management can be advanced.

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Using Socioeconomic Data in the Management of Fishing and Hunting

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Introduction

The use of public resources such as timber, wildlife, water and forage directly affects regional economies. For example, during a big game hunting trip, hunters typically purchase several services and goods from the businesses in a state, county, or community. The economic effect of these purchases does not stop here, because businesses must buy goods and services to meet their own needs. These purchases also filter throughout the regional economy, resulting in either additional transactions or "leaking" from the area's economy in the form of import purchases. As these transactions occur throughout the economy, income is earned and labor is employed. Resource managers must be able to trace these linkages in order to determine the contributions public resources make to local economic activity.

Clearly, a change in policies governing public resources would affect this economic activity. A policy could, for example, alter the hunter use rate and change the total hunting-related purchases made in an area. A management policy could also cause a shift in the type of use, altering the composition of purchases made by hunters. Similarly, changes in the cost of certain items may affect both the use rate and the composition of expenditures. Assessing these implications is a task often required of public land managers.

To determine the scope of local economic impacts, estimates of recreation use and user expenditures are needed, along with a procedure for predicting economic impacts. Historically, this information has been difficult to acquire. The *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (USDI 1982a) provides an extensive source of information for wildlife-related recreation use and user expenditures. This information covers each state as well as substate wildlife management areas. It also distinguishes between several types of wildlife-related activities. The USDA Forest Service analysis system IMPLAN (Alward and Palmer 1983) provides a way to derive predictive models of regional economies. This paper illustrates the use of the Survey data with IMPLAN models to determine the impacts of wildlife management policies upon the supplying industries and income of regional economies.

Regional Accounts and Recreation Expenditutes

Expenditure data from the Survey can be included in a regional economic accounting framework that can be used subsequently to derive impact analysis models. Economic accounts, either of a region or a nation, systematically describe transactions among various groups of transactors. All forms of economic accounts are characterized by the double-entry system with total debits or expenditures on one hand equal to total credits or income on the other. Given sufficient distinctions among the various economic groups (e.g., industries, institutions, regions), this method permits detailed examination of the transactions both between and within the groups.

The Social Accounting Matrix (SAM)

The economic account discussed here is the social accounting matrix, or SAM (Stone 1961). The SAM differs from other economic accounts in its approach to stratifying an economy and its flexibility for examining a number of economic functions. A highly aggregated SAM is illustrated in Table 1. By convention, expenditures are always entered in the columns and receipts across the rows. Only a general description of a SAM is given here in order to focus upon wildlife-related recreation expenditures. A more comprehensive discussion of social accounts is given by Bulmer-Thomas (1982) and Pyatt and Roe (1977).

The primary components of the economy are the production, institution, and trade sectors. The production sector, devoted to the production of goods and services, is further divided into two groups: (1) activities, which are the industries and firms that produce goods and services; and (2) factors—capital and labor—that provide value-added to production. The institutions sector covers the consumption and accumulation functions of an economy. This sector shows entries for different kinds of institutions, in this case households, corporations and governments. Household expenditures have been divided to separate outlays for hunting and fishing from all other consumption expenditures. Similarly, spending by governments on fish and wildlife programs has been separated from all other government purchases. The trade sector captures interactions between the economy and the rest of the world. Again, expenditures on hunting and fishing by nonresidents of the study region have been separated from other export sales.

The submatrices of a SAM highlight a number of important economic interactions. Submatrix T contains transactions between industries while V shows factor payments by industries. Factor payments are distributed as household income by submatrix Y. Various transfers (taxes, transfer payments, savings, investment) are given by the TR submatrices. Payments for imported goods and factors appear in the m submatrices. Spending by institutions for locally produced products are given by the c, g, and b submatrices. Sales to nonlocal buyers appear in submatrix e. Total expenditures are given by column totals while total income is shown by row sums.

Three submatrices of the SAM in Table 1 are pertinent to recreation expenditures by households. The first submatrix, c_r, represents hunting- and fishing-related expenditures by the region's households for goods and services produced by local industries (or conversely receipts by local industries for the commodities sold to the region's households). The distinction of *local* or the *region's* industries and households is made to separate these entries from those in the the trade sector. Submatrix m_r (where the households account intersects the trade sector) shows recreational purchases by the region's households of commodities imported from the rest of the world. These purchases are actually made while residents travel outside the study region. All hunting and fishing expenditures by households residing in the study region are entered into these two submatrices. Similar interpretations can be given to the submatrices g_w and m_w for government expenditures on fish and wildlife programs. The Survey provides information for directly estimating the entries in submatrices c_r and m_r, and some data for submatrix g_w.

The accounts discussed so far do not cover all expenditures made by hunters and anglers in a region. While the expenditures by resident households made either within or outside the region have been captured, purchases by nonresident hunters and anglers have not. These are shown in submatrix e_r. In this case, purchases made by nonresident hunters and anglers travelling to the study area constitute domestic export sales for local industries. Again, the Survey provides information for directly estimating these transactions. Since

Table 1. An aggragated Social Accounting Matrix.

	Production		Institutions					Trade		Total Income
	Activities	Factors	Households		Government		Corporations			
	1 . . . n	1 . . . f	Recreation	Other	Wildlife	Other	1 . . . m	Recreation	Other	
Production										
Activities										
1 . . . n	T	—	c_r	c_o	g_w	g_o	b	e_r	e_o	t_1
Factors										
1 . . . f	V	—	—	—	—	—	—	—	—	t_2
Institutions										
Households	—	Y	—	TR_{hh}	—	TR_{hg}	TR_{hb}	—	TR_{ht}	t_3
Government	—	—	—	TR_{gh}	—	TR_{gg}	TR_{gb}	—	TR_{gt}	t_4
Corporations	—	—	—	TR_{bh}	—	TR_{bb}	TR_{bb}	—	TR_{bt}	t_5
Trade	m_a	m_f	m_r	m_o	m_w	m_g	m_b	—	—	t_6
Total Expenditures	t_1	t_2	t_3		t_4		t_5	t_6		

this is a SAM of only one region, purchases by nonresidents that are made elsewhere (e.g., in their home state) are not shown in the study region's accounts.

To summarize briefly, hunting and fishing expenditures are entered in a regional SAM in three different places depending upon the participant's residence and the activity site: (1) residents hunting or fishing in the study area; (2) residents hunting or fishing elsewhere; and (3) nonresidents who come to the study area to hunt or fish.

While it is useful purely for description to examine hunting and fishing expenditures in a format like a SAM, this alone does not help a manager evaluate how policies may affect economic functions. With certain assumptions about economic behavior, the data in a SAM can be used to construct models that are useful for tracing the economic implications of resource policies. This paper focuses upon interindustrial input-output (I/O) models, although a wide variety of models can be derived from a SAM (see United Nations 1968). Regional I/O models are an important tool in Forest Service planning and are developed using the IMPLAN system. The Appendix gives the mathematical developmnt of a regional I/O model from a SAM.

Estimating Hunting Trip Expenditures

The simulations presented here used Survey data with the IMPLAN system to estimate the socioeconomic impacts of changes in policies affecting big game hunting in the state of Colorado. The same procedures would apply to analyses of other types of hunting as well as fishing activities. Briefly, the task was to use the Survey to establish a "bill of goods" or list of purchases made during a hunting trip by different groups of hunters. This bill of goods was then used to estimate a change in the exogenous component of the IMPLAN model from which effects upon regional economic activity were derived. The data used here were taken entirely from the Colorado state report (USDI 1982b) and the national summary report (USDI 1982a). Although the needed data appears in these reports, several adjustments were necessary to have the data conform to the conventions of the IMPLAN system. These modifications involved three steps: (1) separating the expenditures of all big game hunters either hunting or residing in Colorado into three groups: purchases by residents hunting in-state, residents hunting out-of-state (which are import purchases with respect to the Colorado economy), and nonresidents hunting in Colorado (which are part of the export component of regional sales); (2) distributing the Survey expenditures (e.g., for food, lodging and transportation) among the appropriate IMPLAN activities; and (3) transforming the data to per-trip expenditures because changes in the number of trips by each hunter group seemed the most likely indicator of policy effects.

Step 1

The initial task established the bill of goods for big game hunter purchases made within the state of Colorado. The in-state expenditures by residents and nonresidents hunting in Colorado appear in Table 24 of the state report, under two consumption categories. The first category encompasses in-state purchases of food, lodging, and transportation while the other category shows expenditures for privilege and other fees. In preparing the state reports, the authors presumed that all equipment expenditures were made within each hunter's state of residence (Hay, pers. comm.: 1983). Equipment expenditures by resident hunters, for both in-state and out-of-state use, are included in Table 17 of the Colorado report.

A more detailed list of purchases by residents while hunting in-state was established by using the information in Table 17 of the state report. This Table shows total resident big game hunting expenditures, both in-state and out-of-state. In order to disaggregate the broad categories of food, lodging, and transportation in their component commodities, the purchases for each of these items was divided by the total expenditure for the group of items. These proportions were then applied to the previously computed resident in-state expenditures for food, lodging, and transportation by residents hunting in Colorado. The results represent the detailed expenditures for food, lodging, and public and private transportation made by residents within the state while hunting in-state. In-state expenditures for privilege and other fees were similarly separated.

Expenditures by residents while hunting out-of-state were computed by subtracting the in-state expenditures for in-state hunting from the total resident expenditures displayed in Table 17. Because we were interested only in the impacts upon the Colorado economy, the in-state purchases by residents hunting out-of-state were separated from their total expenditures. This required several assumptions. First, Colorado hunters going out-of-state were assumed to have purchased all of their lodging outside of Colorado; and second that those hunters bore all of their public transportation expenses and 25 percent of their private transportation costs within Colorado. Finally, it was presumed that 10 percent of their food purchases were made in Colorado. These assumptions were based upon subjective inspections of the Survey data for trip distance, duration and mode of transportation.

Hunters also purchase durable equipment for hunting. Because it was assumed earlier that these expenditures occur only in the hunter's state of residence, the equipment expenditures in Table 17 of the state report represent only in-state resident purchases. These expenditures were apportioned to the in-state and out-of-state resident hunter groups using the proportions of each group's trips to the total resident trips. Although the equipment purchased may last a number of seasons, it was unnecessary to distribute the expenditures over the estimated useful life of the equipment. Given the entire population of big game hunters in Colorado, similar spending on new equipment can be expected annually, even though an individual hunter may purchase equipment infrequently.

Nonresident in-state big game hunting expenditures were split into the Survey consumption categories using the same calculations described for the resident in-state expenditures, except that Table 21 from the national report was used instead of Table 24 in the state report. The entries in Table 21 represent nationwide big game hunting expenditures. It was decided that this average distribution better represented the pattern of expenditures for nonresidents than did the distribution for Colorado residents only. Again because of the assumption about where equipment purchases were made, the calculation of nonresident in-state expenditures also differed from the resident in-state calculation in that no equipment expenditures occur in Colorado.

Step 2

The second step in transforming the Survey's information involved allocating the expenditures described by the bills of goods to the appropriate IMPLAN accounts. Some of the Survey categories represent purchases of individual commodities while other categories include purchases of several commodities. Each of these two categories required different treatment.

Transportation, wholesale, and retail services have been kept separate from the primary production of consumer goods in the accounting conventions of the IMPLAN system. Consequently, if a good is purchased from a company other than the one that made it, the total sale value for the good must be partitioned or "margined" among the firms which handled the good. That is, the portion of an expenditure allocated to each of the service industries handling an item (the service "margin") must be separated from the portion attributed to the industry that made the good. Several of the expenditure categories presented in the Survey required this change.

In the case of the purchase of a single commodity, the producing industry was identified and likewise the appropriate IMPLAN activity. If the purchase was made directly from a producer, the entire amount of the expenditure was attributed to the producing industry. If not purchased directly from the producer, the wholesale, retail, and transportation portions were estimated using the personal consumption expenditure margins prepared by Sullivan[1].

In the case of a Survey expenditure representing the purchase of several commodities, the personal consumption categories were used to margin the expenditure among the production, transportation, and trade sectors. The appropriate personal consumption expenditure category was selected and the portions of the expenditure to be allocated to each IMPLAN activity were calculated by multiplying the margins and the expenditure. If an industry listed in the personal consumption expenditure category was not present in the state of Colorado, that portion of the expenditure was considered an import purchase and disregarded.

Step 3

The final transformation of Survey data was to determine expenditures per trip. The number of resident in-state, nonresident in-state, and resident out-of-state big game hunting trips that occurred in 1980 are shown are shown in Table 6 of the state report. Each group's expenditures were divided by the corresponding number of trips, yielding expenditures per trip. Although policies may not change the number of trips for which hunting is not the primary purpose, these trips were included in this calculation rather than just the trips for which hunting was the primary purpose. This was done because no distinction was made in the Survey between expenditures ocurring on trips for which big game hunting was the primary purpose and trips for which it was not the primary purpose. Considering only the primary purpose trips would lead to overestimating the expenditures per trip.

Policy Simulations

For managing wildlife and fish resources, state and federal resource management agencies typically consider a range of policy alternatives, which may affect the expenditures, number of trips, and mixture of resident and nonresident participants. Three policy simulations are used here to illustrate the economic impacts that can occur when the policy effects are expressed in three different ways: (1) through changes in the total number and group composition of trips (Policy A); (2) by altering the expenditures per trip (Policy B); and (3) by causing substitution of one activity for another and thus changing the total number of trips and group composition (Policy C). The estimated direct effects of each policy upon the expenditures and number of trips by each participant

[1] Sullivan, B.J. 1982. Determining changes in final demand for IMPLAN economic impact analysis. Unpublished working paper. USDA Forest Service, Fort Collins, Colorado.

group are shown in Table 2. Likely policy circumstances that might cause the hunter behavior are given below.

Policy simulation A represents the effect of changing the opening day of elk hunting from a holiday weekend to a midweek day and reducing the total hunting period of 14 to 10 days. The objective of the policy is to reduce the total harvest. Changing the season opening and length is expected to reduce the total trips taken for elk hunting by residents hunting in-state by 20 percent, increase the number of trips taken by residents hunting out-of-state by 35 percent, with no change in out-of-state hunter trips to Colorado.

Policy simulation B describes the effect of increasing the number of regular hunting season permits in big game management areas that are more than 200 miles from the Colorado Front Range population center and adding two 20-day post regular season opportunities in January and February in those same game management areas. One effect of this policy is to have more residents from the Front Range area drive further to hunt, thereby increasing the transportation expenditure of residents by 5 percent. Expenditures by residents hunting out-of-state remain the same although nonresident hunters in Colorado, like their resident counterparts, travel further from the Denver airport, adding 2.5 percent to their transportation costs. Also, the supplemental seasons in late winter result in more hunters renting motels and motorhomes because of the colder weather. This causes resident expenditures for lodging to increase by 5 percent and nonresident lodging purchases to go up 2.5 percent. No change occurs for expenditures of Colorado residents hunting out-of-state.

Policy simulation C shows what might result from changing the antelope season to run concurrently with the regular October elk season. Resident elk hunters are expected to take 40 percent fewer in-state trips. Of those no longer hunting elk in-state, 10 percent are expected to take out-of-state trips, 15 percent substitute antelope hunting for elk, with the remainder choosing not to hunt. Nonresident participation in elk hunting drops by 25 percent, 10 percent of whom apparently currently hunt antelope as well. No change occurs for Colorado residents hunting antelope out-of-state.

The potential economic effects of the three policy scenarios on the economy of Colorado are given in Table 3. The production activities comprising the State's economic structure have been grouped into 14 industrial categories. Three parameters describe each policy's effect: (1) net expenditures of, or direct sales to, all hunter groups; (2) wage income earned by labor in the State; and (3) the number of employed persons. Each of the parameters is shown as the difference between the current activity levels and the estimated level with implementation of the policy.

Each policy resulted in economy-wide changes in each parameter. The most notable effects were concentrated in a few activities, including the wholesale and retail trade activities, nonfood manufacturing, finance-related activities, and the service sectors. Among these activities, the impacts upon the wholesale and retail trade sectors dominated.

Policy A is characterized by reductions in nearly all activities. The decline in in-state hunting trips reduced in-state expenditures, resulting in decreased regional sales, income, and employment. In contrast, policy B shows increased activity in nearly all sectors. The higher in-state expenditures per hunting trip, with the number of trips held constant, increased total in-state expenditures, income, and employment. Finally, policy C is marked by reduced activity in nearly all sectors. In this case, an increase in total expenditures caused by more antelope hunting trips was more than offset by the decrease in total expenditures caused by fewer elk hunting trips. This resulted in net reductions in economic activity.

Table 2. Direct policy effects on hunting in Colorado.

Hunter groups	Policy A		Policy B		Policy C (Elk)		Policy C (Antelope)	
	Current	With policy	Current	With policy	Current	With policy	Current	With policy
Residents hunting in Colorado								
Number of trips	721,100	476,900	721,100	721,100	455,700	273,400	17,700	45,000
Expenditures per trip								
Food, lodging, transportation	$ 27.57	$ 27.57	$ 27.57	$ 30.33	$ 27.57	$ 27.57	$ 27.57	$ 27.57
Equipment	33.96	33.96	33.96	33.96	33.96	33.96	33.96	33.96
Licences, fees	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71
Expenditures per trip	$ 63.24	$ 63.24	$ 63.24	$ 66.00	$ 63.24	$ 63.24	$ 63.24	$ 63.24
Residents hunting outside Colorado								
Number of trips	15,100	20,400	15,100	15,100	0	18,200	2,200	2,200
Expenditures per trip								
Food, lodging, transportation	$ 11.69	$ 11.69	$ 11.69	$ 11.69	$ 11.69	$ 11.69	$ 11.69	$ 11.69
Equipment	33.96	33.96	33.96	33.96	33.96	33.96	33.96	33.96
Expenditures per trip	$ 45.65	$ 45.65	$ 45.65	$ 45.65	$ 45.65	$ 45.65	$ 45.65	$ 45.65
Nonresidents hunting in Colorado								
Number of trips	176,600	176,600	176,600	176,600	134,600	100,900	300	3,700
Expenditures per trip								
Food, lodging, transportation	$263.70	$263.70	$263.70	$276.85	$263.70	$263.70	$263.70	$263.70
Licences, fees	64.19	64.19	64.19	64.19	64.19	64.19	64.19	64.19
Expenditures per trip	$327.89	$327.89	$327.89	$341.04	$327.89	$327.89	$327.89	$327.89

Table 3. Estimated economic effects.

Industries	Policy A			Policy B			Policy C		
	Direct sales[a]	Wage income[a]	Employ-ment[b]	Direct sales[a]	Wage income[a]	Employ-ment[b]	Direct sales[a]	Wage income[a]	Employ-ment[b]
Agriculture	$ −0.59	$ −0.79	−33	$ 0.25	$ 0.55	19	$ −0.56	$ −1.00	−38
Mining	−0.01	−0.84	−6	0.01	0.71	5	−0.01	−1.28	−9
Construction	0.00	−0.30	−13	0.00	0.30	14	0.00	−0.37	−17
Food manufacturing	−2.66	−0.75	−36	2.13	0.60	29	−3.91	−1.09	−53
Other manufacturing	−7.13	−3.79	−178	1.89	1.02	49	−6.28	−2.90	−134
Transportation	−0.68	−0.72	−30	0.59	0.64	27	−1.03	−0.97	−40
Communications	−0.81	−1.02	−24	0.89	1.15	27	−0.95	−1.20	−28
Trade	−8.25	−5.61	−390	15.63	9.98	641	−9.40	−6.42	−436
Finance, insurance	−3.54	−3.33	−53	3.88	3.66	58	−4.15	−3.97	−64
Hotels and lodging	−0.35	−0.22	−28	0.34	0.22	28	−0.79	−0.45	−58
Eating and drinking	−1.75	−0.74	−105	1.52	0.67	95	−2.48	−1.02	−144
Other services	−2.94	−2.77	−195	3.03	2.93	203	−3.85	−3.44	−258
Government enterprises	−0.25	−0.30	−18	0.28	0.34	20	−0.29	−0.35	−21
Scrap and used merch.	−0.07	0.00	0	0.07	0.00	0	−0.08	0.00	0
Total	$−29.03	$−21.18	−1,110	$30.51	$22.77	1,217	$−33.78	$−24.45	−1,300

[a] Millions of dollars.
[b] Number of jobs.

Figures 1 and 2 illustrate the differences between the incidence of the direct expenditures by hunters upon the parts of the State economy and the direct and indirect effects these purchases have upon wage income (employment follows a similar pattern). Figure 1, constructed from the data in Table 3, shows the percentage distribution of total in-state expenditures by all hunters for each policy scenario. Figure 2, also made from the data in Table 3, presents the percentage distribution of wage income earned as a result of the direct and indirect effects of hunter expenditures in Colorado. Comparing the two figures shows that the distribution of the direct effects of hunter spending is quite different from the resulting pattern of income earned throughout the economy. Clearly, the effects of management policies extend beyond the immediate and directly affected portions of the economy. These indirect linkages are traced by the multiplier matrix given by the IMPLAN I/O model.

Conclusions

The examples shown here are subject to two important limitations. The simulations were based upon speculations about hunter responses to management policies, not empir-

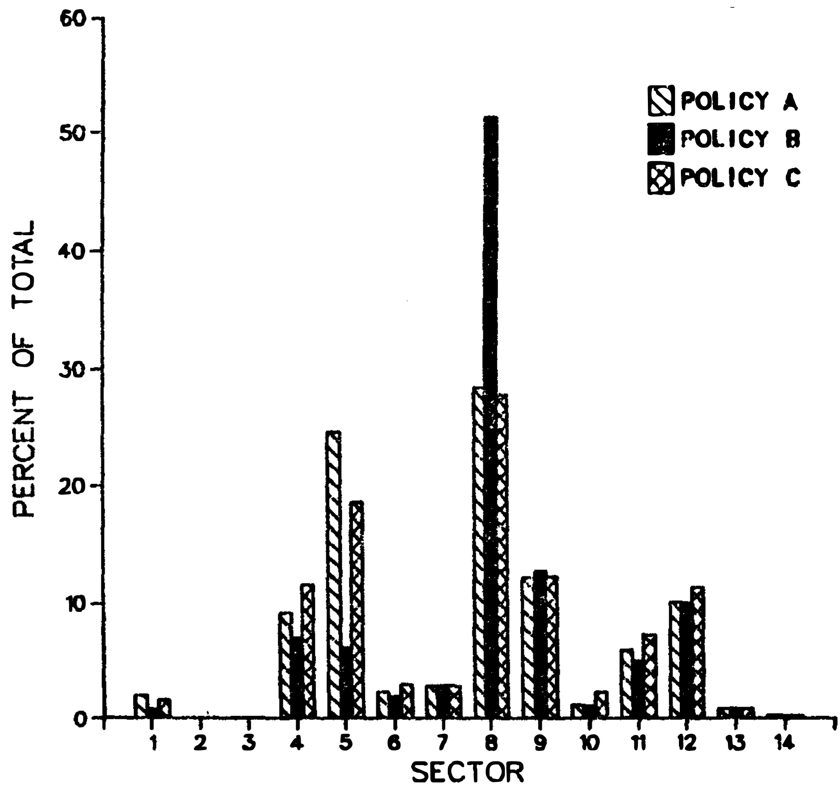

Figure 1. Distribution of direct expenditures by industrial sector.

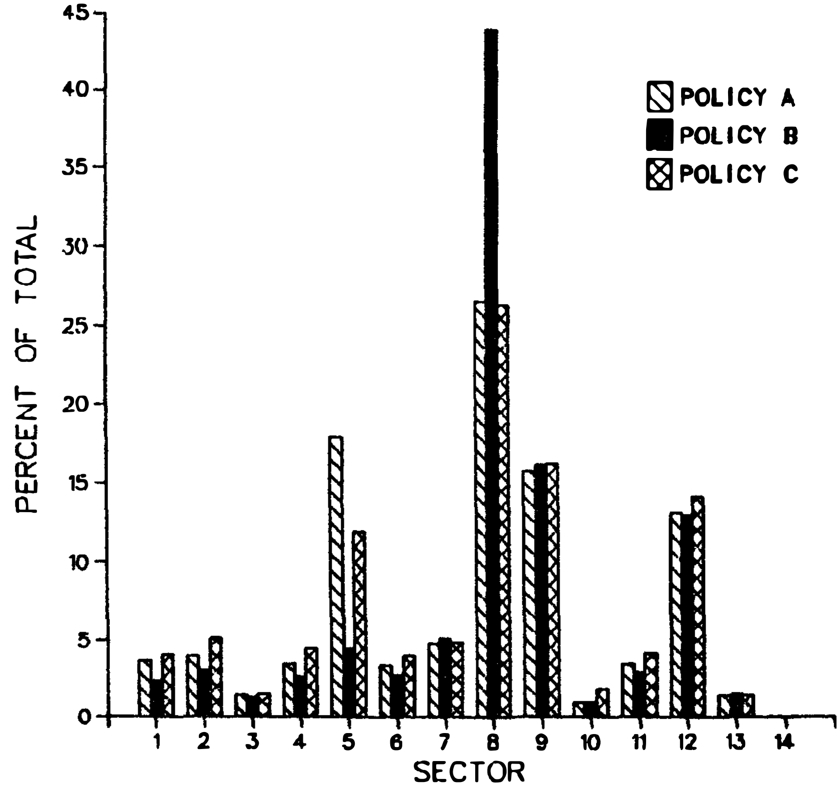

Figure 2. Distribution of direct and indirect income by industrial sector.

ical evidence. Clearly, appropriately specified demand schedules could provide much better information about hunter responses. Some research has been undertaken to do this, although the resulting schedules are typically limited in their range of applicability to management policies. The second shortcoming is that no attempt was made to enumerate all net changes in household consumption spending. For example, gross reductions in expenditures due to fewer recreational trips may be offset by spending on substitutes, including nonrecreation endeavors. Again, appropriately specified demand schedules would be extremely helpful, if they included cross-price terms for activity substitutes. Unfortunately, the state of the art in deriving such schedules is in its infancy, often requiring analysts to resort to subjective judgements.

This paper showns that data given by the Survey can be extremely useful in the context of regional economic analysis. With a few manipulations of the data to make it conform to the conventions of the IMPLAN input-output system, information can be used directly from the Survey to evaluate the economic implications of various resource policies that may affect hunting and fishing behavior.

Appendix

The first step in making an I/O model from a SAM is to distinguish the independent or exogenous sectors of the economy from the dependent or endogenous sectors. Since the purpose here is to trace effects upon supplying industries and labor income, the production accounts are the endogenous sectors (submatrices T and V in Table 1). Transactions of the institutions and trade sectors constitute the exogenous parts of the model, especially the hunting and fishing expenditures.

The basic premise of an I/O model is that independent changes in transactions of the exogenous accounts (in this case, changes in hunting and fishing expenditures) cause predictable responses in the production sector. The model is derived from the production sector balance statement for receipts:

$$x=T+c_r+c_o+g_w+g_o+b+e_r+e_o. \qquad (1)$$

This equation describes total industrial sales (x) as being the sum of intermediate sales to industries, consumption expenditures by institutions, and export sales to the rest of the world. Matrices are denoted by uppercase letters, vectors by lowercase. From the expenditure side, a similar balance holds:

$$x'=T'+V+m_a. \qquad (2)$$

This equation shows that total industrial outlays are the sum of intermediate purchases from industries, payments to factors of production, and imports. The apostrophe indicates a transposed vector or matrix. The two accounts balance since total industrial output is equal to total industrial outlay. If the exogenous accounts in equation (1) are summed to a single vector (z), then the equation can be rewritten:

$$x=T+z. \qquad (3)$$

Assuming an industry's input purchases from other industries are proportional to the industry's total outlays, a matrix of purchase coefficients can be computed from the SAM:

$$A=T\hat{x}^{-1}. \qquad (4)$$

The matrix $\hat{x}$ is diagonal, derived from the x vector. Substituting equation (4) into equation (3) yields:

$$x=Ax+z \qquad (5)$$

which can be rearranged to give estimated industrial output x^* as a function of changes in the exogenous sectors z^*:

$$x^*=(I-A)^{-1}z^*. \qquad (6)$$

Equation (6) describes a simple I/O model in which the effects of changes in consumption demand upon a region's production activities are estimated using the Leontief multiplier matrix $(I-A)^{-1}$. Similarly, the proportion of total outlays going to labor and other factors (N) is a function of total industrial outlay:

$$N=V\hat{x}^{-1}. \qquad (7)$$

With estimated changes in industrial output (x^*) from equation (6), effects upon factor payments including labor income are given by:

$$V^*=Nx^*. \qquad (8)$$

Employment effects, being directly related to the magnitude of factor payments to labor, can also be estimated.

The Forest Service IMPLAN system is used to estimate the multiplier matrices $(I-A)^{-1}$ and (N). This is done by using a data file for all U.S. counties describing submatrices T, V, c, g, b and e of the SAM shown in Table 1 and algorithms that derive the multiplier matrices.

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Socioeconomic Profiles of Missouri Deer Poachers: Management Applications

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Introduction

The need for a better information base for effective wildlife law enforcement has been stressed by several authors (e.g., Giles et al. 1971, Hendee and Potter 1971, Beattie et al. 1977). One phase identified as needing attention is the social and economic status of violators, especially as compared with the non-violating hunter, or the general public. Socioeconomic characteristics, specifically of big-game violators, have been studied by Amidon (1968), Vilkitis (1968), Shafer et al. (1972), Kesel (1974), and Sawhill and Winkel (1974). These researchers concluded that socioeconomic information about big-game resource users could provide direction for development and implementation of conservation educational and informational programs and improved enforcement effort to reduce wildlife violations.

In 1979 a 2-year investigation was initiated in Missouri to (1) determine the most effective patrol methods to apprehend and deter deer poachers, (2) determine characteristics of closed-season deer violations (not during the legal hunting season), and (3) describe social and economic characteristics of convicted deer poachers. This paper addresses the third objective.

Methods

Data on socioeconomic characteristics of deer poachers were collected statewide from 398 persons who were convicted for closed-season violations that occurred between July 1, 1979, and June 30, 1981. Conservation agents interviewed deer poachers and recorded their responses on standardized data sheets. In addition, each deer poacher's previous arrest history was determined by searching Missouri Highway Patrol and Missouri Department of Conservation official arrest records. Frequency distributions of data were prepared by using Barr and Goodnight's Statistical Analysis System (Barr et al. 1979), with X^2 tests of independence at $P=0.05$.

Results

Ages of deer poachers ranged from 15 to 65 years and averaged 28 years (SE=10.1). Slightly over half (52.6 percent) of the poachers were younger than 26, and only 13.6 percent were older than 40 (Table 1). The largest age group was 21 to 25 years. Because

Table 1. Social and economic characteristics of closed-season deer poachers convicted in Missouri, July 1, 1979, to June 30, 1981.

Characteristic	*n*	Percentage of total
Sex		
Male	392	98.7
Female	5	1.3
Age		
15–20	80	20.1
21–25	129	32.5
26–30	58	14.6
31–35	44	11.1
36–40	32	8.1
>40	54	13.6
Education		
Elementary school only	16	4.7
Some high school	68	19.9
High school graduate	252	73.9
College graduate	5	1.5
Estimated income		
$ 6,999 or less	121	35.4
7,000–$13,999	161	47.1
14,000– 20,999	52	15.2
21,000 or more	8	2.3
Work status		
Employed	278	70.0
Unemployed	119	30.0
Occupation		
Blue collar	318	81.3
Farmer	28	7.2
Student	19	4.8
White collar	11	2.8
Retired	6	1.5
Disabled	5	1.3
Military	3	0.8
Housewife	1	0.3

almost all of the poachers were male (98.7 percent), women were not considered as a special group in data analyses.

Almost three-fourths of poachers had completed high school (73.9 percent) or college (1.5 percent, Table 1); 5.6 percent were still attending high school. No significant relationship between age and educational level was determined. However, 32.0 percent of poachers 30 years or older ($n=103$) had not completed high school and almost 10 percent had not advanced beyond the seventh grade.

Most poachers (81.3 percent) had blue-collar occupations, primarily construction, sawmill operation and logging, truck driving, and farm labor. Other major occupations included farm owners (7.2 percent) and students (4.8 percent). Using poachers' occupations in conjunction with other socioeconomic information, conservation agents estimated that most poachers (82.5 percent) earned less than $14,000 per year (Table 1).

Thirty percent (n=119) of the poachers were unemployed when they were arrested (Table 1). Of these, about 71 percent were age 30 or younger. The highest rates of unemployment were among poachers under 21 years (37.5 percent) and over 40 years (33.0 percent). High school attendance probably explains the high unemployment record of younger poachers.

More than half (53.5 percent) of the poachers (N=381) were married. As expected, most (86.7 percent) of the unmarried violators were 30 years of age or younger. About half (53.9 percent) of the married poachers supported two to four family members. Forty-one percent of poachers supported only themselves.

Many poachers (56.7 percent) were lifetime residents of the county in which they committed a deer violation, and only 19.3 percent had never resided in the county. Poachers' homes were located almost equally in rural (52.3 percent) and urban areas (47.7 percent). About 95 percent of the poachers were residents of Missouri.

A search of Department of Conservation and Missouri Highway Patrol records showed that a substantial number of deer poachers had prior arrests (Table 2). According to Department of Conservation records, 10.1 percent of the poachers had been convicted of wildlife violations. Of these poachers, almost 60 percent were convicted of wildlife violations not related to deer, and about 40 percent involved deer. Fewer fish and game violations were observed for younger poachers than for those over 25.

Missouri Highway Patrol records indicated that almost 47 percent of deer poachers had been arrested for traffic violations, and almost 20 percent (N=66) had committed felony violations (Table 2). Felony crimes included murder, attempted murder, felonious assault, manslaughter, armed robbery, rape, and various drug violations. The 66 persons with felony records had been charged with over 250 violations of Missouri statutes. The 31–40 age group had the highest frequency of felony arrests (30.0 percent), and the 21 or below age group had the lowest frequency (6.5 percent). Number of felony arrests was significantly (X^2, $P<0.05$) related to age.

Nearly 42 percent of 372 poachers had been drinking alcoholic beverages when apprehended. A comparison of poachers' behavior and whether they were drinking alcohol showed a significant (X^2, $P<0.05$) relationship. Drinkers of alcoholic beverages were more likely to be belligerent or violent than nondrinkers. This relationship was even more

Table 2. Frequency of prior misdemeanor and felony arrests[a] for 385 convicted deer poachers in Missouri by age group.

		Wildlife arrest		Traffic arrest		Felony arrest	
Age	*N*	*n*	%	*n*	%	*n*	%
15–20	107	3	2.8	46	43.0	7	6.5
21–30	162	14	8.6	92	56.7	29	17.9
31–40	70	11	15.7	28	40.0	21	30.0
Over 40	46	11	23.9	16	34.7	9	19.6
All ages	385	39	10.1	182	47.2	66	17.1

[a] Records showed only arrests in Missouri.

evident (X^2, $P<0.05$) for drinkers whom conservation agents considered intoxicated (18.2 percent).

Acquiring meat (50.6 percent) and recreation-vandalism (34.0 percent) were the two principal reasons given by poachers for committing deer violations (Table 3). Poachers' ages were related to their reasons for poaching. Young deer poachers (≤20 years) committed poaching violations just as often for fun as for meat. Older violators poached deer primarily for meat and markedly less for recreation. Commercialization of venison was most prevalent in the 31–40 age group; whereas poachers over 40 were more likely than their younger counterparts to poach because they had not killed a deer in open season.

A significant (X^2, $P<0.05$) relationship was observed between the poacher's family size and his reason for poaching. A higher proportion with families to support poached for meat than did individuals without families. In addition, poachers' reasons for poaching were related to income level. Significantly (X^2, $P<0.05$) more poachers who earned under $14,000 per year poached for meat than did poachers with annual incomes of $14,000 or more. No significant relationship existed between poachers' types of work and reasons given for poaching.

Discussion

Little published information describes demographic and behavioral characteristics of deer poachers. Consequently, conservation agents rely primarily on experience gained from previous deer poacher arrests to detect potential deer violators. Possibly more deer violators would be identified and apprehended if agents were familiar with overall social and economic characteristics of convicted closed-season deer violators. Kaminsky (1974) reached a similar conclusion.

A comparison of deer poachers, legal deer hunters, and the general population in Missouri showed a significantly ($P<0.05$) higher proportion of males among poachers than among the other two groups (U.S. Bureau of Census 1977, Porath et al. 1980).

Deer poachers were proportionally much younger than legal deer hunters or the general public. The median age for deer poachers was 24 years; 86.4 percent of them were age 40 or less. On the other hand, legal deer hunters had a median age of 33 years, and only 66.0 percent were age 40 or less (Porath et al. 1980). In the general male population the median age was 29, and only 46.3 percent were less than 45 years old (U.S. Bureau of Census 1977). In Idaho, Vilkitis (1968) concluded that big-game poachers there were also significantly ($P<0.05$) younger than licensed big-game hunters.

Table 3. Reasons for closed-season deer poaching given by 379 deer poachers convictsd in Missouri, July 1, 1979, to June 30, 1981.

Reasons	n	Percentage of total
Meat	192	50.6
Recreation–vandalism	129	34.0
Commercial	9	2.4
Failure to kill deer in open season	30	8.0
Other reasons	19	5.0

Missouri poachers appeared to have a slightly higher high school completion rate than legal deer hunters, but not higher than the general population (U.S. Bureau of Census 1977, Porath et al. 1980). Deer poachers had a high school completion rate of 75.4 percent, whereas only 68.9 percent of legal hunters had graduated from high school. However, census data (U.S. Bureau of Census 1977) showed that 78.0 percent of males between 18 and 25 years old had completed high school, and 63.5 percent of males 25 or older had completed high school; thus the apparent difference in education level of poachers simply may have reflected a better education level of younger persons in the public as a whole. Vilkitis (1968) reported that similar percentages of licensed big-game hunters and big-game poachers in Idaho had completed high school.

The fact that a high percentage of deer violators in Missouri had graduated from high school points out the potential for educating youngsters about the undesirable impact of poaching on wildlife.

It is important that the unemployment rate of deer violators was over 30 times greater than that of legal deer hunters and about 4 times that of the general male population (U.S. Bureau of Census 1977, Porath et al. 1980). Surprisingly, unemployed violators indicated they poached as much for fun as for meat. Thus, unemployment may lead to poaching, but more so to combat boredom than to secure food.

Blue-collar occupations were listed by deer violators substantially more often than by legal deer hunters or males in the general population. Over four-fifths of the poachers claimed blue-collar jobs, but only 59.9 percent of licensed deer hunters and less than half of the statewide male population were listed as blue-collar workers (U.S. Bureau of Census 1977, Porath et al. 1980). These results imply that conservation agents need not be greatly concerned about persons classified in jobs other than blue-collar.

About one-half of the poachers stated that they poached for meat. A possible reason for this high percentage might be that poachers were attempting to make their arrests seem less culpable to local citizens, and to elicit sympathy for acts of poaching. If this assumption is correct, recreational poaching may be even more of a reason for poaching than our study indicated.

From a sociological viewpoint, it is probable that Missouri deer poachers belong to a subculture from which they derive distinct values and norms. This was indicated by the uncommonly high rate of unemployment among violators, in addition to the high percentage drinking alcohol when arrested, and the large segment with extensive criminal arrest records.

It can be theorized that within the subculture, deer poaching is socially accepted and is categorized as a sport activity. Consequently, to members of the subculture, poaching perhaps serves a recreational function upon which no social stigma is placed, as it would be in the society at large. A possible reason for the acceptance of deer poaching by the subculture is that it is a measure of a member's manliness, and when a member kills a deer out of season his image and influence are increased among the subculture's membership. In support of this theory, Kellert (1978) identified a type of sport hunter who hunted primarily to show a mastery and control over animals. The term dominionistic was used to identify this hunter. Kellert pointed out that this type of hunter valued animals largely for the opportunities they provided to engage in a sporting activity involving mastery, competition, shooting skill, and expressions of prowess. To the dominionistic/sport hunter, hunting was appreciated more as a human social event than as an animal-oriented activity. Kellert (1978) stated that a focus on sport hunting frequently stressed masculinity and the importance of using firearms.

If our interpretation is correct, it is possible that this type of group behavior could influence individuals outside the subculture to poach deer. Young adults who are seeking a means to raise their social status might observe the positive recognition given to deer violators by members of the subculture. These youngsters may select poaching as an immediate solution to their social shortcomings and subsequently become members of the subculture. If this happens, the net result will be persistence and perhaps growth of the subculture, ensuring that deer poaching will remain a major wildlife management problem.

Management Applications

The purpose of our study was to provide wildlife managers and the general public a scientifically derived description of deer poachers' social and behavioral characteristics. Socioeconomic profiles of Missouri deer poachers have been used primarily in development of Missouri Department of Conservation informational pamphlets, news releases, educational programs, and conservation agent training.

A description of socioeconomic characteristics of deer poachers, based on our study, was included in a pamphlet designed to promote a recently implemented "Operation Game Thief" reward program in Missouri. This program, sponsored by the Conservation Federation of Missouri and the Missouri Department of Conservation, is intended to help expose and apprehend poachers by providing a state-wide, toll-free hotline, reward incentives, and a better public understanding of poaching and how to recognize and report violations. The program has had considerable early success: 291 arrests in the first 15 months. Of these, 161 involved deer violations.

News releases about this study and its results both by the Department of Conservation and the University of Missouri-Columbia resulted in widespread coverage in newspapers (often rural papers) and magazines, both in Missouri and elsewhere.

The principal purpose of these pamphlets and news releases has been to make the general public more knowledgeable about unsavory or dangerous characteristics of poachers and to increase citizen involvement in identifying and apprehending them. Moreover, it is possible that some actual or potential poachers who are otherwise generally law-abiding will have second thoughts about putting themselves in company with felons and will not indulge further in poaching.

Currently, personnel of the Missouri Department of Conservation's Education Division are using human socioeconomic information to design conservation education materials. These materials will emphasize teaching conservation concepts to children from pre-kindergarten through secondary school. Specific programs include development of educational materials designed to teach not only management concepts and practices, but ethical and moral viewpoints of violating wildlife laws as well.

One objective of the recently revised education program is to identify conservation problems that exist in Missouri and to delineate those problems that are most prevalent in the various regions of the state. For example, our results indicated that severe deer-poaching problems exist in the Ozark region of Missouri. The educational program will target this area and use the school system to teach good conservation principles with special emphasis on problems associated with poaching. Through this approach, it is hoped that the existing philosophy about poaching can be reshaped in the region.

Knowledge of poacher socioeconomic characteristics has been useful in training Missouri conservation agents. The senior author has made numerous oral presentations, both to veteran agents and to trainees, explaining results and applications of this study. Written accounts of the study have been provided to all agents. The information has served to confirm some previously undocumented beliefs held by agents, and it has also helped establish a standard by which officers can evaluate a person's potential to commit a deer violation. This improved ability to recognize types of potential deer poachers should enhance conservation agents' effectiveness in apprehending them. Documentation that many poachers are convicted felons emphasizes the need for caution as agents investigate or arrest suspected deer poachers.

In an indirect application, this study furnished a prototype data-set for developing a broad-scope computerized retrieval system for wildlife arrest records in Missouri. The latter system, in operation since April 1983, has already proved its worth. It has helped pinpoint local fish and wildlife violation problems; this information, in turn, will be valuable in developing regional education programs. It has also aided enforcement administrators by permitting detailed analyses of previously unused arrest records. A recent example is an almost instantaneous response to a question about arrests relevant to a proposed gun-case law in Missouri.

The ultimate test of the value of this study is whether the incidence of deer poaching is eventually reduced. As results of the study have been available for less than two years, it is too soon even to attempt an evaluation. However, it is apparent that our findings are being applied in several ways to enforcement and education programs in Missouri, and there is reason to be optimistic about the outcome.

Acknowledgements

We acknowledge all conservation agents, Missouri Department of Conservation, whose cooperation and assistance was essential to success of this study; J.N. Burroughs, University of Missouri, and S.L. Sheriff, Missouri Department of Conservation, for assisting with statistical analyses of data; R.B. King, J.V. Frye, D.J. Witter, W.R. Porath, N.F. Giessman, and D.K. Heard, Missouri Department of Conservation for administrative support and technical assistance; and R.R. Campbell and S.S. Clark, University of Missouri, for their valuable suggestions during preparation of the manuscript. We are indebted to L.E. Yeager (deceased), K.G. Hay, American Petroleum Institute, and L.R. Gale, Missouri Department of Conservation, for their support and guidance during developmental stages of the project.

This paper is a contribution from the Missouri Department of Conservation and the Missouri Cooperative Wildlife Research Unit (U.S. Fish and Wildlife Service; Missouri Department of Conservation; Wildlife Management Institute; and School of Forestry, Fisheries and Wildlife, University of Missouri, cooperating); also from Missouri Agricultural Experiment Station Project 184, Journal Series No. 9562.

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The Conservation Benefits of USDA's Acreage Reduction Programs

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Introduction

I appreciate very much the opportunity to be with you today and to review some of our findings on the conservation effects of USDA's acreage reduction programs. The Agricultural Stabilization and Conservation Service (ASCS) has performed a quantitative analysis of the conservation effects of the 1983 commodity programs. This analysis included the condition of wildlife cover. As Director of ASCS' Conservation and Environmental Protection Division, I am involved directly in the administration of programs dealing with soil and water conservation. These programs, of course, have a direct affect on wildlife. I also have a personal concern for wildlife, especially the pheasant, grouse, quail, and sometime the deer that I see and enjoy on my farm in Utah.

PIK and ARP Programs

To strengthen farm prices and ease the burden of surpluses, USDA introduced the 1983 Payment-In-Kind (PIK) Program. This acreage reduction program differed from past ones in that payments were made in surplus commodities. This enabled us to reduce production and surpluses at the same time.

The program was very successful: farm prices are improved; the surplus has been cut; storage and handling costs were reduced; farm program costs for 1984 will decline; and conservation benefits were realized.

The land idled under the 1983 commodity programs was called Conservation Use

Acreage or CUA. Program provisions required the protection of CUA from excessive wind and water erosion. Some of the cover types used to prevent soil erosion on the CUA included: natural cover, new seedings (grass and legumes established after August 1, 1982), established seedings (grasses and legumes established before August 1, 1982), crop residue (from 1982 crop), voluntary stands (of grasses and legumes), small grain cover crop, and fallow.

CUA Evaluation

To determine how successful these measures were at reducing soil erosion and providing wildlife cover, a CUA evaluation was undertaken. The evaluation was the joint effort of several USDA agencies. The Economic Research Service insured the statistical validity of the 227 sample counties and provided computer programs. The Soil Conservation biologists selected evaluation parameters and guidelines concerning wildlife cover. The Soil Conservation Service conducted field visits for data collection. ASCS provided the reporting system entering all farm data such as location, size, type, etc; and analysed the compiled data.

Data collected included land capability class. Figure 1 shows land idled under the program had roughly the same class distribution as cropland in the National Resource Inventory, meaning that farmers didn't "idle the worst and plant the best." In irrigated areas, water used before designation as CUA was compared to water used after designation. Approximately 13 million acre feet of water or 1.6 acre feet per acre was conserved because of the 1983 commodity program.

Soil erosion was calculated and compared to *'T'* or tolerance level of the individual fields. Soil tolerance has been determined to be the rate of erosion which an area can tolerate and not decrease long-term production capability. The pie charts in Figure 2 show that the amount of land eroding at rates higher than acceptable tolerance levels was reduced by 10 percent.

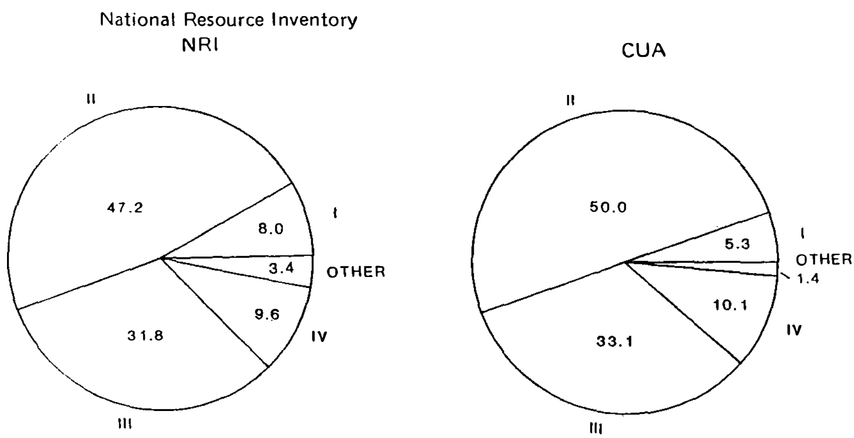

Figure 1. Comparison of land class distribution of National Resource Inventory (NRI) and Conservation Use Acreage (CUA).

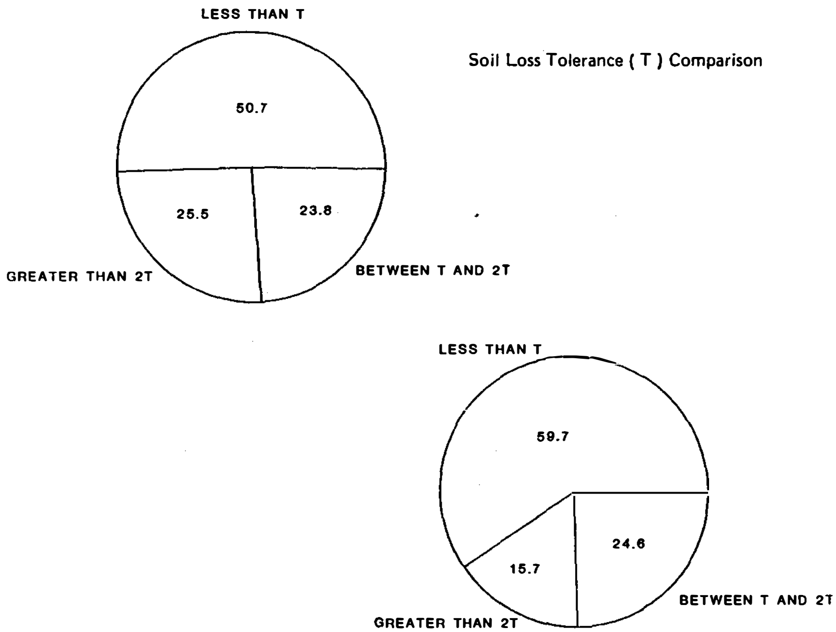

Figure 2. Soil erosion before (left) and after (right) implementation of CUA Program.

Data elements that were evaluated to determine the condition of wildlife cover included: type of cover (crop residue from 1982 crop—fallow—natural cover—new seedings—small grain cover crops and voluntary stands of grasses and legumes); percent of ground cover; and the intended use of the acreage in 1984 (which included type of crop to be planted and the use of conservation tillage). The evaluation period was the 12 months between the winter of 1982 and winter of 1983. Based on these parameters, we found nationally that *35 percent of the CUA provided satisfactory cover for a wide variety of wildlife species*. There was high regional variation due to difference in cover type. PIK program rules allowed excess wheat coverage to be used as CUA cover in winter wheat areas. In areas not subject to wind or water erosion clean tilled land was permissable if the Soil Conservation Service concurred. The Southeast production region had the highest percent of satisfactory wildlife cover at 88 percent. The low was in the Mountain and Pacific regions where less than 15 percent of the CUA provided satisfactory wildlife cover. Figure 3 shows that there was also a wide variation in the wildlife value of the cover types. The CUA acres with new seedings, old seedings, and voluntary stands of grasses and legumes had the highest percentage of satisfactory cover.

12 State Study

The State of Minnesota Department of Nàtural Resources, Farmland Wildlife Populations and Research Center also coordinated a study on the wildlife value of CUA. The

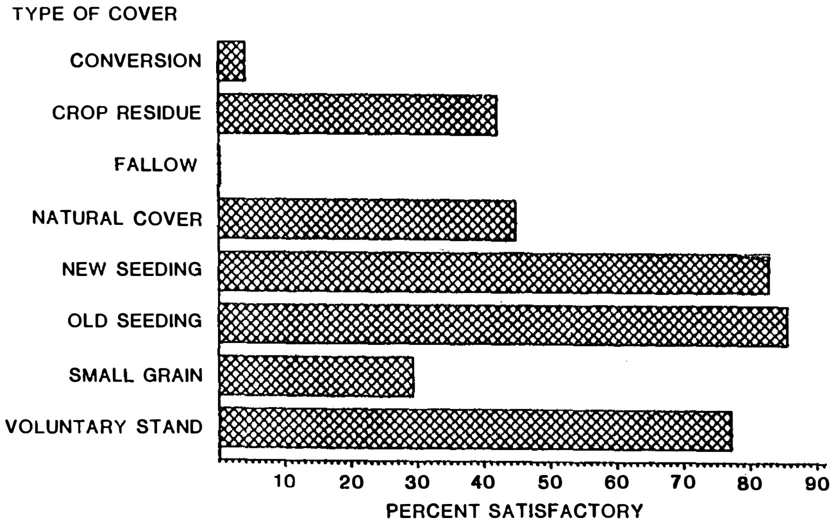

Figure 3. Wildlife habitat distribution by cover type.

study was conducted on 12 Midwest states and stated that: 42 percent had little or no wildlife cover (fallow or poor stubble); 44 percent had some cover, but unsafe for nesting; and 14 percent had valuable wildlife cover. It is very difficult to make a comparison of the results of this 12-state evaluation and ours. We rated cover as only satisfactory or unsatisfactory while they used three categories. Furthermore, the evaluation criteria probably differed.

Our analysis shows that wildlife cover provided by CUA is something that can be and needs to be improved upon, and we are responding to this need. On December 8, 1983 Secretary Block announced the Acreage Conservation Reserve program for 1984. This program combines production adjustment with conservation by cost-sharing *long-term conservation practices* on idled land. Practices available are permanent seedings of grasses and legumes and tree planting. Minimum lifespans are 5 and 10 years respectively. This extended period of good cover should improve wildlife habitat.

On January 6, ASCS Administrator Everett Rank announced that, in order to try to get more consistency and unified understanding and application of Conserving Use Acres, the SCS would approve conservation practices applied in each State.

Summary

In summary, our evaluation shows that:

- Land eroding at higher than acceptable tolerance levels was reduced by 10 percent.
- 35 precent of CUA provided satisfactory wildlife cover with new seedings, established seedings, and voluntary stands of grasses and legumes all showing over 70 percent satisfactory cover.
- Established or "old" seedings provided the best wildlife cover, while a fallow condition provided the worst.

- 1.6 acre feet per acre of water was conserved on CUA ground.
- Steps are being taken to improve the wildlife cover conditions.

We hope that the changes in place for future farm programs will help ensure enhanced CUA cover for wildlife.

Federal Land Retirement Program: A Land Management Albatross

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Introduction

The 1983 U.S. Department of Agriculture's (USDA) land retirement program (Set-Aside and Payment in Kind [PIK]) has received much attention in various professional journals and the media. The large acreages taken out of production (80.6 million acres, or 32.6 million ha), and the tremendous cost (estimated at over $12 billion—nine times more than average) of the program were only part of the concern expressed by many critics. The fact that the program helped little in the fight to conserve our precious soil resource drew much fire (Cook 1983). The negative impact on various wildlife populations also did not add to the program's popularity among taxpayers.

The 1983 program is an important historical landmark because USDA land retirement programs have been influencing the American farm community for 50 years. This historical perspective, coupled with taxpayer's scrutiny, makes this a critical time to review the various programs of the last 50 years, evaluate their effects on land use, soil conservation and wildlife, and discuss potential remedies.

History

Federal land retirement programs were created during the height of the depression and dust bowl years in an attempt to stabilize rural economics suffering from overproduction. The Crop Adjustment Act (CAA) of 1934 and 1935 retired between 16 and 20 million acres (6.5 and 8.1 million ha) under annual contracts with no cover crop stipulations (Edwards 1984) (Table 1).

The Agricultural Conservation Program (ACP) of 1936 provided annual contracts that required the land be seeded to grasses and/or legumes. ACP acreages increased from 28.5 million in 1936 to 42.6 million (11.5 to 17.2 million ha) in 1941 (Edwards 1984) (Table 1).

The onset of World War II and the subsequent increased demand for agricultural commodities for the war effort brought the retired lands quickly into production. From 1943 until 1953, the 0.12 to 6.4 million acres (0.05 to 2.6 million ha) retired under ACP were used to encourage the production of legume seed (Edwards 1984) (Table 1). No land was retired in the years 1948–1950, 1954 and 1955 (Edwards 1984) (Table 1).

After the Korean War, overproduction and resulting low farm income again appeared. In 1956, the next era in USDA farm programs was conceived. During the first three years of the Soil Bank program, between 12 and 21.4 million acres (4.9 and 8.7 million ha) were retired under annual contracts in the Acreage Reserve (AR). This program did not require any permanent grass and/or legume seedings (Edwards 1984). The 1.4 to 9.9 million acres (0.6 to 4 million ha) retired under 3 to 10 year contracts in the Conservation

Table 1. Amount of cropland retired under the various U.S. farm programs from 1934 to 1983.

	Acreages in million (hectares)								
			Soil Bank						
Year	CAA[a/b]	ACP[b]	AR	CR	FGP	WHP	CAP	CTR	Total
1934	20.5(8.3)								20.5(8.3)
35	16.9(6.8)								16.9(6.8)
36		28.5(11.5)							28.5(11.5)
37		29.2(11.8)							29.2(11.8)
38		30.0(12.1)							30.0(12.1)
39		41.5(16.8)							41.5(16.8)
1940		42.4(17.2)							42.4(17.2)
41		42.6(17.2)							42.6(17.2)
42		38.3(15.5)							38.3(15.5)
43		3.1(1.2)							3.1(1.2)
44		6.4(2.6)							6.4(2.6)
45		4.1(1.7)							4.1(1.7)
46		2.7(1.1)							2.7(1.1)
47		1.6(0.6)							1.6(0.6)
48									0.0
49									0.0
1950									0.0
51		0.24(0.1)							0.24(0.1)
52		0.19(<0.1)							0.19(<0.1)
53		0.12(<0.1)							0.12(<0.1)
54									0.0
55									0.0
56			12.2(4.9)	1.4(0.6)					13.6 (5.5)
57			21.4(8.7)	6.4(2.6)					27.8 (11.3)
58			17.2(7.0)	9.9(4.0)					27.1 (11.0)
59				22.5(9.1)					22.5 (9.1)

Table 1. Amount of cropland retired under the various U.S. farm programs from 1934 to 1983. (continued)

			Acreages in million (hectares)						
			Soil Bank						
Year	CAA[a/b]	ACP[b]	AR	CR	FGP	WHP	CAP	CTR	Total
1960				28.7(11.6)					28.7 (11.6)
61				28.5(11.5)	25.2(10.2)				53.7 (21.7)
62				25.8(10.4)	28.2(11.4)	10.7(4.3)			64.7 (26.1)
63				24.3(9.8)	24.5(9.9)	7.2(2.9)			56.0 (22.6)
64				17.4(7.0)	32.5(13.2)	5.1(2.1)			55.0 (22.3)
65				14.0(5.7)	34.7(14.0)	7.2(2.9)			55.9 (22.3)
66				13.3(5.4)	34.7(14.0)	8.2(3.3)	2.0(0.8)	4.6(1.9)	62.8 (25.4)
67				11.0(4.4)	20.3(8.2)		4.0(1.6)	4.9(2.0)	40.2 (16.2)
68				9.2(3.7)	32.4(13.1)		4.0(1.6)	3.3(1.3)	48.9 (19.7)
69				3.4(1.4)	39.1(15.8)	11.1(4.5)	3.9(1.6)		57.5 (23.2)
1970				0.1(<0.1)	37.4(15.1)	15.7(6.4)	3.8(1.5)		57.0 (23.1)
71				<0.1(<0.1)	18.2(7.4)	13.5(5.5)	3.4(1.4)	2.1(0.8)	37.2 (15.1)
72				<0.1(<0.1)	36.6(14.8)	20.1(8.1)	2.8(1.1)	2.8(1.1)	62.3 (25.2)
73					9.4(3.8)	7.4(3.0)	2.8(1.1)		19.6 (7.9)
74							2.7(1.1)		2.7 (1.1)
75							2.4(1.0)		2.4 (1.0)
76							2.1(0.8)		2.1 (0.8)
77							1.0(0.4)		1.0 (0.4)
78					8.3(3.4)	9.6(3.9)		0.3(0.1)	18.2 (7.4)
79					4.8(1.9)	8.2(3.3)			13.0 (5.2)
1980									0.0
81									0.0
82					3.2(1.3)	5.8(2.3)		1.6(0.6)	9.4 (4.2)
83					41.5(16.8)	32.3(13.1)		6.8(2.8)	80.6 (32.7)

[a] CAA = Cropland Adjustment Act
ACP = Agricultural Conservation Program
AR = Acreage Reserve-Soil Bank
CR = Conservation Reserve-Soil Bank
FGP = Feed Grain Programs
WHP = Wheat Programs
CAP = Cropland Adjustment Program
CTR = Cotton & Rice Program

[b] Source: Edwards 1984.

Reserve (CR) portion of the Soil Bank, however, were seeded to various grasses and legumes.

AR was discontinued in 1959 while the CR portion was expanded. The CR acreage reached its peak in 1961 at 28.5 million (11.5 million ha) (Table 1).

In 1961, another land retirement program was initiated. The Feed Grain Program (FGP) was an annual program that did not require any grass-legume seedings, but recommended annual cover crops (e.g., oats), which had to be destroyed before setting seed. This program and the similar Wheat Program (WHP), which began a year later, combined with the existing CR contracts retired a record 64.7 million acres (26.2 million ha) in 1962 (Table 1).

CR acreages gradually declined while FGP and WHP acreages increased. In 1966, the multi-year contract Cropland Adjustment Program (CAP) was added to the existing three programs. CAP, which required that grass-legume seedings be left undisturbed for five or 10 years, was similar to CR. Unfortunately, due to limited funding, CAP accounted for a maximum enrollment of only four million acres during its 11-year lifespan (USDA 1972) (Table 1).

The FGP and WHP, which retired a peak of 56.7 million acres (22.9 million ha) in 1972, were greatly reduced in 1973 and not funded in 1974 (Tables 1 and 2). This action was promoted by the Nixon administration under Secretary of Agriculture Butz. Road ditch to road ditch farming was encouraged by Secretary Butz despite predictions by leading agriculture forecasters of surpluses within four years. (1973 per. comm., P. Hasbargen, Univ. of Minn.).

As predicted, surpluses began building despite record overseas grain sales and drought. Although over $1.3 billion in price support and storage payments were made in 1977, no lands were retired (Tables 1 and 2). In 1978, 17.9 million acres (7.2 million ha) were set aside at a cost of $1.8 billion in subsidies (Table 2). Despite the 1978 and 1979 retirement programs, feed grain and wheat reserves continued to grow (USDA 1983).

The 1980s were ushered in without a retired acres program. However, FGP and WHP subsidies still totaled $154 million in 1980 and $1.3 billion in 1981. Only 9 million acres (3.6 million ha) were enrolled in FGP and WHP in 1982 despite a desire for a larger enrollment. This resulted in record feed grain and wheat harvests, which complicated an already severe situation (USDA 1983).

Therefore in 1983, the Reagan administration made these programs more attractive with the PIK option and no maximum payment stipulation. A record 80.6 million acres (32.6 million ha) set-aside and a record $12 billion-plus cost resulted (Cook 1983).

In summary, a mean of 15.1 million acres (6.2 million ha) were retired annually during the first 25 years (1934–1958). The maximum of 42.6 million acres (17.2 million ha) was retired in 1941. During the last 25 years, the mean more than doubled to 34 million acres (13.8 million ha) annually, and the maximum of 80.6 million acres (32.6 million ha) was reached in 1983 (Table 1). Some form of subsidy has been paid every year since 1956 (Table 2) (USDA 1983). For the 27-year period 1956–1982, subsidy payments totaled $34.879 billion and averaged $1.292 billion per year.

Impact of Land Retirement Programs

The harsh realities of the 1930s not only created the need for federal land retirement programs but awakened the need for soil conservation efforts. This awareness was put into action with the passage of the Soil and Water Conservation Act of 1935, which

Table 2. Expenditures for the various cropland retirement programs in the U.S. since 1960. Expenditures include payment for diverted or set-aside acres, price supports, storage, and access (in million of dollars).

Year	Program					
	AR[a]	CR	FGP	WHP	CAP	Total
1956	260	12				272
57	614	57				671
58	696	88				784
59		258				258
1960		340				340
61		338	782			1120
62		311	844	286		1141
63		296	846	242		1384
64		200	1171	443		1814
65		154	684	509	698	2045
66		147	1295	681	31	2154
67		126	868	727	57	1778
68		110	1369	746	55	2280
69		40	1644	856	54	2594
1970		1	1510	871	54	2435
71		0.1	1060	886	49	1995
72		0.1	1865	859	38	2762
73			1171	478	36	1685
74					31	31
75					28	28
76					16	16
77			229	1092	8	1329
78			1121	698		1819
79			449	18		467
1980			79	75		154
81			730	559		1289
82			1209	725		1934
83			?	?		12,000–18,000(est.)

[a] See Table 1 footnotes for full program names.

created the Soil Conservation Service (SCS) as a permanent agency within the USDA (Sampson 1981).

The SCS and the newly established Agricultural Stabilization and Conservation Service (ASCS) were immediately given the mission to improve the farm economy and reduce soil loss. To accomplish these objectives, they developed a land retirement program (ACP) that required all retired acres be seeded to grasses and/or legumes (Edwards 1984). This dual-purpose philosophy persisted throughout the life of the ACP and produced numerous benefits in addition to the improvement of crop prices.

Benefits derived from seeding the retired acres to grasses and legumes were improved soil condition (tilth), crop rotation, and the virtual elimination of soil erosion on those acres. In addition, landowners, by retiring these seeded acres for more than one year, also reduced their workload and energy demands that would have been incurred under an annual cover crop (e.g. oats) scenario.

A subtle benefit derived from ACP was its potential effects on various wildlife populations. According to Edwards (1984), the presences of vast ACP acreages in 12 Midwest and Great Plains states from 1936 to 1942 provided a habitat base that spurred on an already increasing pheasant (*Phasianus colchicus*) population to record highs. During those years, undisturbed ACP grass-legume fields covered an average of 12.5 percent of the normally cropped acres (Edwards 1984). Data from several Midwest states suggested a relationship between the availability of ACP lands and pheasant populations (Edwards 1984).

The philosophy of conserving crops on all retired acres weakened considerably in the ASCS after ACP. Since then, annual programs, such as the AR portion of the Soil Bank, FGP and WHP, did not require the seeding of grass-legumes on retired acres. Only multi-year programs (CR and CAP) had such seeding requirements. Like ACP, CR and CAP seedings produced the soil and energy benefits previously discussed. The positive influence of these seedings on Midwest pheasant populations were amply documented (Schrader 1960, Dahlgren 1967, Bartman 1969, Machan and Feldt 1972, Weigand and Janson 1976).

Annual FGP and WHP contracts have emphasized administrative flexibility in commodity control to the detriment of soil and wildlife conservation. The abuses of sound land management encouraged by the FGP and WHP have been amply documented by surveys conducted in Minnesota in 1964, 1965, 1970, 1971, 1972, 1973, 1978 and 1983 and in 13 Midwest and Great Plains states[1] in 1972, 1973, 1978 and 1983 (Berner 1973a, 1973b, Montag 1974, Berner 1978, 1983).

The most recent survey (Berner 1983) of 12 Midwest and Great Plains states found that over 9 million acres (3.6 million ha) of the 43.4 million (17.5 million ha) retired under FGP and WHP set-aside and PIK had no cover (fallow). More than 17.5 million (7.1 million ha) retired acres (40.4 percent) were covered only by stubble residue or volunteer plants when checked in mid-June.Most of these acres, however, were disked black by the second check in late July (Table 3).

Only an estimated 13.9 million (5.6 million ha) retired acres (32 percent) were seeded to a cover crop in 1983 (e.g., oats, sorghum-sudan). Most fields were planted late (June 15 or later) and destroyed by mowing, disking or plowing before the grain matured as required by ASCS regulations. Only 2.7 million (1.1 million ha) (6.2 percent) of the retired acres were in established grass-legume cover (Table 3). Results similar to those just described were obtained from the ASCS-SCS Conservation Use Acres survey of PIK (Cook 1983). This latter survey also indicated that instead of reducing the soil loss on PIK acres by over three tons per acre, the soil savings were less than two tons per acre (Cook 1983).

When compared with the previous surveys (Berner 1973b, Montag 1974, Berner 1978) these results (Berner 1983) (Table 3) suggest that the recommendations of the Farm Programs Committee (Harmon and Nelson 1973), and the changes in the 1974 Farm Act, have found little favor in the ASCS. These surveys further indicate that concern for soil and wildlife conservation benefits on FGP and WHP acres is minimal.

[1] The 13 Midwest and Great Plains states were Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin.

Table 3. The percentage of set-aside acres in each of the four cover categories observed during surveys conducted in 13 Midwest and Great Plains states by state wildlife agencies.

	Unseeded		Seeded	
Year	Fallow	Stubble & volunteer cover	Newly	Established
1972	53.2	4.1	19.8	22.9
1973	53.1	1.0	19.0	26.9
1978	30.5	23.4	31.4	14.6
1983	21.3	40.4	32.1	6.2

This low soil conservation benefits emphasis of recent land retirement programs (FGP and WHP) is very unfortunate considering the present magnitude of soil erosion on our nation's farms. "A General Accounting Office study concluded that despite 50 years of conservation programs and nearly $18 billion spent by the federal government 'soil erosion is becoming serious and USDA programs are not keeping pace with the current rate of erosion' "(AP news release, Mankato, Minnesota Free Press December 2, 1983). Although a portion of this failure can be attributed to past spending of many soil conservation dollars on production practices (e.g., draining, tiling and liming) during the last two decades, the ASCS policies governing annual land retirement programs (FGP and WHP) must share a large portion of that responsibility.

Present land retirement programs (FGP and WHP) are very narrow in scope dealing exclusively with controlling domestic commodities. Therefore, little concern is given to the impact of these annual programs and their policies on land use.

According to Mekelburg (1983: 324): "the major problem is this: Acreage histories determine base crop acres for set-aside. Farmers who plant their farms fence to fence with the commodity in surplus get a larger base acreage because of history." Conversely, farmers who use soil building crop rotation or install conservation structures (e.g., terraces, field windbreaks) are penalized by not having a large base of surplus commodity. Also, cropland acres allocated to installed conservation structures are subtracted from the farm unit's cropland base. In the latter case, this not only lowers the base but eliminates the use of the cropland acres, removed by the practice, as set-aside. These policies, therefore, not only hinder the installation of needed conservation practices, but also encourage farmers to convert as much non-cropland as possible to cropland even if those lands are highly erodible.

The inconsistency of programs from year to year and the annual contracts find little favor with farmers. Uncertainities of the program from one year to the next make planning very difficult. Farmers, therefore, prepare all acres for planting each year, thereby exposing even retired acres to 8 to 12 months of wind and water erosion. Retiring land under annual programs is also more costly per acre to the farmer. Annual preparation costs are over two times greater than for land retired for 3 or more years. Therefore, the government must pay more per acre under annual programs to obtain the desired degree of participation.

Lastly, policies that allow summer fallowing and late seeding (after May 15) and require early destruction of cover (prior to September 1) on retired acres graphically illustrate the lack of concern for soil conservation and wildlife habitat needs.

The potential of retired cropland acres to provide much needed grassland habitat throughout the Midwest has been discussed by numerous wildlife researchers (Joselyn and Warnock 1964, Nelson and Chesness 1964, Gates and Ostrom 1966, Nelson et al. 1972). However, despite these demonstrated benefits, FGP and WHP have provided little quality wildlife habitat (Berner 1973b, Montag 1974, Berner 1978, 1983). These surveys indicated that between one-quarter and one-third of the retired acres in 1972, 1973 and 1978 and about 18 percent in 1983 provided good to excellent nesting cover (Table 4). Therefore, the 1983 results showed that on the average, the FGP and WHP provided 4.6 acres (1.9 ha) of unsafe[2] nesting cover for each acre (0.4 ha) of safe cover; in Minnesota the ratio was much worse at 15:1.

The FGP and WHP policies previously discussed have resulted in large acreages of unsafe nesting cover and encouraged the conversion of cover types important to wildlife (e.g., wetland, pastures, haylands, woodlot) to cropland for feed grains and wheat production. Both actions have had a negative impact on various wildlife populations in the Midwest. Most affected have been those species that depend on blocks (5 acres+, or 2 ha+) of undisturbed perennial grasslands. A recent Illinois study (Graber and Graber 1983) observed that key grassland bird species have declined over 90 percent in that state since 1957. Similar population changes have been observed for both the jackrabbit (*Lepus townsendi*) and pheasant in Minnesota (Figure 1).

The long term declines in these wildlife populations have been due primarily to the conversion of grassland types to cropland, particularly to row crops. Superimposed on these trends has been the effects of weather and the impact of retired acres management.

An analysis of covariance of pheasant roadside counts from south central Minnesota indicated that pheasant chicks per 100 miles (160 km) were significantly greater ($P<0.025$) in years without FGP set-aside for the period 1958-1983 (Figure 2). The data showed that with equal amounts of undisturbed perennial nesting cover available 30 percent fewer chicks would be seen if FGP set-aside acres were present and providing the large tracts of unsafe nesting cover.

The inadequate treatment of retired acres has not only increased soil erosion but the large amounts of unsafe nesting and brood cover created by the annual land retirement programs (FGP and WHP) have taken a toll of wildlife as well. Research, however, has shown that this need not be the case. Managing set-aside acres with wildlife habitat needs in mind has produced dramatic results. A 1970–1975 study in south central Minnesota

Table 4. The percentage of set-aside acres rated as having good to excellent nesting cover during various set-aside acres surveys conducted by state wildlife agencies.

Year	Minnesota	Midwest & Great Plains States
1970	22.8	No Survey
1971	24.8	No Survey
1972	24.4	28.8
1973	17.2	32.7
1978	44.2	26.0
1983	5.9	17.5

[2] Unsafe nesting cover is annual cover crop (planted or volunteer) destroyed before seed heads set or perennial cover (grasses-legumes) disturbed before July 1.

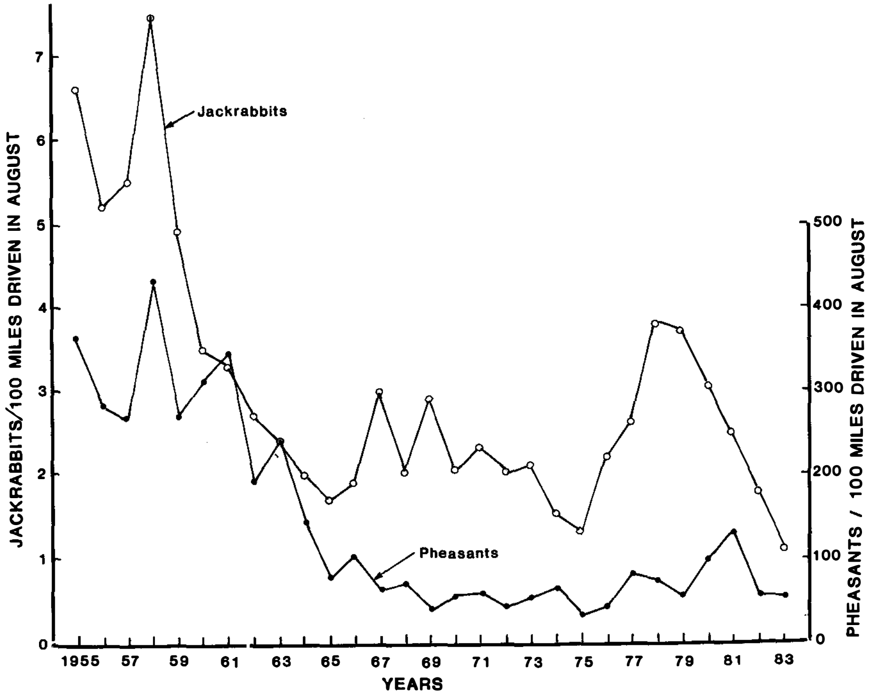

Figure 1. Population trend data for jackrabbit and pheasant populations in 64 agricultural counties of Minnesota, 1955–1983.

showed that spring hen pheasant populations increased a mean of 83 percent in two years when approximately 12 acres (4.9 ha) of undisturbed grass-legume cover and 12 acres (4.9 ha) undisturbed small grains per square mile were provided on set-aside acres in four townships (Figure 3. From files of the Farmland Wildlife Research Center, Madelia, Minnesota).

Therefore by encouraging long-term retirement options, the resulting grass-legume stands not only virtually eliminate soil erosion on those acres but also provide excellent reproductive and roosting habitat for a wide array of farmland wildlife. Proper management of cover on acres set aside on an annual basis can also greatly reduce soil loss and improve their value for wildlife.

A New Emphasis

The years of surplus commodities have not yet passed. Data from leading agricultural forecasters indicate that crop surpluses (feed grains and wheat) will probably be with us into the 21st century (Sampson 1981). Therefore, land retirement programs will continue to be part of America's farmland management scene for at least another two decades.

As discussed, the recent annual land retirement programs (1961–1983) have grossly aggravated our nation's soil erosion and wildlife habitat problems and encouraged unwise

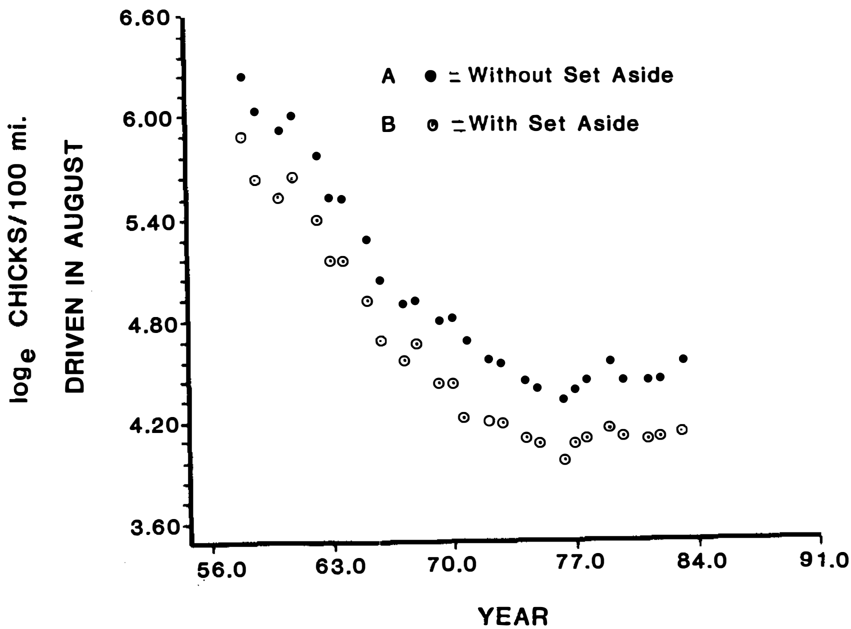

Figure 2. The points predicted from a multiple regression for years with and without set-aside from pheasant population and land use data in 11 south central Minnesota counties, 1958–1983. The year specific variables are acres of undisturbed perennial nesting cover per square mile, severe winter or not, and year since severe winter, 0,1,2, or 3.

land use. However, if redirected to mesh with a sound U.S. Farm Program, these future land retirement programs could in fact be a major part of any solution to these problems.

Before addressing the elements needed for a multiple-benefit land retirement program, the U.S. Farm Program goal of "maintaining a sustainable, healthy agriculture" must be recognized (Sampson 1981: 333). Sampson (1981:333) has taken the time to elaborate a more comprehensive statement of such a goal.

> A sustainable agriculture is one that produces the food, fiber, energy and other crops that we need as a nation, including a marketable surplus that can be sold abroad. It produces this on the average year, not just during times of unusually good weather. It can stand a bad year by drawing on stored fertility and moisture in the soils; stored water in reservoirs; stored weatlh in financially secure farms; and stored food products in the granaries of farmers, industries and government. It can profit from a good year by setting aside extra commodities or making an extra effort to see that they are sold abroad, without driving prices through the floor and creating financial hardship and ruin among producers. In addition to meeting our food needs, a sustainable agriculture would reduce the waste and pollution of water, provide better wildlife habitats, slow the advance of desertification and soil salinization, reduce the loss of prime farmlands and fragile topsoils, and, in general, make rural America a far more healthy, satisfying and financially rewarding place to live. It is an utopian goal, perhaps, but the essential goal nonetheless.

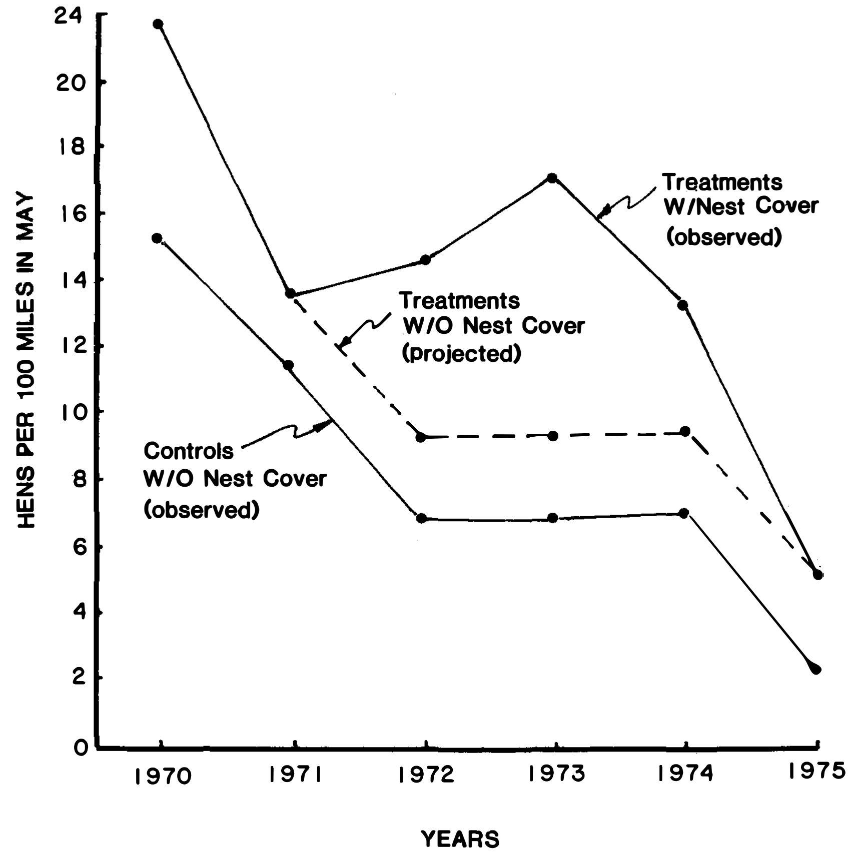

Figure 3. The changes in hen pheasant populations in six south central Minnesota townships, 1970–1975. An average of 12 acres (4.9 ha) of grass-legume stands and 12 acres (4.9 ha) small grains per square mile were contracted for on set-aside acres in the four treatment townships in 1971 and 1972 and none in the two controls. About 80 percent of the contracted cover was lost with a reduction in the FGP in 1973. All cover was lost in 1974.

Keeping this goal and the shortfalls of past land retirement programs well in mind, an adequate multiple-benefit Farm Program can be designed. It should include the following objectives and regulations.[3]

1. Minimize topsoil erosion by:
   a. requiring that future land retirement programs set-aside five percent of the nation's cropland base (20 million acres, or 8.1 million ha) to be seeded to grasses and legumes and left undisturbed for 3 to 5 years.

[3] Many of the recommendations were developed by an Ad Hoc Committee set up to draft a position on Farm Programs for the International Association of Fish and Wildlife Agencies: Members of the Committee were: A. Berner, T. Bremicker, R. Holmes, T. Isley, B. Joselyn, L. Nelson, and M. Nelson of the Minnesota Department of Natural Resources; C. Madsen, B. Oetting, D. Smith of the U.S. Fish and Wildlife Service; and K. Harmon of the Wildlife Management Institute.

b. requiring any portion of the retired acreages above the 20 million (8.1 million ha) minimum be under annual contracts which stipulate that lands must have established stands of grasses and/or legumes or be seeded to a cover crop by May 15 and not disturbed before September 1. When disturbed, sufficient regrowth or residue must remain (>30 percent) over winter to prevent erosion.
c. providing sufficient funding and technical expertise to aid farmers to install structures needed to reduce soil erosion and to actively promote no-till farming.
d. allowing cropland acres devoted to certified conservation practices (soil erosion and water pollution prevention and wildlife habitat) to remain part of the cropland base and eligible as set-aside acres.

2. Minimize the recruitment of unneeded cropland by:
   a. developing an equitable method of calculating farm crop base that takes into account such factors as soil conserving rotation acres, land capability, etc.
   b. eliminating the federal tax incentives that increase the economic feasibility for converting critical wildlife habitats and erosion prone lands to cropland.
   c. making those cropland acres that have been converted from wetlands, timber, riparian areas, native grasslands and other such non-cropland areas since 1984 ineligible for receiving any price supports, land retirement payments, commodity loans and storage payments in the future.
   d. providing an incentive program, such as the Waterbank Program, to maintain the native woodlots, prairie grasslands, bottomland hardwood forests and riparian habitats that are on lands with future cropping potential.
3. Minimize the conversion of prime cropland to irreversible uses (e.g., housing, shopping centers) by:
   a. eliminating the federal tax incentives for such development on prime cropland.
   b. identifying prime croplands to be used only for agriculture.
4. Maintain and create quality wildlife habitat in all farmland areas by:
   a. carrying out 1a, b, c, and d; 2b, c and d
   b. allowing landowners to seed a portion of the retired acres to a wildlife food plot to be left or to be harvested and transported to an area of greater wildlife needs.
5. Legal representation on the national, state and county committees must include soil conservation, water quality, agribusiness, fisheries, wildlife and forestry interests.
6. Adequately publicize all USDA soil, water, and wildlife habitat conservation programs and make information and technical expertise for implementing these programs available to landowners at the local level.

It is clear that the attainment of these objectives in the manner described will also "assure more stability in the lifestyle and economic future" of our nation's land managers—the farmer (Sampson 1981: 307). At the same time, all citizens will also benefit from the enhanced protection of our soil, water, and wildlife resources.

In conclusion, the history of USDA Farm Programs relates how multi-purpose programs (e.g., 1936–51 ACP, CR and CAP) were degraded to single purpose (AR, FGP, WHP). The annual programs during the last 22 years represent single constituent applications of over $40 billion of public funds by a federal agency. Not only has the public paid the tax bill for these agribusiness programs, but it has paid the higher food prices which are a consequence of land retirement and subsidy programs. In addition the public has seen their environment degraded by the increased soil erosion, water pollution, and decreasing populations of numerous wildlife species. Their quality of lifestyle, thereby, has been jeopardized by these annual USDA Farm Programs.

Where does the fault lie for this extreme short sightedness? The USDA-ASCS must share the majority of the criticism. The ASCS has been unresponsive to the data-supported program recommendations made by numerous soil and wildlife scientists. However, the scientific community must also share some of the responsibility for these failures. At best we have attempted changes through proper channels—risking little! We have not vigorously pursued the unified course of action needed. State fish and wildlife agencies and soil conservation agencies have been too provincial and too politically cautious to spearhead an active public awareness and lobbying campaign.

Today with these golden opportunities before us and a 22-year history of failures behind us, these same agencies must overcome the unwillingness to pool their financial and political resources to impact the Farm Programs. The tremendous returns in soil conservation and wildlife habitat benefits that could result from a multiple-purpose Farm Program dictate no other course of action but to join together as a unified force to make the needed public and political impact.

In 1983 to initiate this needed course of action, the Minnesota Department of Natural Resources (MDNR) has made an annual commitment of over $20,000 to impact the 1985 Farm Program legislation through the coordinated efforts of the Wildlife Management Institute (WMI) and the MDNR. Greater collective action and financial support of the WMI effort *must* be undertaken *now* to postively affect the 1985 Farm Program's law and resulting regulations. *Time is running out!*

Acknowledgements

I would like to thank K. Harmon and M. Nelson for their continuous support, interest and help, all the wildlife biologists who have coordinated the set-aside acre surveys in their respective states throughout the years and T. Bremicker, B. Joselyn, R. Lake and J. Galli for their assistance and editorial comments.

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Integrating Wildlife Habitat Features in Agricultural Programs

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The bad news is that neither the wildlife associated with America's farms nor our farmers themselves have ever been in worse shape. An exploding human population has demanded more and more food and fiber. Our government has encouraged foreign grain sales made at prices well below production costs. And our farmers, as a result, have put all their tillable land and then some into grain production, in some cases ruining their farms through land exhaustion, only to find themselves deeply in debt or bankrupt.

The Reagan Administration's answer—spending some $28 billion last year in farm income support programs including the payment-in-kind or PIK effort—apparently not only failed to help the small and middle-sized farmers who are hurting the most, but was a nearly complete failure at helping to control soil erosion, improve water quality, or benefit wildlife.

It's hard to believe—before PIK, farm wildlife populations already were steeply down from historic levels—but, according to a new Midwest survey, the PIK program hurt wildlife "considerably."

The good news is that, finally, both the Secretary of Agriculture, John Block, and key Members of Congress, including Senator Roger Jepsen and Representative Ed Jones, seem poised to sponsor needed statutory reforms and provide supportive direction to convert the old Agricultural Conservation Program (ACP)—often more truly a local political pork-barrel and commodity production practice subsidy—to a bona fide, long-term soil, water, and wildlife conservation practices cost-share program.

And the community of private national environmental conservation associations, led in this particular instance by the Wildlife Management Institute, the International Association of Fish and Wildlife Agencies, the Izaak Walton League of America, and the Natural Resources Defense Council, seems ready to put aside past differences and rivalries, form the requisite broad-based action coalition, and devote the same high level of energy to the passage of the necessary wildlife-related reforms in the 1985 Farm Bill and related appropriations legislation as this community has devoted in past Congresses to such projects as passage of the Endangered Species Act, the Wilderness Act, the Clean Water Act, the Clear Air Act, and the Alaska National Interest Lands Conservation Act. There's literally no stopping an aroused, well-organized, grassroots-based, multi-organization conservation constituency, as the Alaska Coalition proved in the late 1970s, whether or not you approve of the results of their work.

The signs are propitious. The potential for a successful campaign to earmark a respectable proportion of the ACP appropriation to important, targeted conservation objectives utilizing multi-year contracts comparable to the Great Plains Conservation Program and the old Soil Bank seems very real.

Not a moment should be lost, then, by any national citizen group interested in wildlife conservation in joining with its sister organizations in an Alaska Coalition or Clear Air Coalition-type all-stops-out education and lobbying effort to assure a grand victory for soil and water conservation and wildlife habitat when the 1985 Farm Bill is signed by the President . . . whoever he or she happens to be.

Habitat Crisis Documented

After the Dust Bowl years of the 1930s, massive federal programs placed once-cropped acres into woodland and grasses. As shelterbelts, windbreaks, sod waterways, terraces, contour plowing, strip-cropping, crop rotations, reductions in field length, and farm ponds dotted the countryside, gradually the land and its wildlife began to recover from the "doldrums of dust."

The greatest federal program boon to wildlife came by accident—the result of the Department of Agriculture's Soil Bank program. It wasn't planned that way, but it did have many positive impacts on wildlife populations. Permanent vegetation provided the cover and sustained food supply needed by species that couldn't survive in a monoculture environment.

That diversity ceased to exist by the 1970s, however, as production went all out in fencerow to fencerow cropping. Declining wildlife habitat quality usually has not been considered a high-priority conservation problem by the local farmer-elected Agricultural Stabilization and Conservation Service (ASCS) committees charged with allocating ACP dollars. Nor until very recently has wildlife habitat received much attention by the U.S. Department of Agriculture, in its Soil and Water Resources Conservation Act (RCA) process and related conservation programs.

Dramatic evidence of the serious plight of farm wildlife in the United States was provided by the Farm Wildlife Habitat Council, organized in 1979 by the Association of Midwest Fish and Wildlife Agencies. The association was prompted to take action because of its concern over the declining farm wildlife habitat base in its 14 member states (Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin) that together contain a major portion of the Nation's prime agricultural lands.

To provide documentation of declining farm wildlife habitat and a basis for developing goals and management strategies, the Association instructed wildlife biologists from each of its member states to select a representative indicator species that used farmland wildlife habitats and for which population survey data were readily available. The data were to be analyzed to determine relative abundance and distribution of the indicator species for two time periods, the first being some time in the past when the population of the indicator species was at an acceptable level and the second being the most recent year for which data were available.

Biologists from 12 of the 14 states selected the ring-necked pheasant as the indicator species. The data, which for the most part compared pheasant populations as of the late 1950s or early 1960s with pheasant populations as of the late 1970s, served to document an astounding decline of the pheasant in the Midwest. The percentage of reduction in pheasant populations, state by state, ranged from a low of 33 percent (Iowa) to a high of 96 percent (Ohio), with 8 of the 12 states reporting reductions of their pheasant populations in excess of 60 percent.

Similar declines were found in the populations of two other indicator species chosen by several of the midwestern states, namely, the cottontail rabbit and bobwhite.

It was noted that habitat quality and quantity had declined drastically throughout the 14-state region, due primarily to changing land use and changing agricultural practices. In a state in which the indicator species population data revealed a 91 percent decrease in ring-necked pheasant, a 72 percent decline in cottontail, and an 83 percent decline in bobwhite, 50 percent of the good nesting cover and 71 percent of the prime winter cover on two study areas were lost between 1971 and 1978. Total land in crops in Indiana rose by 11 to 12 million acres between 1960 and 1978, with land acreage in row crops increasing by 46 percent while acreage devoted to small grain, hay and pasture decreased 54 percent, 33 percent, and 29 percent, respectively, in the same period.

Similar changes in agricultural practices affecting farmland and wildlife habitat were reported in most of the other states, with the following general trends evident throughout the 14-state region:

- Increased loss of agricultural land due to urbanization, accompanied by an increase in total acreage devoted to crops, with a resulting loss of edge, fencerows, old farmsteads, wetlands and idle lands as such lands were converted to cropland.
- Increased farm size and increased field size.
- Significantly increased acreage planted to row crops with significantly decreased acreage in small grains, hay or pasture.

The overall picture has been characterized by Allen Farris and Steven Cole as that of ". . . a major shift from diversified farms with good interspersion of a variety of cover types to more simplistic agricultural landscapes dominated by one or two crops." (Farris and Cole 1981)

Hopeful Signs

Since that survey was conducted, federal policymakers have moved to try to correct the inefficiencies and perversities of agricultural programs as they affect wildlife.

Exactly four years ago, at the 45th North American Wildlife Conference and speaking as the Assistant Secretary of Agriculture for Natural Resources and Environment, I announced that Secretary of Agriculture Bob Bergland soon would approve the first official U.S. Department of Agriculture Policy on Fish and Wildlife, to communicate the department's active support for fish and wildlife protective actions to every USDA employee. Secretary Bergland signed that policy, Secretary's Memorandum No. 2019, on July 8, 1980. For the first time, the Department of Agriculture's official goals explicitly included the development and implementation of program policies and actions to "support the economic, esthetic, ecological, recreational, and scientific values of fish and wildlife, improve their habitats, and insure the presence of viable diverse naturally occurring wildlife populations."

That important high-level direction has not only been adopted and continued, but in fact strengthened by our successors, Assistant Secretary John B. Crowell and Secretary Block, who on August 22, 1983 converted it to Departmental Regulation No. 9500-4, which states:

"It is the policy of the Department to assure that the values of fish and wildlife are recognized, and that their habitats, both terrestrial and aquatic, including wetlands, are recognized, and enhanced, where possible, as the Department carries out its overall missions." "Departmental agencies," says the new regulation, "will provide financial assistance to assist landowners to apply, and improve management practices for fish and wildlife habitats on private forest, range, and agricultural lands." Each USDA agency is required to review its programs affected by this regulation annually and to make necessary administrative changes to bring its programs into compliance with the regulation's thrust.

Distributed with the new regulation to USDA's field offices through its State Food and Agricultural Councils was the National Academy of Sciences report on the "Impact of Emerging Trends on Fish and Wildlife Habitat." The NAS report straightforwardly observes that the future for wildlife and their habitats is "not encouraging" in those areas where intensive practices are employed to produce larger amounts of food and fiber and concludes that "the direct relationship between agricultural practices and wildlife habitats must be more widely recognized," that "the value of fish and wildlife to society must be considered as well as the value of maintaining a productive agriculture," and that these values "can be brought into better balance through careful planning, consistent policy, and appropriate incentives to landowners."

True, the USDA's track record with respect to its administration of the ACP and PIK programs does not inspire confidence. Ken Cook noted in 1981 that the first attempt to evaluate the ACP in its 44-year history revealed that a large proportion of the erosion control practices installed with ACP cost-sharing assistance had been placed on lands that had only minor erosion problems. (Cook 1981) In fact, only one in five ACP erosion control practices were found to have been installed on lands having erosion rates of 14 tons or more per acre per year. Cook concluded that only more federal guidance to local ASCS committee decision makers will make the ACP more effective.

In a similar vein, the Wildlife Management Institute (WMI) reported in October 1983 that "many observers think that the American taxpayer has been abused because USDA appears interested only in using PIK set-asides to channel public funds into segments of the farm economy and to reduce production so that food and feed grain prices will go up" (WMI 1983). WMI reported that when resource managers in 12 Midwest states surveyed 2,451 fields retired in the 1983 set-aside and PIK programs on 829 randomly selected farms, that sample representing 86,738 (35,129 ha) of the 43 million acres (17.4 million ha) retired in the 12 states, they found that there was less cover on the land in 1983 than at any time during the past decade. There was 62 percent less cover than in 1978, 83 percent less than in 1973, and 75 percent less than in 1972. This was the pattern in all states surveyed despite the USDA's "requirement" that set-aside lands be maintained in vegetative cover.

Further, they found that the percentage of unseeded fields was higher in 1983 than during any other survey year. About 9 million acres (3.6 million ha) (20 percent) were completely bare. More than 17.5 million acres (17.1 million ha) were left to crop stubble and volunteer vegetation, of which only 11 percent provided adequate wildlife habitat because the cover was sparse or spotty or was plowed under or mowed. Approximately 14 million set-aside acres (5.7 million ha) had been seeded with a cover crop, but many of these fields offered little to wildlife. Most of these cover crops were planted too late and destroyed too early to be of value to wildlife. In Iowa, for example, many fields were seeded lightly with oats but were mowed or disced during the growing season.

In essence, only about 11 percent, or 4.5 million acres (1.8 million ha), of the 1983 PIK set-aside had established cover from the previous year that provided maximum protection from soil erosion, maintained water quality and benefited wildlife. About 20 percent, or 9 million acres (3.6 million ha), had no cover crop at all and did nothing for soil erosion control, water quality or wildlife. About 37 percent, or 17.5 million acres (7.1 million ha), had the previous year's crop residue and volunteer vegetation or only volunteer vegetation that provided inadequate soil and water protection and even less wildlife habitat. And some 32 percent, or 14 million acres (5.7 million ha), had newly seeded cover crops that produced less soil and water benefits than expected and poor wildlife habitat.

"The reason for this sorry record," concluded WMI, "seems to be USDA's myopic view that set-aside programs should only provide income to farmers and control commodity production . . . a publicly unacceptable position which must be changed in order to link commodity and conservation programs and help build needed support for boosting the sagging farm economy."

Even the Republican-controlled Senate has lost patience with the Department of Agriculture's failure to use its commodity price support program leverage to insist that participating farmers maintain vegetative cover crops of value to wildlife on out-of-commodity-production acres and otherwise implement the conservation plans provided to them free by the Soil Conservation Service.

Late last year the Senate passed Senator William Armstrong's so-called "sodbuster bill," S.663, which would deny price supports and other subsidies to farmers for crops grown on newly plowed rangeland—an attempt to stop the Department from subsidizing speculators who first farm fragile arid grasslands for a year or two and then "farm the system" by obtaining federal disaster payments as the topsoil on their "farms" blows away.

The Chairman of the Senate Subcommittee on Soil and Water Conservation, Forestry, and Environment, Mr. Jepsen, has made clear to Secretary Block his belief that soil erosion has gotten out of hand. In a letter to the Secretary dated September 28, 1983, Mr. Jepsen observed that the conservation benefits of the 1983 PIK program were "minimal" and offered this advice:

"Any 1984 PIK or other land set-aside program should incorporate a conservation objective. The emphasis should be to stress that the government feels that conservation has a positive value over and above any potential crop value. An additional emphasis of the program would be to target this set-aside program to highly erodible acres."

Secretary Block's Response

The Secretary is responding to this criticism. On September 29 he actually said in a speech in Marion, Iowa, that "it is not always in the farmer's best interest to plant fence row to fence row." Take that, Earl Butz! He went on to announce that 10 percent of the 1984 feed grain acreage may be set aside for "acreage conservation reserve purposes." To be eligible for price support benefits, producers must agree to limit their feed grain acreage to not more than 90 percent of their farms' feed grain base and devote the other 10 percent to "conservation purposes."

And on December 8, acknowledging that "the farm commodity and credit programs put in place by Congress and administered by USDA are sometimes at cross purposes with desirable soil and water conservation objectives," he announced two "initiatives intended to close that gap."

The first effort would be $20 million of ACP funds made available in 1984 for farmers who elect to put their erosion-prone acres in long-term conservation set-asides. This program would permit farmers to place erodible land under five to ten-year contracts if they plant those acres to grass or trees. Landowners would receive 90 percent cost-sharing from the ASCS to cover the cost of planting. They would get technical assistance from the Soil Conservation Service on seeding grass and from state extension foresters on planting trees. The Secretary said this 1984 set-aside "will help determine the effectiveness of combining a useful short-term commodity program objective with a long-term conservation objective [and] give USDA and Congress a chance to evaluate the willingness of farmers to make long-term commitments to retire highly erodible cropland." The second initiative is a pilot erosion control program for the Palouse region in Oregon, Washington, and Idaho involving a change in USDA regulations to allow landowners to count unplowed grassland as part of their base acreage for the conservation reserve. Both merit conservationists' vocal support.

More good news. On January 6 of this year, International Association of Fish and Wildlife Agencies Executive Vice-President Jack Berryman announced that a survey of state wildlife agencies regarding the quality of their working relations with their State Agricultural Stabilization and Conservation (ASC) Committees turned up several instances of very effective cooperation:

- Arkansas Game and Fish personnel have prepared a brochure to explain how this PIK Program could be used to benefit wildlife. Arkansas' State ASCS Director reviewed and approved the brochure.
- Kansas' State ASC Committee established a reserve fund for wildlife practices to complement the Commission's private land Wildlife Habitat Improvement Program. Funds are earmarked for ACP wildlife practices to assure proper allocation of funds at the local level. Kansas is working to improve standards and specification of practices.
- Oklahoma's Department of Wildlife Conservation has been working with ASCS since PIK to promote the Governor's Wildlife Habitat Improvement Task Force.
- South Dakota's Department of Game, Fish and Wildlife and the State ASCS have a cooperative agreement, work together on a pheasant restoration program, and cooperate on media programs to promote conservation practices on farmland.
- South Carolina's Wildlife and Marine Resources Department prepared a news release to describe ways that small game could benefit from Acreage Reduction Program and PIK.
- Delware's Division of Fish and Wildlife must approve and inspect wildlife and fishery-related practices that are included in ASCS programs.
- Ohio's DNR maintains regular contact with all executive directors and county committees, and the ASCS seeks DNR input to develop better government programs to benefit wildlife.

Action Recommendations

As this kind of cooperation becomes more widespread, wildlife agency representatives may want to take up with their ASC Committee colleagues the following set of proposed changes in the way in which the ACP is administered. According to the Midwest Association's Farm Wildlife Habitat Council, adoption of these recommendations of theirs would help to conserve soil as well as benefit wildlife:

1. *No* ASCS cost-sharing benefits should be avilable to any landowner who converts Class VI, VII, CII or VIII lands from permanent cover to row crop or small grain production.
2. Higher ASCS cost-share rates should be made available for conversion of marginal croplands to permanent cover involving native grasses rather than cool-season grasses.
3. Higher ASCS cost-share rates should be employed to encourage greater use of legume crops in rotation programs, where soil moisture is sufficient, in order to break down a developing pattern of monoculture, improve soil organic matter, and reduce erosion.
4. Tax structures should be modified to permit conversion from irrigation back to dry-land farming even before the irrigation equipment is normally depreciated.
5. Higher ASCS cost-share rates should be made available to landowners who give consideration to wildlife resources by devoting a minimum percentage of their cropped acreage to permanent cover capable of supporting wildlife.

6. Tax incentives or ASCS cost-share rate incentives should be provided to discourage fall plowing for spring-planted row crops.
7. Whenever land set-aside programs become a part of national agricultural policy in the future, fundamental changes, such as elimination of the "no weeds" policy or provisions of ASCS cost-share payments to establish the required cover crop, should be made.

Stepping back and viewing the entire potential array of policy-improvement options in this field, The Wildlife Society's Committee on Habitat on Private Lands, which I had the pleasure of chairing recently, identified for consideration by the Society's Council a number of opportunities whereby the Society, its chapters and its membership, in concert with similarly concerned organizations, might work to maintain, restore, and enhance wildlife habitat on the private lands of the United States.

Here are some committee suggestions:

1. Protect prime agricultural lands against conversion to other uses. Encourage, by every feasible means, programs designed to retain prime agricultural lands in agriculture and to hinder conversion of such lands to other, non-agricultural uses.
2. Encourage those agricultural practices that retain plant residues or vegetative cover on the land. All recent assessments of current trends in U.S. agriculture indicate that no-till, reduced tillage or conservation tillage systems offer by far the greatest opportunity for reducing the present excessive rates of soil erosion on agricultural lands, retaining moisture in the soil, reducing direct energy inputs in agriculture, and providing some degree of vegetative cover that may be used by wildlife
3. Support the targeting of soil conservation programs to those lands with the most severe erosion problems and the use of the most cost-effective erosion control techniques.
4. Work to obtain cross-compliance with soil and water conservation programs as a prerequisite for qualifying for any form of federal assistance made available to agricultural producers.
5. Work to ensure that wildlife considerations are incorporated in any future agricultural land retirement or land "set-aside" programs.
6. Identify those habitats that are critically important to wildlife on the private lands and be prepared to work for their inclusion in existing or future land acquisition programs or their protection and maintenance by other means that ensure their availability for wildlife. (This recommendation arose from a consideration of land acquisition programs and other means of protecting wildlife habitat short of acquisition in fee title such as conservation easements, purchase of surface rights, purchase of development rights, leasing, etc. in the context of conserving wildlife habitat on private lands.)
7. Encourage alternative farming methods that operate, largely through utilization and retention of cover crops and rotations, to ensure more vegetative cover diversity and provide more wildlife habitat than do conventional farming methods. Several recent studies, including an extensive review by a USDA study team, have concluded that many organic farming practices are economically viable and are effective in reducing soil erosion and non-point pollution of water resources.
8. Expand federal and state programs that provide technical and financial assistance for enhancing wildlife habitat on privately owned forestlands. There may be significant opportunities to enhance wildlife habitat on privately owned forestlands as a result of recent amendments to the Cooperative Forestry Assistance Act of 1978, which

now contains specific language in Section 2 (b) allowing the states to use federal funds for wildlife habitat management assistance on private lands. Among the potential activities that enhance wildlife habitat that could be included in such forestry assistance programs are the seeding of logging roads, landings, and clearings; planting of shrub borders; creating waterholes for wildlife; clearcutting along logging roads; creating grassy or shrubby clearings; modifying timber management practices to leave snags, den trees and mast trees; managing deer yards, protecting riparian zones; and protecting and managing habitat for threatened and endangered species.

9. Remove existing constraints and work to promote expansion of fee hunting or pay hunting systems to provide incentives for private landowners to maintain and improve wildlife habitat on their lands.

Focus on the 1985 Farm Bill

The Congress will soon begin formal deliberations on the 1985 farm bill. Early oversight hearings on USDA's commodity programs could flush out aspects of the existing programs that either frustrate soil, water, and wildlife conservation efforts or potentially could assist them. Unless this is done, conservation will continue to be the orphan of "emergency" conditions that perpetually spawn commodity program decisions. As the Soil Conservation Society of America's Washington Representative, Norm Berg, emphasized before the Joint Economic Committee on June 22, 1983, we must make certain that farm programs, by design and action, buy more conservation than they do now.

In September of 1983, at the 73rd Annual Meeting of the International Association of Fish and Wildlife Agencies, a list of eight "elements" deemed essential for future USDA acreage set-aside programs was adopted and subsequently forwarded to the appropriate committees of Congress. In the opinion of leading wildlife conservationists in Washington, D.C., these requirements must be incorporated in the 1985 farm bill. It is around these recommended provisions that the wildlife profession must rally and, in combination with our allies, flex our political muscles:

- Require a *multiple-year* acreage set-aside program.
- Require *long-term* acreage set-aside on at least 20 percent, and possibly 33 percent, of the base acreage for each commodity (wheat, corn, feed grains, cotton, rice, etc.). The annual set-aside acreage for the last two decades has averaged 20 percent.
- Require the establishment and continuous presence of *vegetative cover* on the multi-year set-aside acreages. Provide adequate funding to help establish permanent (three years or more) vegetation on set-aside acreages. Vegetation established must be maintained by appropriate management throughout the contract period to provide benefits through soil conservation, water enhancement, and wildlife production and survival.
- Require *no mowing and no grazing* or, at most, late mowing or grazing, of vegetation established on the set-aside acreages.
- Continue the 1983 USDA policy of permitting landowners to manage recreational access, including charging user fees, on set-aside acreages.
- Ensure participation of conservation, water quality, agri-business, forestry, fisheries, and wildlife interests in the deliberations of and actions taken by ASCS national, state, and county committees.
- Ensure broad public understanding of the realigned acreage set-aside program, with strong emphasis placed on the integrated commodity/conservation features.
- Eliminate federal incentives (technical and direct and indirect financial assistance) for

converting noncroplands to crop production. Noncroplands shall include acreages devoted to: grassed waterways; terraces; windbreaks; existing, created and restored wetlands; woodlots; bottomland hardwood forests; riparian lands; and natural wildlife habitats.

The overall thrust of these elements is to link commodity and conservation objectives and results much more closely than they have been in the past. This is needed, the International Association observes, to correct and prevent soil erosion, maintain and restore water quality, and sustain production and survival of wildlife, while simultaneously producing food and fiber adequate to meet U.S. domestic needs and a part of the export demand.

As we address ourselves to the conservation shortcomings of USDA's commodity programs and seek improvements in the 1985 farm bill, let us also bear in mind the opportunity we will have eventually to influence the language of the nonpoint source pollution control provisions of the Clean Water Act.

As Peyton Sturges (1983), on behalf of the Natural Resources Defense Council, has observed:

> An effective national program for controlling water pollution from agricultural operations would require that USDA, EPA, and states work together to assure that each state which has agricultural nonpoint source water pollution problems develops and implements a program, approved by EPA, to control these problems. This new program would provide a schedule for states to complete nonpoint planning and implement remedial measures, sanctions which can be imposed on recalcitrant states, and a back-up program developed and implemented by EPA for use where states fail to perform required duties by a given time. USDA and EPA would provide technical and planning assistance to states as they work toward nonpoint control programs, as well as cost-sharing and individual technical assistance to farmers with severe problems.

Such a comprehensive nonpoint source pollution control program, requiring widespread installation of "best management practices," would have major positive ramifications for wildlife habitat, particularly riparian habitat. But the campaign for those amendments to the Clean Water Act may be a few years off.

For the moment, let us concentrate on the 1985 farm legislation and win the needed wildlife-related reforms in it.

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Potential Benefits of Organic Farming Practices for Wildlife and Natural Resources

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Introduction

In recent years, a growing cross section of American society has begun to raise questions regarding the long-term sustainability of American agricultural production practices and farm structure trends. Many agricultural scientists and policy makers, conventional farmers, environmentalists, members of the fish and wildlife community, and lay citizens have voiced their concerns over the increasing dependence of modern agriculture upon nonrenewable resources. These citizens and experts are equally concerned about the depletion of our agricultural resource base and associated environmental degradation, particularly of surface and ground waters and fish and wildlife resources, caused by excessive soil erosion and the heavy use of synthetic fertilizers and pesticides. Modern agriculture's dependence upon these energy intensive, and increasingly expensive, production inputs has also raised questions about human and animal health, food quality and safety, and the continued demise of the family farm.

For many years, these and other similar concerns have been expressed by members of the alternative agricultural community[1]. Now, however, a new and much broader consti-

[1] Throughout this paper, we use the words "alternative" and "organic" to refer to a spectrum of low-chemical, resource- and energy-conserving and resource-efficient farming systems and technologies. Within this context, the definition of organic agriculture developed by the USDA Study Team on Organic Agriculture seems appropriate.

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests (USDA 1980).

Although we treat the terms organic and alternative more or less synonymously, we view "alternative" as a general term which embraces a number of more specific terms, all of which refer to various alternative agricultural production systems. For example, words such as "biological," "ecological," "regenerative," "natural," "sustainable," "biodynamic," "agroecological," and "eco-agriculture" are all currently used by various alternative agriculture spokespersons and groups. We do not object to any of these terms, or the more specific meanings that are associated with them. These approaches, in varying degrees, are designed to provide American agriculture with viable agronomic and economic production and distribution alternatives that can help farmers reduce their dependence on energy and farm chemicals and thereby foster the development of a more balanced, diversified and self-sufficient form of agriculture. Finally, within the current lexicon, the word organic would appear to come closest to being a generic term of these low-chemical, resource-efficient methods of food production. Thus, despite the reluctance of some to accept the term organic, particularly within the scientific community, its meaning, nonetheless, is widely recognized and generally understood by a broad cross-section of the American public. The desire on the part of some within the alternative agriculture community to find a term that is more acceptable to agricultural scientists may, in fact, help to explain the proliferation of these terms.

tuency, which advocates a "New Agenda" for American agriculture, has begun to champion at least some of the principal tenets of the alternative agricultural community's ideology and policy objectives (Youngberg 1984). This has provided an increased measure of attention and respect for alternative farming systems within the agricultural community. Increasingly, both the advocates and skeptics of these low chemical, resource conserving farming systems are beginning to systematically examine the character and potential benefits of organic agriculture within the broader system of U.S. food and fiber production. The fish and wildlife community, including both its professional and lay elements, is no exception. In fact, evidence suggests that the need and desire to preserve and enhance fish and wildlife resources is one of the most important factors accounting for the increased interest in alternative agriculture. The principal purpose of this paper is to discuss the manner in which organic farming systems can benefit wildlife and natural resources. In the process of discussing this particular set of concerns, however, we will also examine the opportunities, obstacles, and benefits associated with the wider-scale adoption and application of these low-chemical systems of farming in general.

Conventional Agriculture and Farm Structure[2]

The structure of conventional agriculture in the U.S. is well known: highly specialized, large scale, capital- and chemical-intensive farms predominate throughout most of the major food producing regions of the Nation. Gradually, over the past 40 years or so, monocultural cropping systems, particularly of cash grains, large confinement animal feeding operations, and fossil fuel-based production inputs, especially inorganic pesticides and fertilizers, have been widely adopted by America's farmers. These structural trends have, for the most part, run counter to the development of biologically-based, diversified, resource-conserving alternative farming systems. Indeed, the basic trend of farm structure over the past four decades (e.g., larger average farm sizes, the increased concentration of farm sales and assets, and growth in the capital and energy intensiveness and specialization of farm enterprises) has created a highly industrialized form of agriculture.

While it is relatively easy to explain how and why this structural pattern developed,[3]

[2] Wayne Rasmussen, Chief, Agricultural History Branch, USDA, ERS, Washington, D.C. has suggested the following definition of farm structure. According to Rasmussen, "farm structure simply is the control and organization of resources needed for farm production. Its dimensions include the numbers and sizes of farms by commodities and regions; the degree of specialization in production and the technologies employed; the ownership and control of the productive resources; barriers to entry and exit in farming; and the social, economic, and political situations of farmers."

[3] Public agricultural policies have contributed to these trends in a number of ways. For example, commodity programs have tended to favor larger over smaller farmers for two principal reasons. First, since larger farmers tend to have a higher proportion of gross sales accounted for by cash expenditures than do smaller farmers (USDA 1981), any additional increment to farm income which is proportional to the amount of the commodity produced will increase larger farmers' net incomes more than those of small operators. Second, farm commodity programs influence farm size distribution through their effects on the land market. Commodity programs essentially transfer income from taxpayers to farmers and provide farmers with the means to compete for land in local land markets. The resultant tendency for commodity payments to be bid into land prices and to result in land inflation has a crucial distributional effect. Land inflation provides the greatest short- and long-term benefits to large landlords and landowners through growing rental income and long-term capital gains. Smaller landowners may find most of the benefits of land inflation dissipated through rising rents, interest payments, and property taxes. Also, land inflation which is realized as capital gains is most lucrative for farmers and landowners who are in high tax brackets. Likewise, interest deductions (due to debt-financed land purchases) from tax liability are of greatest benefit to high income individuals. Tax policy, in particular accelerated depreciation and investment tax credits, represents straight-forward subsidies to farm expansion, thereby providing the greatest benefits to large, expanding farmers and landowners. These tax benefits are likewise most attractive to high income persons. Thus, the dominant thrust of federal commodity and tax policies has been to disproportionately subsidize relatively large farmers.

its virtues are no longer universally acclaimed. It is widely acknowledged that these energy-intensive production technologies substantially account for the abundant supplies of food and fiber produced in this Nation over the past four decades; however, the adverse (and largely unanticipated) long-term effects of so-called conventional agricultural practices are increasingly unacceptable to American society. For example, in the U.S. Corn Belt, an area which contains much of this Nation's prime farm land and which is characterized by the widespread use of conventional farming practices, the average annual soil loss from erosion exceeds 8 tons/acre (18 mt/ha) (Berg 1979). This figure is roughly twice the maximum tolerance rate or "T-value" considered acceptable to maintain high levels of crop productivity in the long-term. Some agricultural scientists now feel that continued soil erosion at these rates could eventually result in yield declines of 30 percent or more.

The adverse effects of conventional farming practices on water quality are also a matter of increasing concern. The recent EPA study (USEPA 1983) of the Chesapeake Bay concluded, for example, that "The nonpoint source runoff from cropland constitutes the largest share of the nonpoint source nutrient load to the Bay." The authors of that report recommended a number of less chemically intensive production alternatives and "best management practices" designed to alleviate excessive nutrient runoff and enrichment (especially by nitrogen and phosphorus) of the Bay from the adjacent cropland.

The rapidly escalating cost of farm production inputs also accounts in large measure for the increased interest in organic agriculture among U.S. conventional farmers. The continuing cost-price squeeze that is being experienced by U.S. farmers, and which could intensify in the future if farm surpluses persist and foreign sales lag, has contributed to a heightened interest among the Nation's conventional farmers in the adoption of lower cost production and management alternatives. While it is highly improbable that rising input costs alone will cause any major shifts in our present farm structure, the likelihood of ever rising input costs helps to explain why more and more conventional farmers are seriously considering lower cost, biologically-based production alternatives. If the recent U.S. Department of Commerce report (USDC 1983) on agricultural chemicals is accurate (it predicts, for example, that nitrogen fertilizer prices could triple by 1985), farmers are likely to be increasingly receptive to the adoption of some of the basic concepts (e.g., crop rotations and nitrogen-fixing legumes) of organic agriculture.

Finally, the USDA *Report and Recommendations on Organic Farming* (USDA 1980) summarized the concerns about the present character of agricultural production practices and farm structure trends as follows:

- Increased cost and uncertain availability of energy and farm chemicals.
- Increased resistance of weeds and insects to pesticides.
- Decline in soil productivity from erosion and accompanying loss of organic matter and plant nutrients.
- Pollution of surface waters with agricultural chemicals and sediment.
- Destruction of wildlife, bees, and beneficial insects by pesticides.
- Hazards to human and animal health from pesticides and feed additives.
- Detrimental effects of agricultural chemicals on food quality.
- Depletion of finite reserves of concentrated plant nutrients; for example, phosphate rock.
- Decrease in number of farms, particularly family-type farms, and disappearance of localized and direct marketing systems.

For these and other reasons, various segments of the conventional agricultural community are now beginning to explore the potential benefits for all of agriculture to be derived from the wider scale adoption of organic farming technologies. These researchers want to know how these low-chemical, energy-conserving farming systems can contribute to the long-term sustainability of this Nation's and the world's agriculture.

The Search for Alternatives: Evidence of Support

To a large degree, the future expansion of alternative agricultural practices in this Nation and abroad will be conditioned by the attitudes, activities, and support of conventional agricultural organizations, companies and publications, the agricultural research and education establishment (i.e., the land-grant university system and the USDA), consumers, agricultural policy makers and, of course, conventional farmers themselves. The alternative agricultural constituency will play an increasingly important role in shaping the character of needed research, education and policy programs pertaining to alternative farming systems. Nevertheless, the wide-scale adoption of these organic methods of farming will depend, to a large extent, upon the acknowledgement of their scientific credibility by the agricultural establishment. Thus, we now turn to these sectors of the agricultural policy making system for a brief assessment of their changing attitudes and levels of support for alternative agriculture.

There are now numerous indications of increasing interest in alternative agriculture among conventional farmers and conventional agricultural spokesmen and farm groups. For example, about half of those who attended (150 persons) the University of Nebraska's alternative agriculture field days in 1981–83 were, according to the organizers of these events, conventional farmers who came seeking information and methods that could help reduce their production input costs. Other universities report increased requests from conventional farmers for information on organic farming techniques. The Agricultural Productivity Act of 1983 (H.R. 2714), which would direct the Department of Agriculture to initiate a long-term research and education effort on alternative agriculture, was recently passed by the U.S. House of Representatives by a vote of 206 to 184. This bill has the support of several conventional farm groups: National Farmers Union, National Farmers Organization, National Grange, National Association of Conservation Districts, Soil Conservation Society of America, and the Texas and Massachusetts Departments of Agriculture. A companion bill is now before the U.S. Senate Agriculture Committee.

The conventional farm press no longer overlooks the accomplishments and potential of alternative agriculture. Recently, for instance, *The Furrow*, John Deere's highly respected bimonthly magazine, featured as its May-June 1983 cover story, a positive account of alternative farming systems (Kessler 1983). A 1983 editorial in the *Des Moines Register*, a mainstream farm newspaper regarded by many as a bellwether on agricultural issues, called for increased research and education in the area of organic agriculture. (*Des Moines Register* 1983).

There is equally convincing evidence that the agricultural research and education establishment is beginning to view alternative farming systems in an increasingly positive light. The following selected developments and activities are illustrative of this trend:

- The North Carolina State University Department of Soil Science has initiated a year-long study of research and education materials pertaining to organic agriculture. This Department also offers a regular, full-credit course called "Alternative Agricultural Systems."
- The Iowa State University Agronomy Department is now conducting a review of all ongoing university and USDA research projects that pertain to organic farming.

- The University of Minnesota Department of Soil Science offered a course entitled "Organic Agriculture" during the Winter Quarter of 1983.
- The University of Nebraska has a number of alternative agriculture research projects underway. In 1983 they published their *Alternative Farming Task Force Report,* which includes recommendations for needed research and education programs.
- Michigan State University is conducting research on "closed systems" agriculture, a term preferred by scientists there. They also plan to co-sponsor a research meeting in 1984 with the International Federation of Organic Agriculture Movements (IFOAM).
- Iowa State University has held two recent symposia on alternative agriculture, one of which directly addressed the interrelationships between conventional farming practices and fish and wildlife resources.
- The American Society of Agronomy will soon publish the proceedings of a special symposium on Organic Farming and Its Role in a Sustainable Agriculture.
- The 1981 Agriculture and Food Act (i.e., the 1981 "Farm Bill") contains explicit language in Title 14 calling for research on organic agriculture.
- The 1980 USDA *Report and Recommendations on Organic Farming* was well received within agriculture establishment research circles. Approximately 55,000 copies have been requested to date, and it has been translated into at least four other languages including Japanese, Spanish, German, and Swedish.
- The Interior Department's Fish and Wildlife Service is in the process of converting several of its refuge farming operations to organic methods.

A survey of research data indicates that the lay public supports alternative agricultural approaches. For example, in a 1980 Harris survey of public attitudes toward soil and water conservation which was conducted as part of the Soil, Water and Related Resources Conservation Act of 1977 (RCA), 61 percent of the respondents felt that this Nation should be moving toward policies that conserve "the natural productivity of the soil rather than (emphasizing) chemical fertilizers and farm technology" (Louis Harris and Associates 1980). Many farm owners and managers (44 percent) took a similar position. The expanding character of the organic and natural foods retail and wholesale industry (Brown 1983) also shows increasing support for the expansion of alternative farming activities.

Current Status and Character of Organic Agriculture

Organic farming differs considerably in certain respects from widely practiced conventional agriculture, mainly with respect to tillage and cropping methods, livestock management, and in the way that crop nutrients are supplied and pests are controlled. Organic farmers generally follow a holistic approach to farming which involves a strong interdependency among crops, animals, and management practices that provide for a highly complex production system that is stable, sustainable, resource-efficient, and economically- and environmentally-sound. Compared with conventional agriculture, organic methods tend to employ less inversion tillage, greater crop diversification, and include livestock production as an integral part of the farm operation. Another major difference between organic farming and conventional agriculture is that organic farmers avoid or restrict the use of chemical fertilizers and pesticides in their operations. Practices employed by organic farmers can result in conservation benefits to fish and wildlife by reducing soil erosion, which in turn would minimize the movement of sediment, nutrients, and pesticides from cropland into surface waters.

Production Practices Used by Organic Farmers

Cropping practices—Organic farmers make more extensive use of meadow and small grain crops and, therefore, grow less row crops than conventional farmers. On many farms, either a legume or grass, or mixtures thereof, may involve 30 to 50 percent of the rotation. For example, the USDA *Report* cites a 6-year crop rotation used by an organic farmer in Iowa that was 50 percent hay, i.e., oats-alfalfa (3 yr.)-corn (2 yr.). An organic farmer in Kansas was following a rotation of oats-alfalfa (3 yr.)-corn-soybeans-corn-soybeans, or nearly 40 percent hay. Monoculture cropping, such as continuous corn or long-term rotations of corn and soybeans, is generally avoided. In addition to less row cropping, organic farmers cited in the USDA *Report* made greater use of green manure and cover crops than did most conventional farmers. The forage produced on organic farms is usually fed to animals, which encourages a mixed grain crop/livestock operation and meadow in the rotation.

Tillage practices—The USDA *Report* also showed that most organic farmers use tillage implements that maintain crop residues at or near the soil surface. They also commonly practice shallow tillage, to depths of no more than 3 to 4 inches, usually with disk or chisel type implements. Deep inversion tillage such as moldboard plowing is avoided because farmers are aware that such tillage disrupts the established microflora near the soil surface and tends to place the organic materials at depths where conditions are less favorable for decomposition and release of nutrients. Because they avoid the use of chemical pesticides and fertilizers, organic farmers are likely to cultivate more frequently for weed control. This extra tillage would probably increase the rate of mineralization of soil organic matter, compared with conventionally-farmed soils where use of chemical pesticides are used intensively in lieu of tillage.

No-till farming is generally not acceptable to organic farmers because of the heavy dependence of this practice on pesticides to control weeds and insects with present technology[4]. Organic farmers question the sustainability of any agricultural system that depends on pesticides because of perceived harmful effects to soil, water, and biological components of the environment. They also believe that some tillage is necessary to maintain soil tilth and a favorable environment for biological activity.

Nutrient supply and management—Organic systems rely heavily on legumes in the rotation for nitrogen supply and, to some extent, on off-farm sources of nitrogen containing organic wastes such as animal manures and compost. Most farmers strive to recycle nitrogen as efficiently as possible by recycling crop residues and on-farm manures and other wastes or byproducts of the farm operation. Special organic fertilizers such as bloodmeal may be used in more intensive cropping systems, depending on cost and availability of material. Some organic farmers will, on occasion, use certain low-analysis inorganic nitrogen fertilizers as a supplement for high nitrogen-use crops such as corn when, for example, the crop has not been preceded by a legume for 2 or 3 years.

Phosphorus and potassium are supplied either by importation of low water-solubility materials such as rock phosphate or greensand, or through the release of these nutrients from soil minerals. Processed fertilizers, such as acidulated phosphate, are used in some situations, for example, where rock phosphate is not locally available or there is insufficient

[4] Richard Thompson, an organic farmer from Boone, Iowa, has been conducting a number of experimental applications of ridge strip-till plant technology without the use of herbicides over the past four years. Although these trials are still in progress, Mr. Thompson's results are encouraging. See "No-Till Soybeans Without Herbicides," *The New Farm*, Sept/Oct., 1982, (Rodale Press, Emmaus, PA).

crop response to this material. The USDA *Report* showed that relatively few organic farmers were applying phosphate and potassium minerals to the soil; instead, they depend primarily on the breakdown and dissolution of soil minerals to supply the crop's requirement for these nutrients.

Organic farmers generally avoid the use of high-analysis inorganic fertilizers such as anhydrous ammonia, urea, and concentrated forms of phosphorus and potassium. A strong consensus is that concentrated materials are generally harmful to the soil biota and can ultimately lead to nutrient imbalances, reduced earthworm activity, impaired soil physical properties, compaction, and pollution of groundwater.

Pest control—Organic farmers rely almost entirely on a combination of nonchemical methods for control of weeds, insects, rodents, and diseases in field crops, vegetables, and fruits. Pest control is achieved primarily through crop rotations, with crop sequences within the rotation adjusted so as to maximize effectiveness in disrupting pest cycles. Supplemental weed control is achieved by mechanical cultivation, mowing, adjustments in planting date, and certain biological methods such as crop competition and animal grazing. Organic farmers also place considerable emphasis on preventive methods. For example, weed sanitation techniques are used to prevent the establishment of unwanted vegetation that might harbor weed seeds and insect pests. When absolutely necessary, some organic farmers use registered herbicides selectively and sparingly to support cultural and mechanical practices. They sometimes use organic insecticides for controlling particularly persistent insect pests in the production of fruits and vegetables.

Demography and Economics

Information on the demography of alternative agriculture is limited. Relatively little systematic research has been done on the growth, number, sizes, geographical distribution and marketing characteristics of organic farms. Similarly, information on the personal traits of organic farmers, the energy and labor efficiency of these alternative farming systems, and their economic performance is also sparse. These limitations notwithstanding, however, it is still possible to reach relatively firm conclusions regarding most of these matters based upon a variety of completed researches. Moreover, it should be noted that the research results reported to date express remarkably similar findings and conclusions.

According to the USDA *Report*, there are between twenty and thirty thousand organic farmers in the United States, a figure regarded by the *Report's* authors as a conservative estimate. While precise figures on the number of organic farms are unavailable, there is little disagreement about their geographic distribution: Alternative farming systems are found in all major production regions of the U.S. with the exception of the Southeast and desert regions where the combination of soil, climatic, and pest conditions tend to limit organic farming activity. Even in these regions, however, examples of successful alternative farming operations do exist. Despite the widespread geographic distribution of alternative agriculture, such systems tend to be concentrated in the Northeast, Midwest, Western Corn Belt, Upper Midwest, Pacific Coast, and Northwest sectors of the U.S.

Alternative agriculture is practiced on a wide range of farm sizes and does not appear to be limited by scale. For example, the USDA *Report* included many farms in the six- to eight-hundred acre (243–324 ha) range, with one case study respondent farming 1500 acres (607.5 ha) without any use of synthetic chemical fertilizers and pesticides. Other researchers report a similar pattern with respect to farm size and organic methods (Lockeretz et al. 1981, Blobaum 1982, Madden 1983).

Even though relatively few micro-economic analyses of alternative farming systems have been done to date, they have all reached the same general conclusion: In most cases, net farm income on organic farms compares favorably with net income on conventional operations (Klepper et al. 1977, Roberts et al. 1979, Berardi 1978). The differences (Lockeretz et al. 1981, for example, reported 4 percent less net income overall between 1974–77, and 13 percent less net income in 1978), in fact, are aften attributable to site-specific factors such as management ability, soil and climatic conditions, markets and enterprise mix.

Without comprehensive data regarding the micro-economic and production characteristics of organic farms, it is difficult to estimate the macro-economic and structural impacts of various degrees of shift away from conventional production methods toward alternative ones. Recently, however, Olson et al. (1982), did arrive at some conclusions in this regard through the development of an elaborate simulation model. In brief, this research concluded that the following would result from a total shift of U.S. agriculture to organic methods:

- Net farm income would rise.
- Domestic demand would be met.
- Consumer food costs would increase.
- Regional shifts in production would occur.
- Marginal lands would be brought into production.

This analysis did not consider the relationship between the livestock and crop production industries in the U.S.

While some have questioned the production assumptions used in this model (many observers feel that the assumptions are too low), the results do not indicate that a catastrophic situation would ensue from a total shift to organic agriculture. This, coupled with the fact that shifts toward organic farming would, in all likelihood, be incremental, would seem to indicate that gradual adjustments during such a transition period could be made without creating insurmountable production, supply, price and market dislocations.

Benefits to Natural Resources and Wildlife

Soil and Water Conservation

Approximately one-third of this Nation's 413 million acres (167.3 million ha) of cropland is subject to annual erosion losses which exceed 5 tons of soil per acre. In many cases, this rate of loss is far greater than the natural rate of replacement. Much of this problem can be attributed to intensive row-cropping, continuous production of cash grain crops, lack of sod-based rotations, and failure to implement soil and water conservation and management practices.

Consequently, there is a growing concern that excessive soil erosion will significantly reduce the productive capacity of this Nation's cropland. At a recent workshop more than 100 prominent agricultural scientists and administrators were asked to identify national research priorities regarding the uses, management, and conservation of our soil and water resources. "Sustaining the productivity of our agricultural soils", was selected as the most important agricultural research priority (Larson et al. 1981). It would appear that organic farming, from its long time dedication to soil conservation, could play a significant role in achieving this national goal.

The USDA *Report* concluded that most organic farmers utilize soil and crop management practices that are recognized as "best management practices" for controlling soil erosion and water pollution from cropland. These include the use of sod-based crop rotations, contour farming, conservation tillage, cover crops, and green manure crops (USDA/EPA 1976). There is no question that such practices enhance the conservation of soil, water, plant nutrients, and wildlife resources. Tillage methods that conserve and maintain crop residues at or near the soil surface are highly effective in controlling erosion and for reducing sedimentation and nutrient runoff. The diversity of crops in rotation systems also contributes substantially in controlling weeds, insects and plant diseases. Thus, organic farming can greatly minimize the need for chemical pesticides through integrated pest management approaches. When the grain and forages produced in these systems are fed to animals, and the crop residues and manures are recycled back on the land, the need for chemical fertilizer (particularly nitrogen) is markedly reduced and sometimes eliminated entirely.

Studies have shown that the proper management of organic wastes and residues, combined with conservation tillage practices and sod-based rotations, can substantially improve the tilth, fertility, and productivity of agricultural soils (Cooke 1977, Oschwald 1978, USDA 1978). Where the rotation includes grasses and legumes, the content of soil organic matter can actually be increased, which correlates with increased crop productivity and decreased erosion. For example, Wischmeier and Smith (1978) estimated that, for some soils, an increase in the soil organic matter content of one percentage point would decrease the erosion potential by approximately 10 percent.

Environmental Pollution: Prevention and Abatement

On a national basis, sediment from soil erosion is by far the major pollutant of surface waters. Each year about one-third of the 4 billion tons of soil that erodes from some 400 million acres (162 million ha) of croplands washes into the Nation's streams and lakes. The problem is exacerbated by the large amounts of nutrients and unknown quantities of pesticides used in conventional agriculture that are transported with the sediment. Several years ago it was estimated that 10 to 15 percent of the nitrogen contained in some 40 million tons of commercial fertilizer used, became a pollutant of either surface waters of groundwater (Pisano 1976). Excessive fertilization in relation to crop uptake is probably the leading cause of such pollution. With conventional farming methods, runoff and aerial losses of pesticides have been estimated to range from undetectable levels up to 20 percent of the amount applied (USDA 1978). As previously stated, organic farming has the potential to greatly reduce soil erosion, and subsequently the pollution of surface waters by sediment. Since organic farmers tend to avoid, or largely exclude, the use of chemical fertilizers and pesticides, this alternative method of farming would contribute few of these chemicals to environmental pollution.

Benefits to Wildlife

Up until about four decades ago, conventional agriculture in the U.S. was, for the most part, beneficial to the support and proliferation of many wildlife species. The reasons for this are twofold: (a) crop rotations provided the necessary food base and diversified habitats for protection, and (b) large scale use of pesticides had not yet begun. Crop rotations soon gave way to monoculture cash grain production along with intensive row cropping, clean tillage cultivation, larger machinery, and heavy applications of chemical fertilizers and pesticides (particularly the chlorinated hydrocarbon types). This resulted in a concommitant decline in the food base, habitat areas, and in turn, the numbers and species of wildlife (Rogers and Wooley 1983).

Very few definitive studies have been conducted on the effects of organic farming on wildlife. Just how this method of farming affects the abundance and diversity of bird and animal species is of primary interest. Most of what is known or has been reported is from preliminary studies still in progress, from surveys, and from observations by farmers and biologists. The potential benefits of organic farming on wildlife would be associated with increased amounts of cover and habitat areas, control of erosion and sedimentation, and minimal use of chemical fertilizers and pesticides (Dahlgren 1982, 1983).

Effect of cropping practices—Several studies suggest that populations of breeding birds are higher on organic farms as compared with conventional farms as a result of the greater diversity of crops and use of meadow on the organic farms. Ducey et al. (1980) found that an organic farm in eastern Nebraska had eight times more bird territories than adjacent conventional farms. Similar results were reported by Gremaud and Dahlgren (1982) for breeding bird populations on organic compared with conventional farms in Iowa. Dahlgren (1983) concluded that the amount of crop litter, seed abundance, and crop cover affected the use of the field by birds, but reported no effects from the use of chemicals.

Effect of erosion—Decreased soil erosion associated with organic farming practices would reduce the level of water pollution from sediment and chemicals as compared with that from many conventional farms. The greatest benefit to be derived would be the improvement in water quality of fish and wetland habitats. If soil erosion should continue at present rates it will surely have devastating effects on wildlife species in wetland and estuarine areas in the future.

Effects of Pesticide Chemicals—A great deal of information has accumulated on the effects of chlorinated hydrocarbon pesticides on fish and wildlife, from their intensive use starting in the early 1950s until they were banned or severely restricted some 20 years later. These were highly stable chemicals that could persist in the environment for years, could undergo biomagnification in food chains, and accumulate in higher species, causing chronic effects detrimental to some of these populations (Klaas 1982). Most of the insecticides and herbicides in use today are short-lived chemicals that persist in the environment for hours or days.

When applied at field application rates, most of the herbicides now used would be relatively nontoxic to birds and animals. Wildlife biologists and ecologists are more concerned with the herbicidal destruction of habitats and their food base rather than any direct toxic effect on animals. In the case of insecticides, however, mortality can result from direct toxic effects on birds and animals, or after they have ingested poisoned invertebrates (Klaas 1982). Direct biocidal effects of pesticides on the soil micro- and macro-fauna is of increasing concern. Many of these species provide a source of food for wildlife, especially birds. Some of them (e.g., collembola, springtails, and earthworms) play vitally important roles in decomposing organic wastes and residues, increasing nutrient availability, and improving the tilth and productivity of soils.

Nevertheless, currently used chemicals have been implicated as the cause for decline in bird and animal populations; however, there is considerable controversy as to how acute and widespread the effects may be. Again, some adaptation of organic farming methods would restore habitat areas and greatly reduce the likelihood and severity of adverse effects of such chemicals on wildlife in the future.

Future Research Needs

Organic farming has the potential to greatly reduce soil erosion and nutrient losses from this Nation's cropland, which in turn could significantly decrease the pollution of surface waters by sediment and agricultural chemicals, and improve the quality of fish and wildlife habitats. Our ultimate goal should be that of developing agricultural systems that are stable, sustainable, environmentally-sound, and productive over the long-term, and which provide maximum protection to our soil, water, and wildlife resources. To achieve this goal future research should focus on the following areas:

1. Investigate organic farming systems using a holistic, multidisciplinary research approach to study the interrelationships of recycling organic wastes and residues, nutrient availability, crop and animal production and protection, energy conservation, and environmental quality.
2. Conduct research to improve present methods used by organic farmers, e.g., conservation tillage, nonchemical pest control, crop rotation sequences, and nutrient cycling.
3. Determine long-term effects of organic farming methods on soil properties that influence the erodibility and productivity of soil.
4. Investigate how biological pest control, nutrient cycling, crop rotations, mechanical cultivation, and other cultural methods used in organic farming systems can reduce heavy dependence on chemical pesticides and fertilizers in present minimum tillage and no-till cropping systems.
5. Conduct economic studies on organic, compared with conventional farming systems, taking into account not only short-term farm income, but also such factors as
   a. differences in long-term social costs for pollution of surface waters and groundwater by sediment and chemicals,
   b. changes in soil productivity,
   c. hazards to human and animal health, and to wildlife species from pesticides, and
   d. benefits from increasing the organic matter content of soils.
6. Investigate how organic and conventional farming concepts can be integrated so as to incorporate the best features of each into productive, economically-viable, and environmentally-sound management systems.
7. Determine factors responsible for low crop yields during the transition from conventional to organic farming, and how these relate to changes in soil properties, nutrient availability, and pest and soil microbial ecology.
8. Determine the effect of transition from conventional to organic farming on changes in the numbers and species of wildlife, i.e., birds and animals, and how these relate to changes in the food base, type of cover, and habitat development.
9. Determine the effect of transition from conventional to organic farming on changes in the numbers and species of soil invertebrates, and how these relate to changes in the rate and frequency of pesticide application, soil organic matter content, soil physical properties, crop rotation sequences, and populations and species of wildlife.
10. Develop models to predict and verify responses of wildlife to changes in their food base and habitat as affected by soil and crop management practices, particularly conservation tillage, crop rotations, monoculture systems, and integrated pest management.

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Minnesota Landowner Attitudes Toward Wildlife Habitat Management

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Wildlife Habitat Management—What Is It?

For a moment, let us briefly consider what wildlife management means. Most wildlife professionals would agree that the wildlife manager has the most widespread influence on wildlife populations by regulating how these populations are utilized. The wildlife manager is least effective in directly controlling the production of wildlife; the quantity of land that wildlife managers have controlling influence over is quite small. Furthermore, we can agree that wildlife is a product of land and water. That being the case, the land use decisions are in effect wildlife management decisions.

We identify ourselves professionally as wildlife managers, but how many of us look upon a land-use planner, a farmer, a timber manager, or a developer as a wildlife manager? Yet, if we accept the premise that wildlife is a product of the land, then anyone making a land use decision is indirectly a wildlife manager.

What Are Some Wildlife Management Decisions That Are Made By Non-Wildlife Managers?

A forest manager chooses to reforest a cutover area to conifers; that is a wildlife management decision. An agricultural landowner drains a marsh; that is a wildlife management decision. A landowner chooses to clear a wooded tract and convert it to farm land; that is a wildlife management decision. A developer has 640 acres (259.2 ha) of idle farmland near a major metropolitan area that he intends to develop; that is a wildlife management decision. A land-use planner prepares, for a suburban area, a comprehensive land-use plan that systematically converts vacant land to subdivision housing; that is a wildlife management decision. Each one of these actions on the part of an individual landowner, a land-manager, or a land-use planner are wildlife related actions because they affect how the land base is to be utilized and consequently the type of wildlife that will inhabit the land. In some cases these decisions may be beneficial to wildlife; in other cases they may adversely affect wildlife. In any case, each of these decisions and any decision that affects how land is used is a wildlife management decision.

A former professor of mine at the University of Minnesota, Dr. William H. Marshall, made a statement in a wildlife orientation class that I'll never forget. He said that "Wildlife management is people management." We, as wildlife professionals, must not forget that.

In promoting the wildlife resource to the general public, the wildlife manager has two advantages. First, there is a high level of interest in wildlife. *The 1980 National Survey of Fishing, Hunting, and Wildlife—Associated Recreation* (U.S. Department of Interior 1982) presents a variety of statistical evidence which documents the interest of the public-at-large in wildlife related activities. For example, about 80 million people over the age of 16 (47 percent of the population) found enjoyment in being able to appreciate wildlife around their own homes. From an economic standpoint, survey results indicate that the U.S. adult population spent 2.6 million dollars on a variety of equipment, including field gear, cameras, binoculars, motorhomes, tents and trailers, etc., primarily for nonconsumptive wildlife related uses. Another indication of the intensity of interest in wildlife is the investment in wildlife art prints. Although precise sales estimates are difficult to obtain, one dealer in Minnesota estimated that Minnesota sales alone exceeded 10 million dollars annually.

Our second advantage is that the wildlife profession possesses a great deal of knowledge about management opportunities for wildlife. Our challenge is to bring about an exchange of knowledge between those interested and those knowledgeable. We must create an awareness of the management potential of wildlife species and motivate landowners and managers to a desirable course of action, i.e., to manage for wildlife in a positive rather than in a negative sense.

Survey of Minnesota Landowners

In order to better understand the needs and desires of private landowners regarding wildlife habitat management on private lands, the Minnesota Chapter of the Wildlife Society undertook a questionnaire survey of Minnesota private agriculture and forest landowners. The purpose of this survey was to gain a better understanding of how landowners feel about wildlife on private lands and to obtain ideas from landowners regarding techniques which might encourage a higher level of participation in private land wildlife management.

A chapter committee was formed with representation from public agencies and private companies. The purpose of this committee was to draft the questionnaire that would be utilized to survey the private landowners. Financial sponsorship came from private landowners, conservation organizations, the U.S. Fish and Wildlife Service, Minnesota Department of Natural Resources, and the University of Minnesota. The Soil Conservation Service provided access to landowners files so that a random list of agricultural landowners in the state could be generated.

The questionnaire was sent to nine different groups of landowners. These included participants in the Private Lands Forestry Program, Farmer's Union county presidents, a selected group of individuals who have participated in soil conservation practices in the past, landowner's in the U.S. Fish and Wildlife Service Mid-Continent Pilot Study Area, Wildlife Habitat Improvement Program participants, township and county officers, members of the Minnesota Forestry Association, randomly selected forest landowners, and randomly selected agricultural landowners.

In all, 1,920 questionnaires were mailed. The first mailing was made in August, 1982, with a follow-up reminder post card in September. The second questionnaire was mailed in early December, following the fall harvest, with the reminder sent approximately two weeks later. Three-hundred-sixty questionnaires were returned after the first mailing, and 461 were returned after the second mailing.

What the Landowners Said

Table 1 shows the various groups sampled and the percentage of questionnaires returned by each group. An examination of the returns shows that those individuals participating in conservation programs had a higher return rate than the other groups.

Table 1. Private landowners survey response rate.

Respondent group	Total sent	Total returned	Percent returned
Private forest management program participants	191	134	70.2
Farmers Union county presidents	81	31	38.3
Selected soil conservation program participants	162	92	56.8
U.S. Fish and Wildlife Service Mid-continent Study Area Landowners	366	130	35.5
Wildlife Habitat Improvement Program participants	66	42	63.6
County/Township Officials	100	50	50.0
Minnesota Forestry Association members	46	31	67.4
Randomly selected forest landowners	392	128	32.6
Randomly selected agricultural landowners	516	184	35.7
Total	1920	821	42.8

Of the total number of responses (821), 708 (85 percent) were usable, and 39 of the respondents did not wish to participate. The balance of the nonparticipants were either deceased, no longer owned the land, the land parcel was too small and they felt they could not participate in the survey or they lacked knowledge to fill out the questionnaire.

One of the questions was designed to determine the respondents' knowledge about wildlife habitat management. To evaluate the response to this question, 15 different key words relating to habitat and management were identified. The respondents' answer was scored by the number of key words that appeared in their response. Forty-six percent of the respondents did not list any key words, 42 percent mentioned one or two of the elements, and only one percent identified five or more elements.

When asked what obligation private landowners had regarding wildlife management, 18 percent said the private landowner had little or no obligation, 11 percent said that the private landowner had either a social or a moral obligation, and 23 percent said the choice should be voluntary.

Seventy percent of the respondents agreed that government should provide incentives to private landowners. Six percent of those agreeing said the federal level of government should provide the help, 18 percent said the state level, 15 percent identified the county level, 10 percent indicated that the township should provide wildlife management help, and 11 percent suggested that a combination of state and local units of governments should provide help.

The opportunity to observe wildlife was ranked very highly by private landowners. Of those who expressed an opinion, 90 percent considered the opportunity to observe wildlife either important or very important.

We also asked private landowners for their opinions towards government leasing, purchasing or regulating private land for wildlife purposes. The respondents agreed that the government should either lease (65 percent) or purchase (60 percent) private land for wildlife. Eighty-two percent of the respondents either disagreed or strongly disagreed that government should regulate private land for wildlife purposes. Yet 90 percent of the same respondents considered the opportunity to observe wildlife on their land as important to highly important.

The private landowners were also asked who they felt were reliable sources of wildlife information. A list of 23 different types of individual information sources were listed including professionals, such as foresters and wildlife managers; individuals in positions of influence, such as editors of magazines and newspapers; and also friends, neighbors, and public officials. The responses generally fell into three categories. The resource professionals were considered highly reliable sources of information; friends, neighbors, respected individuals in the community, and editors of farm magazines or outdoor sports writers were considered to be a moderately reliable source of information. Generally unreliable sources of wildlife information included state and national legislative representatives, local public officials, local radio personalities, and former professional sports figures.

How Can This Information Be Used?

The data analysis for this project is just beginning, so extensive cross tabulations and detailed analyses have not been completed. But these are some preliminary results that have a significant bearing on how wildlife managers could be responding to the private landowner. The private landowner is looking for assistance in two areas: financial assistance in the cost-sharing of wildlife management practices and tax credits for land set aside or left idle for wildlife. The private landowner is also looking for technical notes and other information to provide guidance on how land might be managed for wildlife.

We, as professionals, recognize that wildlife management information is there, but what we recognize as being there may not be available or accessible to the private landowner. Any one of us who has seen a browse line in a cedar swamp can certainly recognize the fact that what appears to be available may not necessarily be accessible. The same thing holds true when it comes to having information regarding wildlife management practices and techniques available to the public. What is available may not necessarily be accessible, and it is up to us to bridge the gap and satisfy the hunger that the private landowner has for wildlife management information.

Our survey results suggest that this can be best accomplished in several ways. The best way is to utilize local sources of information, such as conservation officers, county extension agents, and local sportsmen's groups. Many of the respondents indicated an interest in local workshops, seminars, information sessions, and direct personal contact by knowledgeable individuals.

In Minnesota, the township level of government is relatively strong, and many people felt that involvement at the township level in wildlife management matters would be particularly helpful. The survey results suggest that the local network is most important. Even if the information originates at the state level, it must be provided through local sources. These sources must be knowledgeable and credible individuals. Local radio programs and newspapers can provide the announcements needed to advertise the training sessions or seminars and also indicate the availability of knowledgeable individuals interested in helping private landowners develop their land for wildlife purposes.

It is important to remember that, though we are by training wildlife resource managers, our greatest involvement must be with people. We need to be advisors to that segment of the public which holds the greatest wildlife management potential for the future, the private landowner.

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Farm Wildlife Production: What Does It Cost?

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For the past 28 years, Remington Farms has had as its prime objective demonstrating how wise land use can make possible the coexistence of modern farming and wildlife management. During this time our farming practices have kept pace with the new machinery and technology. We've been active participants in, as well as witnesses to, the shift from traditional crop rotations and mixed farming to row crop monocultures that has occurred across the prime farmlands of our nation.

We've had our successes with our demonstrations, but we've also shared a frustration common among the conservation community. We've been witness to precipitous declines in farm-wildlife numbers and diversity around us. We've experienced the helplessness that comes from seeing a neighboring farmer destroy the fencerows, hedges, and grassy coverts, and seeing the creeks run yellow with silt. These have not been pleasant times for those of us who enjoy wildlife, love to hunt, and who live in America's prime farmland regions.

Our message to the farmer to save existing areas of grass, shrubs, and trees, or to plant them where they are lacking, to grow wildlife foods, to build ponds, and to preserve wetlands too often go unheeded. The reason for this—some would agree—is the disincentives to produce wildlife on private farmlands: the harassment and problems that come with more hunters, the increased crop damage that may result from higher wildlife numbers, and the loss of income from land diverted from crop to wildlife production. The solution—some would also agree—is that wildlife should pay its own way.

Is the recreational value of wildlife on prime farmland worth the cost? If it is, who shall pay the cost? If it is the hunter, then we need to give the hunter a realistic estimate of the cost of producing wildlife on prime farmland.

What does it cost a farmer to produce wildlife? Unfortunately, there is no one correct answer. The diversity of crops grown, land values, accepted land-use practices, and wildlife vary across the prime cropland region. Typical corn yields in the heart of the corn-belt are near 130 bushels per acre (321 bu/ha), with some fields and farms routinely producing near 225 bushels per acre (556 bu/ha). Farms in the mid-Atlantic states commonly produce 110 bushels per acre (272 bu/ha). Farm land values, rental values, and income vary accordingly.

Large and varied as yields and income per acre may be, it is instructive to look at some typical values and relate them to the farmers' cost of foregoing crop income to produce a wildlife crop for the public good.

Hamor (1968) presented the example of a farmer in good duck-producing country in the north-central United States developing a 10-acre (4-ha) duck marsh in a portion of his pasture and setting aside an additional 5 acres (2 ha) of nesting cover around the impoundment. Updating Hamor's 1960 cost figures (dam and structure, $5,000; fence, $880; amortized at 10 percent for 20 years; annual maintenance, $60; annual grazing income lost, $20 per acre [$49/ha]) and assuming a 50 percent Agricultural Conservation Program (ACP) cost sharing, the farmer's annual cost would be about $1,100, the publics',

$295. Hamor thought that this marsh development could potentially add 40 ducks annually to the fall population. At today's prices the cost per duck is about $35. Hamor did not estimate the number of muskrats, rails, herons, or yellow-headed blackbirds that might be produced, but their combined numbers would certainly exceed those of ducks.

Second to wetlands, no cover type uses space more effectively to produce wildlife on farmland than shrubby fencerows or hedges (e.g., Graber and Graber 1963, Kabat and Thompson 1963). A 500-acre (202-ha) farm might have one percent of its area in fencerow type cover (Shalaway 1979, Best 1983), equal to 2.75 miles (4.4 km) of 15-foot (4.6-m) wide fencerow. The annual income lost to the farmer from these nonproductive 5 acres (2 ha) would be about $378 (110 bushels per acre [272 bu/ha] @$2.55 per bushel, the 1984 national loan support price; minus $205 per acre [$506/ha] production cost; excluding land costs), to which we must add $125, the value of the approximate 25 percent reduction in yield in the adjacent two corn rows caused by the "sapping" and shading of the corn by the fencerow (Labisky and Anderson 1965, Soutiere unpublished data).

These 2.75 miles (4.4 km) of shrubby fencerow would provide a home for 80 to 120 cottontail rabbits (Dahl 1956, Morgan 1981), at a cost per rabbit of about $5. The fencerow would also support a summer population of 70 to 175 songbirds of some 16 to 30 species (Shalaway 1979, Best 1983).

Farmstead shelterbelts, like fencerows, can be an important shrubby and wooded habitat for wildlife in an otherwise monotonous landscape of row crops. Primarily recommended to farmers for the protection they provide to homes and domestic animals from high winds, windchill, and snowdrifts, they additionally provide this same protection to wildlife. As wildlife production areas they serve as breeding habitat for as many as 28 species of birds (Yahner 1982). The mourning dove is the one important game bird that nests in shelterbelts and production can range from about 1 to 34 per acre (3 to 84/ha) (LaPointe 1958).

A four-row shelterbelt, two of conifers and two of shrubs, might occupy 1.25 acres (0.5 ha) and cost the farmer about $1,870 to establish (80 balled and burlapped conifers @$20, 200 shrubs @$90, labor $180). Amortized over 20 years, the annual cost for establishing the shelterbelt is about $220, to which should be added $94, the annual income lost from the 1.25 acres (0.5 ha), taken out of production. The cost per dove for the 20 mourning doves potentially produced is $15.70.

From each acre of good, undisturbed grass-legume nesting cover, we can expect 1.2 to 1.5 (3 to 3.7/ha) pheasant chicks to be added to the fall population (Farris et al. 1977:57). But because grass-legume haylands are usually mowed before mid-June, few nests are successful and many hens are killed by the cutting bar. To avoid this loss, wildlife agencies suggest that the farmer delay the first hay cutting one or more weeks, preferably until mid-July, to allow the nesting cycle to be completed.

For the farmer, this delay results in a lower tonnage of hay harvested and a less digestable and lower protein-content forage. A dairy cow fed late harvested hay will require 1.5 to 2 times more grain supplement, and the grain mixture needs to contain an additional 5 percent protein (Doane Agricultural Service 1978). The cost per acre to the farmer for delaying mowing of a 10-acre (4-ha) hayfield could result in the addition of 12 to 15 pheasant chicks to the fall population at a cost of $510 to $638, or $30 to $50 per pheasant. As a bonus, the grass-legume cover would also provide nesting cover to a number of other nongame and passerine birds (Duebbert and Lokemoen 1976).

A final example is food plots. Providing for a food supply near good escape and winter cover is an accepted axiom of wildlife management. One recommendation is that the farmer leave a few rows of grain standing along the edges of woodlots, fencerows, or sloughs.

Planting an acre of small grain, soybeans or corn costs the farmer about $70, $95 and $150, respectively (Edwards and Thompson 1983). Four 30-inch (76.2-cm) rows of corn left standing along a 0.5-mile (0.8 km) fencerow only removes 0.6 acres (0.24 ha) from the harvest, but still the farmer's direct cost is $90. The farmer hopes to make a profit in addition to covering his costs, so, add another $45 for lost profit.

Are wildlife numbers increased by providing food plots? Probably not at the level of intensity likely to be undertaken on today's farm (Murray 1958, Wunz 1959, Ellis et al. 1969, Schumacher 1969, Brown 1974). So it is probable that no additional animals are produced for the farmer's $135 expenditure.

A benefit of food plots is that wildlife tends to concentrate near them, making hunting easier. For this purpose food plots can be cost effective, particularly for attracting and holding concentrations of migratory birds. Each year at Remington Farms thousands of ducks and geese flock to the blocks of corn, sorghum and millet left standing, and the 3 to 5 acres (1.2 to 2 ha) of sunflowers planted draw thousands of mourning doves (also see Madson 1978:91). In these circumstances, the cost per bird bagged by hunters is about $2 to $4.

Returning to the question, is the recreational value of wildlife worth the cost? Some might answer, no. The costs are too high, and diverting land from food production is not in the national interest. Wildlife production should be relegated to the less fertile, marginal lands (Allen 1981, Burger and Teer 1981). Their points are valid, but they offer little hope or encouragement to those of us who enjoy wildlife and who love to hunt, and whose homes and lives are tied to the prime farmlands of the United States. Our answer would be, yes. But then, who shall pay the cost?

Can we reasonably expect the farmer to spend $200, $500, $1,000 a year to produce wildlife and to provide public access hunting without compensation? The farmer has given us his answer. He continues to drain the wetlands, to bulldoze out the fencerows, and to mow the grassy coverts.

If you accept that compensation to the farmer needs to be made on the basis of the acres of wildlife habitat provided (Berryman 1957), that wildlife needs to compete on the same economic footing as corn, wheat, and hogs (Higbee 1981), then the costs for wildlife on prime farmland are very high. In fact, pen-raised game-farm animals are a bargain at these prices.

Taking the wide acceptance of the USDA Payment-In-Kind (PIK) programs as a clue, compensation to the farmer for wildlife habitat would probably need to be at least equal to 75–80 percent of the market value of the yield per acre of food and fiber normally produced on the land set-aside for wildlife habitat. Habitat on Kansas wheat land could cost annually $95 per acre ($230/ha), on Iowa corn ground $265 per acre ($655/ha).

Meaningful increases in wildlife numbers probably require that at least 5 percent of the farmland be devoted to wildlife production (Hamor 1968). At the PIK rates of compensation, wildlife habitat on a 500-acre (202-ha) farm would need to produce an annual income of $2,300 to $6,600.

Is "paid hunting" the answer? I think not.

The factors that influence whether a landowner manages habitat for wildlife or permits hunting are more complex than adequate cash compensation (see review, Burger and Teer 1981). For some farmers, no amount of cash compensation would induce them to manage for wildlife or to permit hunters on their land.

As for the hunter, he only pays $5, $10, or $15, for his hunting license, possibly an additional $5 or $10 for a habitat stamp. Little, if any, of these fees reach the farmer. The hunter should be paying more for his sport, and more should be going to the landowner, but will he?

There is actually little evidence to suggest that the average hunter is willing, or able, to pay the true cost of producing farm game (see review, Burger and Teer 1981). The average hunter cannot afford, any more than can the farmer, to raise $5 rabbits and $30 pheasants. The hunter's cost per game animal bagged will, of course, be several times greater. At best, user-fees collected from the hunters can only be expected to partially compensate the farmer for his cost of producing wildlife.

Any solution to producing wildlife on farmland must include the broad acceptance of farming practices that fortuitously produce wildlife as a no-cost by-product. The wildlife agencies need to aggressively advocate and demonstrate the new farming technologies that help both the farmer and wildlife. Chisel plowing, no-till planting (Basore and Best 1982) and ecofallowing (Baxter 1982) can help the farmer control his costs, reduce soil erosion, and benefit wildlife. The establishment and proper management of warm-season grass pastures can increase livestock yields and provide nesting cover for wildlife (George et al. 1981). Narrow-row soybeans (Wooley et al. 1982) and the underseeding of row-crops with legumes to provide "home-grown" nitrogen (Gogerty 1984) hold promise for benefitting the farmer and wildlife.

But in the final analysis we return to a theme often repeated at this and other conferences. "The best approach to wildlife management on private lands is to deal with natural resource problems and programs that encourage sound land use for all the resources of the land over the long term" (Karr 1981:182). For the prime agricultural lands of our nation this requires that we implement a national agricultural policy that goes beyond the mere control of prices and production to a policy that is based on the conservation of soils, water, and wildlife (Farris and Cole 1981).

We know how to manage for wildlife on farmland, but even with our best management, wildlife is, as Aldo Leopold noted, a "thin crop." To this I would add, an expensive crop. Wildlife's only hope on prime farmland is to ride on the "coattails" of farm practices, programs, and policies that bring reduced costs or added income to the individual farmer, and the conservation of soil and water to the nation.

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Forest Landowners' Perspectives on Wildlife Management in New England

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Introduction

Wildlife managers traditionally focused their attention on game species and the consumptive user. Management activities were biologically oriented, and benefits to users were primarily accomplished through the direct result of habitat manipulation and the regulated hunting of game species. Although the basic objectives of the wildlife management profession—habitat management and benefits to humans—are still valid today, the scope and focus have changed dramatically. Among the most important challenges confronting the profession today are increasing demands placed on existing wildlife habitats and major shifts in the clientele interested in wildlife.

A growing need exists to manage wildlife to provide human benefits associated with amenity and nonconsumptive uses. Much of the general public's interest in wildlife now relates to the enjoyment of simply viewing animals in natural settings and the desire to ensure the continued existence of wildlife species and habitats (Kellert 1979, 1980).

Wildlife species receive protection from overharvesting or wanton destruction through myriad state and federal wildlife laws, acts, and regulations. Despite these and other conservation measures, the existence of many species has been and will continue to be more dependent upon the quantity and quality of habitat. As a consequence, our wildlife management programs need to devote as much attention to conserving habitat as to protecting species. What makes this goal especially difficult is that most wildlife habitat is in private ownership. Approximately 60 percent of the total surface area of the United States is privately owned. This includes 97 percent of the cropland, 60 percent of the pasture and rangeland, and 70 percent of the forest land (USDA 1980). Private, non-industrial forests (PNIF) comprise over 58 percent of the commercial forest land in the United States. Over three-fourths of this private land base is located east of the Mississippi River.

New England, a six-state region with a total land area approximatley the size of North Dakota, has a population of over 12 million people. Over 80 percent of this land base is classified as forest land (Irland 1982). More than half of this "Yankee Forest" (Gould and Reidel 1979) is owned by some 455,000 PNIF landowners. Nowhere in our nation is a greater proportion of the forest land held and controlled by the private landowner than in New England. It is the "Yankee Forest," not the relatively small amount of crop or pasture land, which provides essential habitat to much of New England's wildlife. It has been estimated that of the approximately 3,000 species of vertebrates found in the continental United States, over 90 percent are associated with forest ecosystems (Shaw 1981). It is not unreasonable to expect, thus, that the continued abundance and diversity of New England's wildlife will depend on the actions of the primary custodian of the forest habitat—the private forest landowner.

New England's Private Forest Landowners

Two base-line studies of New England's forest landowners were conducted by the U.S. Forest Service in 1976 and 1977 (Kingsley 1976, Kingsley and Birch 1977). A number of other forest landowner studies have been conducted, but most were limited to individual counties or groups of counties within a state. These studies focused primarily on landowner characteristics and attitudes toward timber management and, to a far less extent, on amenity and environmental values associated with forest landownership (Holmes and Diamond 1980, Kelley 1981, MacConnell and Archey 1982, Meservy 1975, Weiseman 1983, and White and Jones 1980).

These investigations found the average size of PNIF ownership in New England is approximately 50 acres (20.2 ha) with a median acreage size of less than 10 acres (4 ha). Only 10 percent of the landowners own more than 100 acres (40.5 ha), although these large landowners hold over 75 percent of all private forest land. One-fourth of the ownerships are considered "suburban" forest land (Irland 1982). PNIF ownership is somewhat unstable, with less than 25 percent owning their land for more than 20 years. Most forest landowners in New England are white, male, over 50 years old, and live on or adjacent to their property. The primary reasons for owning forest land include: a part of residence, recreation, investment, and a variety of environmental and aesthetic reasons, including wildlife and wildlife habitat. Fewer than 10 percent of PNIF landowners specifically manage their land for timber, and profit from timber management was not often cited as a major motivating factor for landownership. Most studies indicate landowners are not adamantly opposed to timber management providing it does not interfere with other more amenity-related considerations (e.g., a negative impact on scenery or wildlife).

The federal land management agencies have declared as a national goal the strengthening of natural resource management on privately owned land through the encouragement of voluntary conservation practices. This objective has been pursued, in cooperation with the states, by a variety of financial incentive and technical assistance programs for private landowners (Berg 1981, Lee 1980). Some existing programs include soil and water conservation assistance, wildlife conservation, and timber management. Timber stand improvement is currently the primary state and federal policy for managing private forest lands in the Northeast (Ganser and Herrick 1980). Participation by New England's PNIF landowners has been notoriously low (Irland 1982). Kingsley (1976) reported, for example, that only 11 percent of southern New England landowners received any form of assistance, and over 50 percent indicated uncertainty regarding which agency to contact if interested. Although a wide range of opinions exist about the cause or possible solution to this "problem," it seems likely that current cooperative forestry assistance programs do not adequately address the most important interests of the PNIF landowner, particularly those concerning wildlife and wildlife habitat.

Methods

The overall objective of this study was to derive a better understanding of factors influencing PNIF landowner perceptions of and relations to wildlife on their forest land. Specific research questions included: (1) What do PNIF landowners in New England use and value their land for? (2) Is there a relationship between the size or the location of the property ownership and the level of interest in wildlife management? and, (3) What are the landowner's perceptions concerning the effects of forest management on wildlife populations?

PNIF landowners ($n=204$) who own land in Connecticut, Massachusetts, and New Hampshire were personally interviewed to develop a better understanding of their attitudes, knowledge, species preferences, and activities relating to wildlife and forest management. Over 250 variables were measured, including a number of socio-economic and demographic factors pertaining to the forest property and the landowner.

A stratified-random sampling scheme was utilized to ensure an adequate sample of rural and suburban forest landowners, as well as different size forest landownerships. Five rural and five suburban towns were chosen in each of the three survey states based on rural-suburban classifications and geographic location. Utilizing public tax records, eight forest landowners were randomly selected in each town. An introductory letter was sent to potential participants with a follow-up telephone call to arrange a convenient time and location for the interview. Less than 6 percent of those initially contacted declined to participate in the survey. The mean interview time was 75 minutes.

Although more costly and time consuming than mail or telephone surveys, a personal interview typically yields more and better quality information, and is adaptable to individual situations. To minimize the biases and sources of error that invariably result from survey research, we felt it was important to communicate directly with survey participants. The occasional use of open-ended questions, in particular, enabled interviewers to avoid misunderstandings and provided the landowner with an opportunity to express important opinions and views.

Due to space limitations and the large number of variables examined in this study, only a restricted number of selected results will be presented.

Selected Results

Landowners were asked to describe what they considered to be the three most important uses of their forest land. The eight land-use categories listed in Table 1 represent the terminology most often used by the respondents. Thirty-seven percent indicated the primary use of their land was as a "woodlot," although other important uses included scenery, open-space, recreation, and wildlife habitat.

To many New England landowners, "woodlot" is a purposely broad term that can be used in a variety of contexts. For instance, it is an appropriate *land classification* for

Table 1. Use of private, nonindustrial forest land in New England as perceived by the landowner. (Figures indicate percent response.)

Land uses	Primary use	Secondary use	Tertiary use
Woodlot	37	14	5
Open-Space (undeveloped land)	22	5	25
Recreation	14	21	14
Scenery/view	11	17	13
Wildlife habitat	9	23	28
Part of farm (also sugaring)	2	5	3
Hunting	2	4	4
Privacy/seclusion	2	1	1
Unsure	1	3	8
	100%	100%	100%

property tax assessment. In most New England towns, a "woodlot" would not be taxed the same as a wooded building lot. "Woodlot" can also refer to the *present condition* of the property (i.e., forested as contrasted to a field, an abandoned pasture, or "just-a-swamp"). "Woodlot" can additionally signify the *potential use* (not necessarily the current use) of the land (e.g., timber or fuelwood production).

With the exception of a personal supply of fuelwood, New England landowners rated commodity (extractive) benefits— such as income, timber products for personal use, or hunting—as relatively unimportant landownership benefits. Only 20 percent indicated income as an important benefit, and less than five percent said this was the most important landownership benefit. Additionally, only four percent reported that hunting on their land was important. These results were not associated with either the suburban-rural location or the size of the property.

In striking contrast, nonextractive and noncommodity benefits were regarded as relatively important to the great majority of New England landowners. Over 52 percent of the respondents rated nonconsumptive recreational activities, such as hiking and viewing wildlife, as an important benefit derived from their land. Twenty-one percent cited these activities as the most important satisfactions associated with landownership. In addition, intangible or subjective benefits—such as open-space, scenery, and "pride-in-ownership"—were rated important by over 70 percent of the respondents. When asked to choose what benefit they considered to be the most important, "pride-in-ownership" was stated most often (25 percent of all respondents).

Because private forest landowners do not seem to be primarily motivated by income, hunting, or timber production considerations, the relationship between forest landownership and a variety of amenity and noncommodity wildlife considerations was examined in greater detail.

Landowner responses to a question concerning the benefits or satisfaction derived from having wildlife on their property further indicated that PNIF landowners are primarily interested in the amenity and nonconsumptive uses of wildlife. Eighty-eight percent of the respondents ranked either seeing or knowing that wildlife exist on their property as the most important interest. In contrast, 82 percent stated that hunting wildlife on their land was not important, and this perception did not significantly differ by the size of the property or its rural-suburban location. A minority of the respondents (42 percent) felt that it was wrong to hunt wildlife as a sport. However, 63 percent were unwilling to allow hunting on their land.

Despite a strong interest in nonconsumptive wildlife, landowners performed relatively few wildlife or forest management practices to benefit wildlife (Table 2). Those practices occurring most often—putting up nesting boxes, constructing brush piles, not cutting coniferous cover—were conducted by less than 15 percent of the respondents. Few landowners apparently felt a compelling need to conduct wildlife management practices on forested land. Practices that wildlife biologists or foresters might consider beneficial for wildlife, most landowners considered non-essential. Many respondents expressed the sentiment: "Why worry about helping wild animals when they are perfectly capable of taking care of themselves?" Those landowners who did conduct forest/wildlife management activities on their land responded that scenic considerations were as important a motivating factor as "doing things to help wildlife."

When asked what approach to forest management would generally be the most beneficial for wildlife in New England, 22 percent stated "leave things alone." An additional 31 percent believed forest management practices conducted to "maintain the present forest

Table 2. Management practices performed for wildlife by private, nonindustrial forest landowners in New England. (Figures indicate percent response.)

Practices performed	Never	Once	Often
Put up nesting boxes	57	33	10
Construct brush piles	57	28	15
Not cut fruit/nut trees	66	22	12
Plant/protect conifer cover	65	20	15
Create small clearings	70	25	5
Plant fruiting shrubs	76	21	3
Create small ponds/wetlands	82	15	3

conditions" would be the most beneficial. From the landowners' perspective, "maintaining the present conditions" differed from "leaving things alone," as maintenance of an existing forest stand might require cutting dead or downed trees, spraying during insect infestations, or preventing forest fires.

Although 40 percent felt that the best approach was to "make some changes," few landowners were certain about what changes to make. Factors such as size of property ownership, its urban or rural location, or forest stand composition did not affect the perceived need to conduct land management practices. One exception was a significant correlation between landowners who practiced timber management and the belief that wildlife generally benefited from forest management activities. This finding has also been reported by Holmes and Diamond (1980). The number of landowners who actively practiced timber management, however, comprised less than 10 percent of those surveyed.

Because relatively few PNIF landowners practice wildlife or forest management, a series of opinion and trade-off questions were asked to evaluate landowner attitudes toward wildlife management in the context of various competing land uses. Similar to the resource economist's concept that financial decisions can be influenced by a "willingness to pay," this study utilized a "willingness to perform" concept to evaluate a landowner's predeliction toward certain wildlife management practices.

Table 3 indicates the responses to four situations that could confront a typical landowner when cutting fuelwood which might affect wildlife. The responses to statements one and four suggest a strong inclination on the part of the landowners to preserve particular trees or make brush piles to benefit wildlife, despite the potential loss of income or the extra effort involved. Additionally, 80 percent of the respondents indicated they preferred to cut firewood selectively rather than to create small clearings. On the other hand—and further indication of the value placed on firewood—the majority of landowners were inclined to cut standing dead trees, despite their possible use by wildlife.

Perhaps the most revealing portion of the survey involved a series of "scenario" questions. In each scenario, the respondent was asked to choose one of four alternative courses of action relating to wildlife or forest management.

Landowners were generally divided between what course of action to take when confronted with a hypothetical situation of whether to cut a stand of trees that could yield substantial income or to protect a site because a rare bird might be found there (Table 4). Significantly more smaller than large-sized acreage landowners preferred the short-term deferral or "never cut" option. Only 13 percent indicated that they would never cut any of the trees.

Table 3. Opinions of private, nonindustrial forest landowners in New England regarding wildlife/forest practices when cutting firewood. (Figures indicate percent response.)

	Agree	Disagree	Unsure
Statement No. 1			
I am willing to preserve certain trees important to wildlife, such as hollow trees or large oaks and hickories, even if it means less timber production or income.	87	6	7
Statement No. 2			
I prefer to cut standing dead trees for firewood, although they may be of some use to wildlife.	60	22	18
Statement No. 3			
When cutting firewood, I would rather cut only a few trees here and there to maintain the scenery than to make a series of small clearings.	80	9	11
Statement No. 4			
Purposely making brush piles for wildlife when cutting trees strikes me as a lot of work for little benefit.	24	60	16

Table 4. Preferred courses of action by private, nonindustrial forest landowners in New England regarding a harvent-no harvest dilemma. (Figures indicate percent response.)

Scenario No. 1

A Service (or County Forester) tells you that the trees on your land are ready to be cut and that you could receive about $10,000 from the harvest. However, you learn from a staff member of the Audubon Society that you have a rare species of woodpecker living on your land, and that it is likely to leave if most of the trees are cut. Which of the following choices would be probably make?

Alternatives	Acreage		Location		Overall
	5–49	>50	rural	suburb	
1. Cut all the trees the forester recommended and receive $10,000	11	14	16	9	25
2. Cut approximately half the trees recommended, hope the woodpecker stays, and receive only $5,000	14	14	16	12	28
3. Do nothing for now, or wait until the woodpecker finds another area	23[a]	11	17	17	34
4. Never cut any trees	9[a]	4	7	6	13
					100%

[a] Significant difference between acreage classes ($P \leq 0.05$)

A second scenario confronted the respondents with a variety of options for utilizing forest land to produce income for paying property taxes (Table 5). Most landowners indicated a strong preference to cut firewood or sell Christmas trees. Only limited interest was expressed in leasing land for hunting purposes or charging a fee for fishing.

The results of a third scenario question revealed the New England landowners' strong interest in protecting wildlife, despite a hypothetical loss of income (Table 6). When confronted with the possibility of selling land, presently considered a bird sanctuary, to be developed as a shopping center, 70 percent of the respondents indicated that they

Table 5. Land management preferences for generating income by private, nonindustrial forest landowners in New England. (Figures indicate percent response.)

Scenario No. 2

A landowner who owns 50 acres of forestland is considering several ways to generate $250 per year to pay his property taxes. Which of the following options would interest you the most?

Alternatives	Acreage		Location		Overall
	5–49	>50	rural	suburb	
1. Sell approximately 20 cords of firewood each year (stumpage)	30	34	37	27	64
2. Clear 5 acres of land, and grow Christmas trees	19[a]	6	13	12	25
3. Lease the land to a hunting club	1	1	1	1	2
4. Construct a trout pond, and charge a fee for fishing	7	2	4	5	9
					100%

[a] Significant difference between acreage classes ($P \leq 0.05$)

Table 6. Private, nonindustrial forest landowner preferences on selling land considered a bird sanctuary. (Figures indicate percent response.)

Scenario No. 3

You are a landowner who owns 10 acres of forest land that a developer will pay $50,000 in order to build a small shopping center. Currently, the land is considered a bird sanctuary. Which of the following actions would you take?

Alternatives	Acreage		Location		Overall
	5–49	>50	rural	suburb	
1. Sell the property to the developer for $50,000	5	5	6	4	10
2. Sell the property to a conservation organization for $25,000	22	11	19	14	33
3. Not sell the property for now, but plan to develop it at some future date	9	11	10	10	20
4. Never sell the land	21	16	21	16	37
					100%

would never sell the land or would sell it to a conservation organization at half the price offered by the developer.

A fourth scenario confronted New England landowners with a variety of wildlife management assistance programs offered by a state fish and wildlife department (Table 7). Over 80 percent preferred either property tax reductions if the land was actively managed for wildlife, or no-cost technical advice. Less than 20 percent preferred direct assistance programs such as stocking game birds or cash payments. This finding is similar to that reported by Kirby (1981) in Missouri, where the majority of farm operators desired technical advice or indirect assistance for wildlife. In general, PNIF landowners in New England appear skeptical of the demands that could be placed on them (e.g., not to post their land against hunting) if they accept direct assistance from state land management agencies.

The rationale behind many assistance programs is that some form of incentive is needed to help overcome constraints or obstacles. In this regard, landowners were asked what factors they felt limited them from deriving full satisfaction from owning their forest land. As indicated in Table 8, 48 percent of the forest landowners perceived "time" to be the most important constraint. No significant correlation was found between time or other constraints and the landowner's occupation, income, education, or the size or location of the property. The second and third most important constraints were money and physical ability/skill. Interestingly, knowledge and equipment were not regarded as important limitations.

Summary

Several points and considerations warrant re-emphasis.

1. PNIF landowners are primarily interested in intangible benefits and satisfactions such as scenery, open-space, and outdoor recreation. Landowners consider "time", not

Table 7. Wildlife management assistance programs preferred by private, nonindustrial forest landowners in New England. (Figures indicate percent response.)

Scenario No. 4

The State Fish and Wildlife Department is evaluating several types of programs that would encourage more forest landowners to practice wildlife management. Which of the following would interest you the most?

Alternatives	Acreage		Location		Overall
	5–49	>50	rural	suburb	
1. Cash payments to conduct specific wildlife management practices	6	2	4	4	8
2. Property tax reduction if the land is being actively managed for wildlife	22	19	23	18	41
3. Stocking game birds (or fish) and allow hunting (or fishing)	4	6	6	4	10
4. No-cost technical advice land management planning assistance	25	16	21	20	41
					100%

Table 8. Constraints limiting private, nonindustrial forest landowners in New England from gaining full satisfaction from landownership. (Figures indicate percent response.)

Constraints	Important	Not important	Most important
Time	54	31	48
Money	27	54	15
Physical ability/skill	16	70	12
Help from another person	11	80	6
Knowing what to do (knowledge)	9	77	5
Land constraints (size, access)	12	73	4
Lack of tools/equipment	5	85	2
No Limitations	—	—	8
			100%

money or direct assistance, to be the most limiting factor in achieving full satisfaction from forest landownership.

2. Closely related to the scenic and recreational values associated with landownership, PNIF landowners have a strong nonconsumptive (appreciative) interest in wildlife. Regardless of the rural-suburban location or the size of the property, landowners are not particularly interested in hunting, and are disinclined to allow others the opportunity to hunt on their land.
3. PNIF landowners practice few wildlife management activities, and most seem to lack an understanding of the basic principles of wildlife or forest management. They appear willing, however, to conduct forest management practices beneficial to wildlife as long as it does not interfere with scenic considerations.
4. Since most PNIF landowners have non-economic incentives to acquire, hold, or manage their land, it is unreasonale to expect that they can be motivated to manage wildlife on an economic basis.

In short, natural resource managers who deal with PNIF landowners need to recognize the scope of landowner perceptions associated with private ownership, respond to the interests of the landowner, and work within the constraints of existing private land uses. Until we develop a more complete understanding of PNIF landowner relations to wildlife, our efforts to conserve wildlife on private forest land will continue to be frustrated.

Acknowledgements

This study was supported by grants from the U.S. Forest Service–Northeastern Forest Experiment Station, The Wildlife Management Institute, the American Petroleum Institute, the G.R. Dodge Foundation, and the R.K. Mellon Research Program at Yale University. Special appreciation is extended to the two survey assistants, Charles A. Bridges and Nora N. Devoe, and of course, to the New England Forest Landowners who participated in the study.

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The Woodland Owners' Role in Wildlife Habitat Management

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This paper reviews Maine's land ownership patterns and its citizens' interest and involvement in wildlife issues and education. Many of the findings may be helpful in understanding woodland owners and their interest and participation in wildlife management practices.

An educational television series "Yankee Woodlot" developed by the Maine Public Broadcasting Network and the Maine Cooperative Extension Service will be briefly reviewed. An evaluation of the television series revealed some interesting facts relating to wildlife habitat management by woodlot owners.

Land Practices

Many changes in cultural land practices have determined the current New England landscape. New England is the northern extension of the Eastern Seaboard megalopolis, but retains a distinctly rustic persuasion. Once a region of pioneering agriculture, it is now a patchwork of successional forests. Nearly three quarters of a million landowners preside over 28 million acres (11.3 million ha) of forest land in this region.

Maine, the largest state in New England, has 87 percent of the total land area in forests (USDA 1983). Only 2 percent of Maine's forested lands are owned by public agencies. The remainder is divided evenly among the forest products industries and non-industrial private ownerships (Kingsley 1982). More than 8 million acres (3.2 million ha) are owned by an estimated 200,000 individuals.[1] Because 83 percent of the ownerships are less than 10 acres (4 ha), the economies of scale affecting these small acreages may limit forest management for commercial purposes. Nevertheless, with an awareness of other forest values, management for amenity values such as recreation, aesthetics or wildlife can be put into place by owners.

Woodlot Owners

Demographic information for Maine's woodland owners has been prepared and reported by the U.S. Forest Service (Kingsley 1982). However, knowledge about Maine landowners' management intentions or attitudes has been lacking. An informal survey has been conducted by Extension Agents over the past few years to gain information for program development. This information, a literature review, and planning assistance from interested groups and individuals became the foundation for the new television programming.

A Mass-Media Approach

As has been noted, woodlot owners in Maine are a large and diverse clientele group. The one extension forester in the state faced with the task of providing education to these people elected to use the mass-media approach to educating landowners about the potential values of land management (Blumenstock, pers. comm. 1983).

The television medium was an obvious choice. Prior research on the adoption of agricultural practices suggests that mass-media are the most effective communication channels for introducing awareness and information to a new audience (Rogers 1983).

Before proceeding into a description of the television program, it may be helpful to describe the level of Maine residents' interests with wildlife and wildlife habitat. Data on this subject is minimal and consists of indicators of residents' interest in wildlife and not specifically interest in wildlife habitat management.

Indirect Measures of Public Interest in Wildlife

No vigorous study of Maine residents' involvement in wildlife-related issues or management has been found. There are several studies of hunting or fishing preferences and expenditures (Lobdel 1967, Faunce et. al. 1979 Anderson et. al. 1981, Johnson 1981). Also, several economic analyses have been completed for individual hunting and fishing components of the recreation industry (Reiling and Anderson 1983, Reiling et. al. 1982, Taylor and Reiling 1981).

Content Analysis

Various methods are available which allow indirect measurement of wildlife-related interest or activities. Analyses of articles appearing in local newspapers has been in common use since adopted during World War II and is the basis for documentation of a recent best seller (Naisbitt 1982). This method requires analysis of articles published in newspapers for their content and frequency. Articles in the *Bangor Daily News*, the largest circulation newspaper in Maine, provided a source of study for articles published during the years 1979 thru 1983. Content analysis revealed a reduction in nationally-syndicated articles about wildlife with a corresponding increase in state and local interest articles (Table 1). Over this five-year period, localized wildlife articles increased in frequency after a sharp decline between 1979 and 1980.

Membership in Conservation Organization

Public participation in conservation related organizations is another indirect indicator of public interest in wildlife and the environment. Growth in environmental activism is reflected by increasing membership in organizations such as National Audubon Society, Friends of the Earth, and the National Wildlife Federation. Membership trends in Maine, parallel growth in national conservation organizations (Table 2) (Hendee 1983). Growth in the Sportsmans Alliance of Maine (S.A.M.) can, to a degree, be directly attributed to recent activism in support of establishing an annual moose hunt in Maine. The issue came to public referendum in 1983 with a substantial voter turnout. The moose hunt was favored by a majority of the voters.

[1] Discussion October 1983 between Thomas W. Birch, USDA Forest Service, N.E. Forest Experiment Station and M.W. Blumenstock, Maine Extension Forester regarding unpublished Maine land-owners survey data.

Table 1. Content analysis of wildlife-related articles published in the Bangor Daily News[a] 1979-1983[b].

Year	National interest stories	State/local interest stories	% change
1979	71	305	−54%
1980	13	190	+ 1%
1981	10	195	+10%
1982	10	216	+26.5%
1983	30	256	

Source: Compiled by authors
[a] Circulation 80,000.
[b] Includes published letters to the editor concerning wildlife issues.

Table 2. Annual membership in selected Maine conservation organizations.

Year	Membership households[a]			Members
	Natural Resource Council of Maine[b]	Maine Audubon[c]	The Nature Conservancy of Maine[e]	Sportsmens Alliance
1976	2,510	*	*	300
1977	2,050	2,700	*	*
1978	2,475	*	1,000	2,500
1979	2,305	3,700	1,100	*
1980	2,550	4,100	2,500	5,000
1981	3,000	4,700	3,600	5,700
1982	3,400	5,150	5,000	6,000
1983	·3,500	5,200	6,500	6,500
1984	3,750	*	7,000	15,500
Growth—				
1980	47.0%	26.8%	210.0%	180.0%
Most recent year				

Data not available
Source:
[a] No. of members = No. of Households × 2.6.
[b] Telephone call, Mark Iskanian, Membership Dept., Natural Resources Council of Maine.
[c] Personal correspondence, Jane Arbuckle, Wildlife Director, Maine Audubon Society.
[d] Telephone call, John Jensen, Membership Department, The Nature Conservancy, Maine.
[e] Telephone call, Dave Allen, Executive Director, Sportsmens Alliance of Maine.

In 1983, for the first time, Maine residents will have the option for a voluntary donation to nongame species management provided on the Maine state income tax form. Similar bills were proposed in 1981 but did not find organized support for their passage.

Public Input on Management

As public participation in resource management decision-making increases, public education and information about the subject will probably take on greater value. Maine has become a grassroots leader in public referenda on environmental issues (Naisbitt 1982). With the Maine moose referendum, local wildlife professionals now recognize the potential ramifications of public involvement in resource management. We expect local wildlife professionals will pursue new opportunities to provide more education for the public on resource topics.

Direct Measures of Public Interest in Wildlife

License sales figures and data from a national survey offer a view of the consumptive value of wildlife in Maine (USFWS, 1975, 1980).

License Sales

License sales to Maine residents for fishing and hunting have grown at slightly more than one percent above the state population growth for the past five years. Nonresident big game hunting approximately doubled between 1970 to 1980.[2]

Information about Maine taken from national survey data for hunting and fishing, 1975–1980, also aids in identifying trends. Differences in sampling technique and questions make direct comparison of the results impossible (Table 3). With this reference, note the increase in the number of participants but a decrease in the number of user days.

The 1980 national survey could become the foundation for comparison of both consumptive and nonconsumptive use of wildlife. The need for more comprehensive localized study on the subject of wildlife habitat management on private lands in also called for.

Yankee Woodlot: An Educational Television Series

Yankee Woodlot is a ten-part television series intended for the owner, potential owner or user of small woodlands. It was produced by the Maine Public Broadcasting Network and the Maine Cooperative Extension Service. The series was made possible by grants from International Paper Company and other local forestry interests.

Yankee Woodlot was designed to help the landowner determine and formulate goals and objectives for the woodlot, develop an operational plan, and implement that plan using accepted resource management principles. Whether managing for aesthetics, wildlife, recreational, or timber values, the series provides the viewers basic skills and knowledge needed for woodlot management.

The ten-part series has been broadcast six times during the last 24 months by stations of the Maine Public Television Network. Videotape copies of the series have been purchased by six other states and are currently being considered for purchase by another 30 agencies.

[2] Telephone call January 1984 Frederick B. Hurley, Jr., and Owen C. Fenderson, Maine Dept. of Inland Fisheries and Wildlife. National Survey

Table 3. Participation in wildlife-related recreational activities in Maine 1975/1980.

No. of participants	1975[a]	1980[b]	Difference/time
Fisherman	208,886[a]	236,000[b]	+
Hunter	157,602[a]	174,400[b]	+
Nonconsumptive users	282,484[c,e]	818,800[d]	+
Nonconsumptive users who neither fish or hunt	167,000[c,e]	488,200[d]	
No. of activity days	**1975**	**1980**	**Difference/time**
Fishing	6,910,000[c]	6,140,000[b]	–
Hunting days	4,224,000[c]	3,293,800[b]	–
Nonconsumptive use days	11,760,000[c,e]	9,472,000[d]	–

Source: 1975–1980 *National Survey of Fishing, Hunting and Wildlife-Associated Recreation.*

[a] Population 18 years and older
[b] Population 16 years and older
[c] Population 9 years and older
[d] Population 6 years and older
[e] Data collected in telephone screening only

The public television station based at the University of Maine, Orono compiled a market survey[3]. Results of the survey suggest there were from 2,000–10,000 viewers per program for the Orono viewing area. This translates into a range of 60,000–300,000 viewer contact hours, the equivalent of a minimum of 30 years of contact time by some educator, such as an Extension Agent. Additionally, over 8,000 requests have been filled for a home-learning packet that is called the "Yankee Woodlot Operational Plan."

Evaluating Yankee Woodlot

The Yankee Woodlot series was evaluated in the summer 1983. Viewers were polled to determine changes in perceptions regarding woodlot management. A modified pre-test/post-test design was chosen to accomodate limitations imposed by the television medium, and to recognize an inherent difficulty in identifying the television audience (McWilliams 1983, Thompson 1981). A random sample of viewers who had requested a learning packet called the "Yankee Woodlot Operational Plan" were questioned using a mail survey. Followup mailings produced a response rate of 49 percent, with the sample size ranging from 86 to 122 responses for individual questions.

Early and late respondents were compared as one method to test for nonresponse bias. No differences were found. A comparison of the demographic profiles of typical viewers of Maine Public Broadcasting and viewers of Yankee Woodlot showed a difference only in the 65+ age group. Yankee Woodlot had more viewers in that age group (P<05). For these reasons, the sample was considered representative of the normal Maine Public Broadcasting Network section of the viewer audience.

Questions pertaining to wildlife and habitat management were included in several sections of the questionnaire. In one section, viewers were asked to indicate their preference for resource values.

[3] Discussion August 1983 James H. Bisson, Maine Public Broadcasting regarding an informal and unpublished television market survey solicited by Maine Public Broadcasting.

The results of this survey indicated the following rankings:

			Ranks 1 & 2 Combined
Priority No.	1.	Timber	47%
	2.	Investment	41%
	3.	Wildlife	38%
	4.	Visual Beauty	34%
	5.	Recreation	25%
	6.	Other	12%

Wildlife habitat management was addressed in both pre- and post-test questions. Eighteen percent of pre-test respondents indicated they had conducted some form of wildlife habitat management; however, only 4 percent of pre-test respondents had received professional habitat management assistance. In the pre-test analysis, 37 percent of the respondents indicated they planned to undertake some action for wildlife habitat management. After viewing, 54 percent of the respondents said Yankee Woodlot had helped them plan for timber stand improvement to enhance wildlife habitat, a project described in one episode.

Conclusion

Many viewers watching Yankee Woodlot on public television would like to provide for wildlife habitat management on their lands. As a group, these viewers are better educated and own larger acreage than the typical Maine woodlot owner (McWilliams 1983). Their demographic profile suggests it is likely they will adopt new ideas and management concepts earlier than others in their communities and may act as peer group leaders within their communities (Rogers 1983). In the terminology often used by rural sociologists, these people are categorized as "innovators" and "early adopters."

If this group finds success or satisfaction in wildlife habitat management on their lands, it can be expected the demand for wildlife habitat information and assistance will increase.

Currently, wildlife habitat management assistance in Maine is limited. Similar to other states, budget restraints limit the amount of wildlife management assistance available from Maine state agencies. Television programs like Yankee Woodlot can be a first effective step in providing natural resource management assistance to the private woodlot owners.

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Nongame Wildlife: Funding and Programs

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Publicity Strategies and Techniques for Minnesota's Nongame Wildlife Checkoff

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Introduction

The Minnesota legislature followed the lead of Colorado and Oregon by passing a Nongame Wildlife Checkoff bill in April of 1980. The legislation allowed taxpayers to donate $1.00 or more, up to the total amount of their refunds, on their state income tax and property tax returns.

This legislation was the beginning of a new era for wildlife conservation in Minnesota because it was the first time that any significant amount of money was available for nongame wildlife. Minnesota has approximately 600 wild vertebrate species, of which about 490 are nongame.

Since donations to the Nongame Wildlife Checkoff are voluntary, it has been necessary to develop publicity strategies and techniques to solicit adequate donations for the Nongame Wildlife Program. This required both an intensive publicity campaign during the tax preparation season and a secondary publicity effort to show taxpayers how their donations were being spent.

The use of publicity strategies and techniques is novel for many wildlifers who are now initiating nongame checkoff programs in other states. This paper is intended to provide ideas to enable them to benefit from Minnesota's experience.

Goals and Budget

The goals of the publicity efforts are to generate enough revenue to maintain a successful program which benefits wildlife, and to generate favorable opinion, if not enthusiastic support, for both the Nongame Wildlife Program and the preservation of all wildlife resources.

The annual cost for devèlopment and distribution of publicity materials is approximately $12,000, and personnel costs have been about $8,000. The amount of donations received per dollar spent in publicity has been approximately $30.65. The table below is a summary of publicity costs incurred for tax year 1982.

Material Development and Distribution	
TV public service ads (5)	$ 3,863.30
Peregrine falcon poster (20,000)	3,859.00
Radio public service ads (4)	1,558.00
Newspaper public service ads (14) + news releases (printing costs)	1,506.20
Slides and slide program development	473.24
Mailing costs	1,000.00
	12,259.74
Personnel Costs	
Nongame Supervisor (292.5 hours)	$ 4,893.53
Regional Specialists (233.5 hours)	2,755.27
	7,648.80
Total (3.9% of annual budget)	$19,908.54

Approximately 1,700,000 income tax forms and 700,000 property tax returns are filed annually. The donation rate on Minnesota's income tax and property tax forms was approximately 11.7 percent in 1983. This was an increase from 8.9 percent in 1981 and 11.5 percent in 1982. The highest rate in the nation in 1983 was in Utah, which had 12.6 percent.

Strategies

Techniques for checkoff publicity must consider strategies that will generate significant program support and avoid adverse controversy. These strategies need to consider (1) multiplier effect, (2) public support and involvement, (3) areas of special emphasis, (4) message content, (5) feedback to donors, and (6) administration.

1. Use the "multiplier effect" whenever possible to increase publicity impact

One of the greatest problems for modern wildlife biologists is that much of their time is spent dealing with the public one-at-a-time, or giving slide talks to sportsmen's clubs 25-at-a-time. In a state with millions of people, the impact of such information and education efforts is inconsequential. The multiplier effect means dealing with those key people in the media who can reach thousands, hundreds of thousands, or millions of people with the same amount of time and effort we were previously spending to reach a few people at a time.

2. Solicit public support and involvement

Identify various nongame publics, and select the different techniques necessary to reach those publics. Department of Revenue personnel and tax preparers are two particularly important publics.

Don't assume that support for a state nongame program comes from a vaguely defined group of all who do not hunt. Program support should be sought from all kinds of publics which should be specifically identified—birders, hunters, trappers, women's club members, civic club members, garden club members, and anti-hunters. Show these diverse groups their common ground in nongame conservation, and show sportsmen how this program can indirectly help game species. For example, a Minnesota nongame research project on secondary lead poisoning in bald eagles resulted in the discovery that large numbers of Canada geese and mallards were dying of lead poisoning.

Develop a broad base of volunteer involvement in publicity efforts by creating publicity materials which can be easily used by cooperating club members or tax preparers. In our first year we produced a 13-minute 16-mm film about the Nongame Wildlife Program which was made available through our Bureau of Information and Education.

Volunteers need to be rewarded for special efforts. We have produced an embroidered loon patch for volunteers. We have also given engraved plaques to recognize corporate publicity assistance.

Once people have been convinced to give to the checkoff, they probably don't need to be re-convinced to give for at least several years. Therefore, I have tried to keep reaching new audiences each year while still maintaining the intensity of previous publicity efforts.

The general public should also be invited to help identify initial nongame priorities at meetings early in the development of a nongame program. This gives concerned citizens a sense of personal involvement. The results of the priority meetings should be published and followed up by comprehensive planning.

3. Pick areas of special emphasis

Special consideration must be given to identify the featured species in a wildlife checkoff publicity campaign. Well-known, popular, charismatic species are most desirable. Examples are bald eagles, loons, bluebirds, peregrine falcons, trumpeter swans, and popular backyard birds. It is very important for biologists to remember that most people do not know more than 20 or 30 wildlife species (U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, Bureau of the Census 1982). If the checkoff campaign is to be successful, it should relate to these "common ground species." For example, a mail survey in 1982 revealed that Minnesota's most popular birds were the black-capped chickadee, bald eagle, northern cardinal, American robin, and common loon. A variety of subsequent publicity efforts have focused on those species. Also, don't underestimate the powerful appeal of topics like backyard wildlife, helping bluebirds, birdhouse information, and winter bird feeding.

Sounds of wildlife in radio and television ads have a strong impact and should be used whenever possible. Bird calls can be purchased from the Cornell Laboratory of Ornithology.

I have not used potential game species or controversial species in checkoff publicity. Examples are mourning doves and gray wolves. Obscure or unpopular nongame species like bats and snakes are used to a limited extent; those species are mainly featured in information and education projects not related to publicity efforts. For example, we developed a slide tape on Minnesota's frogs and toads in 1982.

Species restoration projects and land acquisition have generated a significant amount of publicity. River otter, peregrine falcon, and trumpeter swan restoration projects have been repeatedly featured by the media. We also acquired land in two parcels: one a 1300-acre (526.5-ha) heronry and the other a 107-acre (43.4-ha) island of value to eagles, loons, and great blue herons. These acquisition projects received considerable media coverage. These efforts provide very tangible examples of program benefits to wildlife and have generated considerable support for the entire nongame program.

As a nongame program progresses, it is worthwhile to incorporate more publicity items about the smaller, less conspicuous nongame species that are not well-known to the public. That is important because people should realize that a nongame wildlife program is seeking to maintain a balance in program emphasis among both well-known and poorly-known species.

4. *Carefully consider message content*

There are several characteristics of effective messages in public service announcements. Messages should be short and catchy. For example, "There's something wild lurking in your Minnesota tax forms," "Look for the loon on your Minnesota tax forms," and "Tax time is your time to help wildlife." Ads should personalize a person's involvement with helping wildlife and appeal to one's pride in the state, its wildlife, and its environmental quality.

For example, "You can personally help preserve Minnesota's bald eagles." Or "Minnesota has more loons than any other state in the lower 48 states. Their abundance is an indication that Minnesota is maintaining a quality environment. You can help keep it that way by donating to the Nongame Wildlife Checkoff."

Learn to identify what is newsworthy to the media. You can learn to make checkoff projects newsworthy and get better news coverage as a result. Several key concepts make a story newsworthy: (1) *Feature new programs or projects*. Ongoing programs or projects are much less appealing to the media. (2) *Feature timely stories*. Checkoff stories are very easy to get publicized each year at the beginning of the tax preparation season from December 26 through mid-January. (3) *"First, biggest, and most" are very powerful words for obtaining publicity*.

For example, in 1981, the checkoff was a *new* program, and in 1982 the checkoff generated *more* donations in its first year than any other state with a nongame checkoff. In 1983, Minnesota received *more* donations than any other checkoff state in the nation. In 1984, Minnesota set a *new record* in the number of donations received. By reviewing a state's donation rate, total number of donations, or total money raised, it is possible to find any number of statistically creative ways to utilize the concept of "first, biggest, and most."

Within either a 30-second public service ad, or a news release, the message is more effective if it has this logic flow: (1) Establish the significance of a species; (2) Identify problems with its survival; (3) Establish that the Nongame Program is helping this species; and (4) You can personally help this species by donating to the Nongame Wildlife Checkoff.

An example is:

"Over 200 pairs of bald eagles nest in Minnesota. To preserve those eagles, we must protect them from disturbance, pesticides, and illegal killing. The Nongame Wildlife Checkoff helps give that protection. You can personally help our bald eagles by donating to the Nongame Wildlife Checkoff on your Minnesota tax forms. Remember, tax time is your time to help wildlife."

In longer messages, several supplemental ideas should be conveyed: (1) This is not the same as the political tax checkoff because it is not part of your taxes; (2) This is a voluntary donation which is tax-deductible on the following year's tax return; and (3) You can donate whether or not you receive a refund.

5. Give feedback to donors

There is a tendency to think of publicity primarily during the tax-preparation season. The purpose of that publicity is to solicit donations. However, it is extremely important to generate a second publicity effort outside of the tax season to show how donations are being spent. An outline map of the state with projects identified is very helpful in this regard. Good records should be maintained for program expenses and personnel time analyses. This information needs to be available to answer inquiries by the public. Annual reports are also useful to provide feedback to program donors upon request.

6. Use Effective Administration

Publicity efforts should originate within the Nongame Wildlife Program, with the Bureau of Information and Education providing technical support. Otherwise the long-term enthusiasm, innovation, and commitment necessary to mount the annual publicity campaign can be diminished. Costs for publicity should be matched from corporate sources whenever possible. Publicity costs can be very modest by limiting them to development and distribution. Do not pay for advertising time or space if possible. Take advantage of time and space for various public interest or public service announcements.

It is very helpful to establish mailing lists and a file system for all categories of program publicity so that details of publicity and contact persons can be readily recorded for use in subsequent years. A weekly progress chart can be used for all publicity products and projects to help plot the progress of each publicity season.

Techniques

Over 40 techniques have been used to publicize Minnesota's nongame wildlife checkoff during the past four years. These techniques have generally included five categories: (1) television, (2) radio, (3) newspapers, magazines and newsletters, (4) posters, and (5) corporate support.

1. Television

The most important form of television advertising has been 30-second public service advertisements (psa's) featuring well-known species which are benefiting from the checkoff: bald eagle, peregrine falcon, trumpeter swan, common loon, and western grebe. Each psa featured close-up nature photography that had been transferred from 16 mm film to 2-inch videotape and edited to a 30-second format. It cost about $700 to develop each psa. Film use rights of $200 to $600 were paid to the original photographers.

Copies of the 2-inch videotapes were duplicated and sent to each of the state's television stations with a request to copy the tape and return it to the DNR. If psa's are not dated by line numbers or references to year, they can be used in subsequent years, thereby reducing long-term publicity costs. Videotapes were distributed in December so they would be ready for use from December 26 through April 15. These tapes have been shared with other states.

Television news coverage has been another important and continuing source of publicity.

There are two good ways to obtain TV news coverage. First, call the news assignment desk or a news reporter known by the nongame staff whenever a special event or project activity is scheduled to take place. Special "media days" have been held to publicize major nongame projects: peregrine falcon and trumpeter swan releases, release of rehabilitated bald eagles, dedication of newly acquired wildlife lands, and loon protection efforts. News release packages should be provided to participating reporters to help insure that project details are accurately reported. A name and phone list for TV news reporters should be compiled.

Other television publicity has included interview programs and cable television features. Interview programs about public causes must usually be initiated by personal contacts at each station long in advance of the tax preparation season. Cable television stations are a relatively new and promising source of publicity. They can provide in-depth news coverage or utilize 3/4-inch videotape filmed and provided by the Department of Natural Resources (DNR).

Each major television station has a public service director who can help plan television psa's. Sometimes it is possible to develop economical ads utilizing 6 horizontal 35-mm slides and a 30-second script. The public service director will prepare the ad free of charge.

2. *Radio*

There have been 2 important types of radio publicity: 30-second public service ads and interview programs.

Five 30-second psa's were sent to all radio stations in the state. The psa's each featured a single wildlife species and its call. The psa's cost $250 each to produce and were also used as the sound tracks for corresponding TV ads. Each psa radio package consisted of a cover letter, a 1/4-inch cassette tape, a copy of the scripts, and a nongame poster. They were distributed in mid-December for use from December 26 through April 15. Larger stations do not use "canned" psa's, but their personnel will read the scripts live.

A letter was sent to all radio stations in mid-December telling about new projects in the nongame program. Stations were invited to conduct interviews with nongame staff persons over the telephone or in their studios. This letter alone has resulted in 30 to 50 radio interviews per year—some up to 40 minutes long.

Weekly programs on wildlife ecology and phenology are featured on two Minnesota stations. Local radio stations have also attended media days.

All radio personalities with whom programs are taped should be listed with their phone numbers for future reference. One way to schedule subsequent programs is to contact radio stations and schedule programs in towns where travel is necessary for DNR business. Call-in programs are generally avoided because of the potential for crank calls or questions not relevant to the Nongame Program.

An outline of key questions about the nongame program should be prepared and sent to a radio station interviewer along with other informational material prior to a live interview.

Finally, one way to improve the effectiveness of radio publicity is to review "arbitron" ratings so that major stations can be targeted for special publicity efforts.

3. *Newspapers, Magazines, and Newsletters*

Several techniques have been utilized to publicize the checkoff in newspapers, magazines, and newslettters: a post-Christmas news release package, a camera-ready public service ad, photo news releases with attached cutlines (scripts), and news release feature stories about winter bird feeding, building bird houses, and general program accomplishments.

The post-Christmas news release package contained six weekly news releases *with accompanying black and white glossy prints* for use each week through January, a camera-ready public service ad, a cover letter explaining all enclosures, and a nongame poster. News releases generally dealt with individual nongame species and how the Nongame Program was helping them. These were sent to all newspapers in Minnesota. Similar news release packages, excluding the glossy prints and camera-ready psa, were sent to all radio and television stations. The black-and-white glossy prints are a very important incentive for newspapers to print nongame articles.

The post-Christmas news release packages were also sent to state magazines and newsletter editors for Minnesota conservation, civic, and business organizations.

Two follow-up news release packages of five or six news releases and glossy prints each were also sent out in February and in March.

Small town newspapers will often print news release materials verbatim. Metropolitan newspapers and larger city newspapers with outdoor writers generally do not print these "canned" news releases but will write stories based on interviews, media days, and visits to project sites.

Again, I have established a list of newspaper reporters and photographers who have taken photos and done stories on the Nongame Program. Subsequent story ideas and news tips can frequently be initiated informally over the telephone with these reporters and photographers.

Excellent coverage in major newspapers has been derived from sponsoring media days. I have always arranged for a live, captive specimen of the featured species (e.g., peregrine falcon or bald eagle) to be present as a "backup bird" in case the wild birds did not cooperate for photographers.

4. *Posters*

Posters are a surprisingly important type of publicity in an era dominated by the electronic media. Each year a 17″×22″ wildlife poster has been printed to publicize the checkoff. Posters have featured a state map of nongame species, a loon photograph, a peregrine falcon photograph, and a winter bird painting. When photos were used, they were enlarged from 2 1/4″ color negatives, not from 35 mm slides. Slides usually lose too much detail in a large poster.

The posters have been distributed free of charge to tax preparers, libraries, banks, county courthouses, newspapers, radio stations, and to a mailing list of friends of the nongame program. The cost of production has ranged from 8¢ each for a 2-color poster to 14¢ to 20¢ apiece for 4-color posters. The number of posters produced in 1980 was 15,000. In four years the demand for the posters has quadrupled, and 60,000 were printed for the 1983 tax season at a cost of approximately $8,000.

Several lessons have been learned from the poster experience. The winter bird poster has by far been the most successful because it contains many familiar backyard species that citizens enjoy. The year has not been printed on posters so they do not become outdated. The greatest demand for posters exists if they are large (17″×22″) and unfolded, and if the printed message is on the border of the picture, which allows the poster to be framed.

The most efficient economic return from posters is derived by providing them in quantities to Minnesota tax preparers so they can be given to clients who make donations to the checkoff. To encourage this practice, a box is placed on the back of the poster where tax preparers can use a rubber stamp to place their name and address.

Folded posters are sent out individually free on request, but this type of distribution is not actively promoted because it is more expensive and time-consuming. Unfolded posters in mailing tubes are available for $2.00 to cover postage and handling costs.

5. Corporate Support

Free corporate support for publicity has been relatively easy to obtain because the checkoff is so popular as a noncontroversial public service cause.

Camera-ready public service ads have been printed on the side panels of half-gallon milk cartons by three dairies. The Clover Leaf Creamery alone has run these ads free of charge on over a half-million milk cartons annually. The ads were typeset by the DNR and sent to the dairies in November to allow adequate lead time before the tax preparation season.

Barzen International, Inc. is the largest birdseed packager in Minnesota and has provided a significant amount of publicity. They distributed nongame wildlife posters to all stores which handled their birdseed. Two-by-three inch gummed labels publicizing the checkoff were printed in rolls of one-thousand each by the Nongame Wildlife Program. Barzen's placed these labels on their birdseed bags during the 1982 checkoff season. They also paid for six prime-time radio ads on Minnesota's most popular radio station. In 1983, Barzen's cooperated to produce the winter bird poster. Barzen's commissioned wildlife artist Susan Southwick to do the winter bird painting, and the DNR paid for the printing costs of the poster.

Lindahl Oldsmobile in Minneapolis has a weekly advertising contract with WCCO-AM radio for 10 commercials each Saturday morning. The audience of this program exceeds 300,000 people. A 30-second public service ad is included with each commercial, and many of these are donated to the Nongame Wildlife Program.

H and R Block tax preparers have also been quite helpful. They have distributed publicity materials through their regional office to their local offices.

The Minnesota Zoological Garden has also sponsored Nongame Wildlife Program exhibits during the tax preparation season.

Techniques which have not been used include bumper stickers, buttons, billboard and bus advertising, and endorsements featuring celebrities or television personalities.

Summary

The Nongame Wildlife Checkoff is an outstanding opportunity to generate substantial funding to help wildlife. During the past three years, over $1,750,000 has been raised in Minnesota. The success of the checkoff hinges on the effectiveness of the publicity efforts. It is possible to conduct a checkoff campaign that is innovative, professional, and inexpensive. Additional benefits of the publicity are that it generates positive attitudes toward the DNR; it raises the level of public awareness about problems confronting wildlife, and it has identified techniques which are useful to natural resource managers for many information and education purposes. I can furnish more detail on Minnesota's publicity materials upon request.

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A Profile of Contributors to the West Virginia Nongame Wildlife Program

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Introduction

Only within the last 15 years have nongame wildlife programs emerged as separate entities within state wildlife resources agencies. The meaning of the term "nongame," although in use since at least the 1860s, has remained relatively unknown except in professional circles. Although nongovernmental conservation societies have been traditionally more involved with lobbying for nongame legislation and species-specific programs, wildlife professionals have consistently considered nongame species in management plans, mitigation procedures, educational programs and law enforcement. The single largest factor inhibiting the development of intensive nongame programs, either as separate programs or combined with game programs, has been funding. Sportsmen have been the logical recipients of most wildlife management efforts, and it has long been deemed unfair for them to assume total financial responsibility for nongame wildlife. In 1977, the Colorado Nongame Citizen's Advisory Council took a giant step toward solving the problem when they developed the Income Tax Check-Off System. Today, 44 states with nongame programs use a variety of methods to garner funds, with 31 states employing some variant of the income tax check-off.

Essentially, the income tax check-off system allows taxpayers receiving a refund to either check a box for a specified amount (similar to the Presidential Campaign donation) or write in any amount they wish to contribute to the program. Some states have mechanisms whereby those owing income tax can designate an additional amount to nongame wildlife programs or contribute directly to the resource agency. Amounts donated may be claimed as a charitable contribution the following year. This method has proven to be the best fund raiser—with the exception of Missouri's one-eighth of one percent of the State sales tax. In 1982, over $6 million was collected from income tax check-off programs in some 20 states.

West Virginia instituted an income tax check-off in April, 1981. In 1982, $164,428 was collected from 5.9 percent of the eligible taxpayers (those receiving a refund). Contributions were down by 21 percent for the second year with only 4.3 percent of the eligible taxpayers donating funds. Approximately $2,000 was collected through direct donations in both years.

Prompted by decreased revenues and number of contributors, the nongame staff felt data were needed to determine causal factors of this decline and to assist in the preparation of strategies for future promotional efforts. Many states have documented similar fluctuations and instituted survey studies. Most of these studies involve mail and/or phone surveys utilizing representative samples of the state population. In 1978, the Colorado Division of Wildlife included survey cards in 25,000 copies of their State magazine, but received a response rate of only 11 percent. Faced with a limited budget and the need for timely and accurate information, the West Virginia Nongame Program decided to pursue another tactic. The West Virginia State Tax Department agreed to supply information directly from the tax returns, within the bounds of disclosure laws. This approach was taken to gain cost effective and reliable information since the participation rate was 100 percent.

Several characteristics concerning the State of West Virginia influenced this decision: (1) the ease of access to and retrieval of data by the use of advanced computer technology, (2) the comparatively low population of the State—under two million individuals residing predominately in rural areas, and (3) the cooperation and willingness of the Tax Department to aid the Nongame Wildlife Program.

The purpose of this study was to provide profiles of those contributing and not contributing to the program and delineate geographical areas where promotional efforts may need to be concentrated.

Methods

The following data were obtained from the West Virginia State Tax Department:

1. A statewide and county list of number of contributors, total contributions, average contribution per contributor, average percent of refund directed to nongame fund, total refund, total number of returns, and average contribution per return for the 1981 and 1982 tax years;
2. A statewide list by age class (under 25, 25 to 50, over 50 years of age and age unknown) of the same seven items as above for both years.
3. A statewide list by gross income (24 classes, e.g., zero to $2,000) of the same seven items as above for both years.
4. A statewide list of zip codes with the number of contributions from each for both years.

Statistics were used from the 1982 tax year in item 2 due to the smaller number of contributors within the unknown age class, as compared to the 1981 data. In item 4, 1981 tax year figures were used as the same trends were observed in the 1982 data. Where five or less individuals appeared in any category within the data provided by the Tax Department, an asterisk appeared as a necessary measure to insure contributor confidentiality.

County average annual unemployment data for 1981 and 1982 were obtained from the West Virginia Department of Employment Security. County education statistics were taken from the 1980 Federal Census. Education data consisted of percentages of high school and college graduates in each county among citizens over 25 years of age. These data were examined to determine geographical distribution of nongame check-off revenues as well as factors which may affect these receipts, including unemployment, age, gross income, and education. To obtain a measure of geographical distribution of receipts, a participation rate was calculated for each county. Participation rate was defined as the percentage of the total county population that contributed through the check-off program.

Data Limitations

Some statistics concerning the characteristics of contributors to the tax check-off program were unavailable from the Tax Department either due to disclosure laws, the method by which information was recorded on the tax form, or the procedure used by the Tax Department in data processing. Because no separate box appeared delineating sex or marital status of the contributor, obtaining this information would violate confidentiality laws. Although a line appears on the form for individuals to write in their occupation, this information was not required and coding to collect these data would have been cumbersome. Statistics involving the date revenues that were received were not recorded by the Tax Department.

Results and Discussion

Nongame Contributions

Contributions to the West Virginia Nongame Fund through the tax check-off amounted to $164,428 for the program's first year (Tax Year 1981) and $129,986 for Tax Year 1982 (Table 1). Approximately $2,000 was received through direct contributions each year. Receipts declined 21 percent from 1981 to 1982. The proportion of taxpayers contributing also declined, but the average contribution increased. In 1981, one in every 17 taxpayers donated to the program, while in 1982, one in 23 contributed.

It is interesting to note that the average direct contribution greatly exceeded the average check-off contributions, by 39 percent in Tax Year 1981 and 44 percent in Tax Year 1982. Without a general population survey, data is unavailable as to whether direct contributors had no refund due them or simply wished to donate more than their refund. West Virginia does not as yet have a system whereby those owing taxes may donate an unlimited amount to the program through the use of the tax form. Promotional efforts could place more emphasis on contributing directly to the program. In addition, investigations are now underway to determine present and future financial involvement of West Virginia businesses and corporations.

Geographic Distribution of Receipts

Nongame contributions through the tax check-off were received from all 55 West Virginia counties and at least 12 other states. Participation rates reveal "trouble spots," areas of relatively low participation. Areas defined as "low" are at or below the median of 1.5 percent in 1981 and 1.0 percent in 1982. The shaded portions of Figure 1 represent the areas of low participation.

Table 1. Contribution information, West Virginia Nongame Wildlife Program, 1981 and 1982.

	Tax year 1981	Tax year 1982
State population	1,949,644	1,949,644
Total tax returns	644,392	648,268
Percent contributing	5.9	4.3
Total contributors	38,180	28,101
Check-off contributions	$164,428	$129,986
Average contribution from check-off	$4.30	$4.63
Average per return	$0.26	$0.20
Direct contributions	$2,009	$1,856
Total direct contributors	184	175
Average contribution from direct donations	$10.92	$10.60
Total contributions	$166,437	$131,842

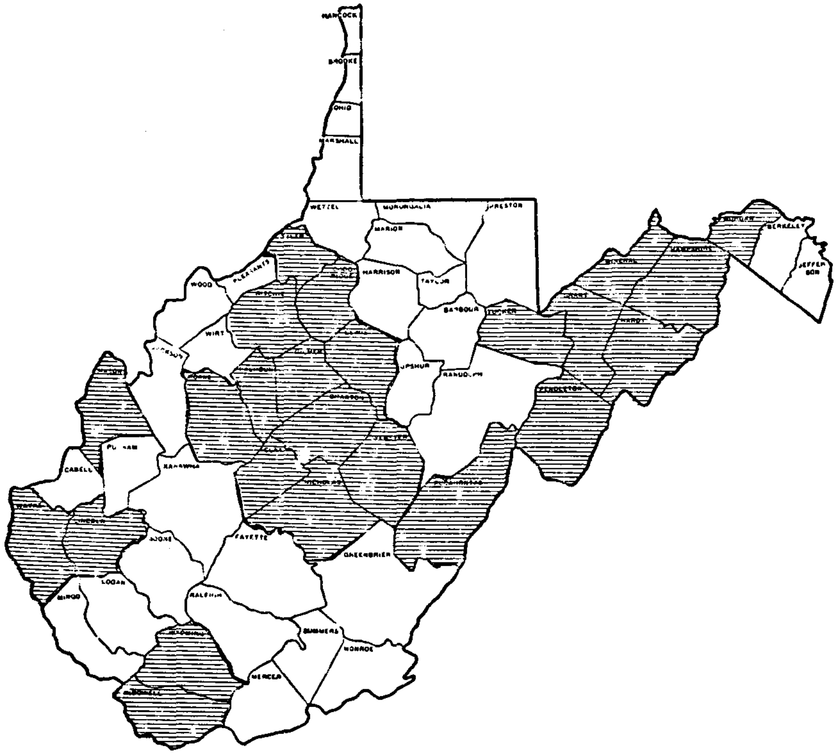

Figure 1. Shaded areas indicating low participation areas in the West Virginia Nongame Program, 1981 and 1982.

Unemployment Versus Contributions

West Virginia is experiencing one of the highest unemployment rates in the nation with an average of 8.5 percent in 1981 and 10.3 percent in 1982. Average annual unemployment rate was compared against the participation rate for each county (Table 2). A strong negative correlation between the two was noted ($r=-0.473$, $p<0.01$ in 1981; $r=-0.417$, $p<0.01$ in 1982). In counties with high unemployment, generally a smaller proportion of the population contributed to the nongame check-off.

A notable exception was the eastern panhandle counties in which unemployment and participation rate were both relatively low (Table 2). While participation rate was lower in these counties, the average contribution was larger that the State average. The other two regions of low contribution rates (central and southern counties) both had high unemployment, low participation and low average contributions.

The low receipts from the three "trouble spots" appear to be due to different factors. In the eastern counties, where participation as well as unemployment was low, we surmise

Table 2. Comparison of areas with relatively low participation in the West Virginia Nongame Check-off Program.

Area	Year	Total nongame contributions	No. of contributions	Average nongame contributions	State average contributions	Unemployment rate	State average unemployment rate
Eastern (7 counties)	1981	$ 3,718.46	809	$4.57	$4.16	7.7%	8.5%
	1982	2,901.53	612	4.70	4.62	9.2%	10.3%
Central (11 counties)	1981	6,657.49	1,642	4.05	4.16	11.3%	8.5%
	1982	5,396.19	1,231	4.38	4.62	13.5%	10.3%
Southern (6 counties)	1981	7,254.05	2,323	3.12	4.16	11.7%	8.5%
	1982	6,119.93	1,543	3.97	4.62	15.3%	10.3%
All other (21 counties)	1981	141,205.56	33,406	4.23	4.16	8.0%	8.5%
	1982	111,208.81	23,780	4.68	4.68	9.7%	10.3%

that a publicity problem exists. These counties are largely rural and agricultural (20.5 people per square mile versus the State average of 80.3). There are no daily newspapers published in these counties, only eight weekly newspapers, one radio station and no television stations. Residents of these counties rely on out-of-state television reception and publications. This may indicate a potential for greater revenues if the nongame program can be better publicized in this area. Specific promotional strategies would consist of contacting directly the weekly publications and out-of-state media.

The lower receipts of the central and southern counties when compared to the State average seem to be basically the result of the economic conditions. It is interesting to note that total nongame receipts declined from 1981 to 1982 in about the same proportion that unemployment increased (21.0 percent versus 21.2 percent, respectively). Thus, we are optimistic that as the economy improves, participation rate will also increase.

However, specific programs are currently being aimed at the central and southern areas. The Nongame Cooperative Projects Program, whereby conservation organizations may submit proposals requesting up to $500 for projects that benefit nongame wildlife, is being heavily publicized in these areas. Information and education efforts in the form of area specific lectures, literature distribution, and slide-tape programs in schools are now being conducted, particularly in the southern counties. As educational and informational literature developed specifically for the program and nongame wildlife becomes available, the central and southern areas will be targeted for distribution of these materials.

In addition, the first issue of the quarterly West Virginia Nongame Newsletter—available at no cost to those who request future issues—has received a wide and uniform distribution to all areas of the State.

Age Versus Contributions

The majority of nongame contributors came from the 25 to 50 year age class (Table 3). This was expected as this age class does not differ significantly from the age of the taxpaying population. It can be argued that the large number of "age unknown" contributors renders this analysis inconclusive. (The inclusion of birthdate is not a legal requirement on the tax form.)

Table 3. West Virginia nongame wildlife receipts by taxpayer age classes, 1982.

Taxpayer age	Total returns	Number of contributors (% of returns)	Total nongame contributions (% of total)	Average contribution
Under 25	101,193	4,735 (4.7)	$ 13,308.96 (10.2)	$3.72
25–50	273,576	17,151 (6.3)	82,589.81 (63.6)	4.74
Over 50	161,423	4,345 (2.7)	24,958.97 (19.2)	7.30
Unknown	111,475	1,855 (1.7)	9,039.63 (7.0)	4.00
Total	647,667	28,086 (4.3)	129,897.37 (100.0)	4.91

Table 4. West Virginia nongame wildlife check-off receipts by taypayer gross income classes, 1981.

Gross income (× 1000)	Total returns	Number of contributors (% of returns)	Total nongame contributions (% of total)	Average contribution
0–10	261,766	11,075 (4.2)	$ 31,712.71 (19.3)	$ 2.86
10–20	174,573	11,337 (6.5)	45,006.20 (27.4)	3.97
20–32	143,762	10,752 (7.5)	53,816.00 (32.7)	5.01
32–44	57,148	3,882 (6.8)	24,403.17 (14.8)	6.29
44–60	17,658	923 (5.2)	6,993.28 (4.3)	7.58
60–80	4,843	158 (3.3)	1,439.77 (0.9)	9.11
80–100	1,778	20 (1.1)	276.27 (0.2)	13.81
100+	2,864	33 (1.2)	780.90 (0.5)	23.66
Total	664,392	38,180 (5.7)	164,428.30 (100)	4.31

However, assuming an equal distribution of "age unknown" contributions among the three age classes, a few generalizations can be noted. The proportion of taxpayer contributions was highest in the 25 to 50 age class (6.3 percent contributed), but those over 50 had the highest average contribution ($7.30). Taxpayers under 25 years of age had a relatively high participation rate (4.7 percent), but the average contribution was low ($3.72).

It must be assumed that the low participation rate for persons over 50 is due to fewer returns with refunds. Recently, 80 bird feeders, seed and literature on bird identification, seed preferences and plantings for wildlife were distributed to nursing and convalescent centers throughout the State in an effort to promote and publicize the Nongame Wildlife Program within this group.

Gross Income Versus Contributions

Contributions were received from all income classes (Table 4). The greatest percentage of both contributors and dollar values were from the $20,000 to $32,000 class. This income class also had the highest proportion of contributors (7.5 percent of those receiving refunds contributed to nongame). In 1982, total receipts rose in the upper income classes (from $44,000 to $100,000) (Table 5). This would seem to indicate that this group was less affected by the economic situation.

Generally, taxpayers with over $80,000 in gross income were least likely to contribute, but the average contribution was higher. A relatively large proportion of taxpayers with a gross income of less than $10,000 gave part or all of their refund to the program.

Table 5. West Virginia nongame wildlife check-off receipts by taypayer gross income classes, 1982.

Gross income (× 1000)	Total returns	Number of contributors (% of returns)	Total nongame contributions (% of total)	Average contribution
0–10	244,374	7,970 (3.3)	$ 23,423.70 (18.0)	$ 2.92
10–20	165,549	7,699 (4.7)	31,032.39 (23.9)	4.07
20–32	141,955	7,596 (5.4)	40,399.19 (31.1)	5.21
32–44	65,021	3,535 (5.4)	23,240.48 (17.9)	6.66
44–60	21,191	1,071 (5.1)	8,762.79 (6.7)	8.25
60–80	5,204	163 (3.1)	1,523.68 (1.2)	9.80
80–100	1,954	43 (2.2)	1,397.95 (1.1)	37.80
100+	3,020	24 (0.8)	206.05 (0.1)	8.59
Total	648,268	28,101 (4.3)	$129,986.23 (100.0)	9.26

Size of Population Centers Versus Percent of Total Contributors

In order to determine whether contributors were primarily urban or rural dwellers, returns were analyzed by zip codes. Utilizing population data from the 1980 Federal Census and Tax Year 1981, 41 percent of the total contributors to the program resided in cities with a population exceeding 10,000, 23 percent from all other areas classified as urban by the Federal Census, while only 36 percent from areas listed as rural (Table 6). As West Virginia is primarily a rural state—67 percent of the total population lives in rural areas—the majority of contributors are from the more populated areas. Thus, two-thirds of the total population produced only one-third of the contributors.

This would tend to indicate a need to determine alternative methods for publicizing the program in rural areas. Possible solutions would be to send promotional literature and project information to county extension 4-H leaders and local conservation societies. Another tactic would be to have program information and/or booths at county fairs which receive wide attendance by individuals in rural areas.

Education Versus Contributions

The participation rate (proportion of the total population contributing) showed a strong positive correlation with the proportion of college graduates ($r=0.638$, $p<0.01$ in 1981; $r=0.709$, $p<0.01$ in 1982). The proportion of the high school graduates was also positively correlated, but not as strongly ($r=0.577$, $p<0.01$ in 1981; $r=0.643$, $p<0.01$ in 1982).

Table 6. Relationship of population to percent contributing to West Virginia Nongame Wildlife Program, 1981.

Population	Percent of state population	Percentage of nongame contributors
Rural	67	36
Urban<10,000	12	23
Urban>10,000	21	41
Total	100	100

Thus, where the greater proportion of a county's population is college educated, a larger proportion contributed to the nongame program. This is also true of high school graduates, although this relationship was not as well defined. Average contribution size, however, was generally not related to education level.

Essentially, the problem is one of education versus awareness. Currently the West Virginia Nongame Wildlife Program is publicized mainly through news releases, magazine articles, and promotional literature including posters, bumper stickers and inserts into the tax booklet. It is doubtful that this material reaches much of the State's population. In addition to increasing local radio and television spots, the strategies discussed in the former section would also apply here.

Application

This study has provided much useful information which will aid in strategy development for publicizing and promoting the West Virginia Nongame Wildlife Program. It is our intent to continue collecting data in subsequent years to determine trends or changes in contribution patterns.

While it may not be feasible for other states to conduct a study such as this (particularly if the technology is lacking) the cost (less than $500 for both years), statistical reliability, and ease of access to data will make it attractive to states with similar characteristics. More specifically, states with low and/or predominantly rural populations may find this study useful for planning promotional efforts. Finally, it would make an interesting study to compare contributor profiles among states.

Acknowledgements

The authors thank Dr. James Crum, James Rawson, Craig Stihler and Dr. Robert Leo Smith for reviewing the manuscript. We are especially grateful to Phil Walls of the West Virginia Department of Employment Security and Alan Mierke and Greg Taylor of the State Tax Department, who provided the data to make this study possible.

We also appreciate the assistance provided by Craig Stihler in data analysis, and Karen Eye and Audrey Pingley for typing several drafts of the manuscript.

Factors Related to Revenue Yield in State Tax Checkoffs

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Twenty states collected revenue for nongame and endangered species management through a checkoff on personal income tax forms in tax year 1982. Eleven more states have been added to that total to begin collections for tax year 1983 (*Outdoor News Bulletin*, 12/83). Since a general mechanism seems to have been adopted for providing funding for expanded nongame programs at the state level, it becomes important to determine why annual revenue yield can be as low as $57,000 (Alabama, 1982) or as high as $1,756,000 (New York, 1982). The purpose of the present study is to identify factors that are related to variation in revenue yield, to generate an empirical model that will provide checkoff states with an objective criterion for predicting revenue, and to obtain insight into those elements of a yield model that might be managed to increase total revenue.

Methods

The analytical format for this study was to use correlation and regression techniques to test hypotheses regarding relationships between the response variables and candidate independent variables. Each year in which a state collected checkoff income provided a case for the analysis. A total of 43 cases was available; complete data sets were obtained for almost all cases. The response variables were (1) the total revenue yield (in $1000's) in a state in a given tax year and, (2) the proportion of eligible taxpayers who contributed to the checkoff program, expressed as number of contributors over total personal income tax returns.

Independent variables fell into three categories. First were demographic or socio-economic characteristics of each state which were judged to be factors that might affect state-to-state variation in revenue yield. These variables are essentially outside the control of the state wildlife agency and are as follows:

1. The total number of personal income tax forms filed in the state during the tax year.
2. The number of personal income tax forms filed in which the taxpayer was eligible for a refund.
3. State population as of the 1980 census (U.S. Bureau of Census 1981).
4. State Area (*Statistical Abstract of the U.S. 1981*).
5. Per capita income of the state during the tax year (*Survey of Current Business 1983*).

Paper No. D-12381-13-84 of the Journal Series, New Jersey Agricultural Experiment Station, Cook College, Rutgers University, New Brunswick, N.J. This work was performed as a part of NJAES Project 12381 supported by the New Jersey Agricultural Experiment Station and McIntire-Stennis Act Funds.

6. The total budget of the state fish and wildlife agency during the tax year.
7. Proportion of a state's population, 16 years of age or older, who hunt or fish, as determined in the *1980 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.*
8. Proportion of a state's population, 16 years of age or older, who are active nonconsumptive wildlife users; again from the 1980 Fish and Wildlife Service survey. In this case, state data are unpublished, and were obtained from the raw data through the courtesy of W. Shaw.

A second category of independent variables was characteristics of the tax check off, per se, in each state. These variables are subject to some control by the management agency, especially prior to the inception of a checkoff program. They are as follows:

1. Number of years the checkoff had been in effect.
2. Whether the contributions were specifically for nongame and endangered species or for broader purposes.
3. Whether there was provision for contributions from taxpayers not receiving a refund.
4. Whether there were specific dollar amounts designated as contribution levels on the tax form.
5. The minimum dollar amount designated as a contribution on the tax form.
6. The maximum dollar amount designated as a contribution on the tax form.
7. Whether the tax form provided for contributing an amount other than designated amounts.
8. Whether there was a competing tax checkoff program during the tax year.

The third category of independent variables, all subject to control by the management agency, are variables related to the level and format of checkoff promotion by the state agency:

1. An estimate of the dollars (in $1000's) expended by the state agency in promoting the checkoff during the corresponding tax year and tax-filing period. Salaries were included only if additional personnel were hired to promote the checkoff.
2. A variable for proportion of promotional effort and a variable for actual dollar expenditure in each of the following promotional media:
   a. television
   b. radio
   c. newspapers
   d. printed matter (brochures, bumper stickers, posters, etc.)
   e. information for tax accountants
   f. information provided with tax forms
   g. personal presentations to groups

A majority of data was gathered by the senior author in telephone interviews of the person identified in each state wildlife agency as most knowledgeable of the checkoff program. In some cases, additional data needed to be gathered from a state's bureau of taxation. Some data were obtained from the published literature.

Data analysis was performed using the Statistical Analysis System. (SAS Institute Inc. 1982). A 0.05 threshold of significance was employed for statistical inferences.

We are indebted to the wildlife agency personnel in each state who provided the data used in this study.

Results

Revenue for all 43 cases of states that had checkoff income through the 1982 tax year totalled $13,864,000; averaged $322,000 per state per year; and varied from a minimum of $57,000 to a maximum of $1,756,000 for a given year.

An initial decision was made to delete New York and Indiana from the analysis. In the case of New York important data were very different from all other states. Checkoff revenue, promotional budget, and number of tax returns with refunds, for example, were two to three times greater than the next highest state. Using the New York data would have caused statistical problems resulting in a less useful model for all other states. In the case of Indiana, the biologist interviewed by the senior author indicated that a major confusion in their department of taxation resulted in an unknown number of intended contributions being returned to taxpayers. He had no way of knowing the magnitude of error generated, but suggested that Indiana would probably not be a valid case for consideration.

Simple correlation analysis of the 41 remaining cases (Table 1) suggested that checkoff revenue was related to variables that measure state taxpayer populations, affluence, and the relative size of a state. All coefficients were positive. In addition, significant correlations with several promotional measures suggested that revenue was enhanced by advertisements, especially if that advertisement occurred on radio or TV.

In regression analysis (Table 2), two types of sociodemographic variables were identified as important in explaining variation in checkoff revenue. One measured the relative number of people in the state and the second appeared to be a measure of the involvement of a state's citizens with the out-of-doors. The best variable in terms of fitting observed data to a regression equation was the number of refund tax forms filed, which is correlated with state population (r=0.69), total tax forms filed (r=0.70), and per capita income (r=0.51). The second variable was state area, which is correlated positively with percent hunters or fishermen in the population (r=0.46) and percent appreciative wildlife users

Table 1. Factors significantly (α=0.05) correlated with checkoff revenue.

Sociodemographic variables	r
Number of refund tax returns	0.51
Wildlife agency budget	0.41
Number of total tax returns	0.39
Per capita income	0.38
State area	0.32
Promotional variables	
Dollars spent on radio promotion	0.69
Proportion of promotional budget spent on radio	0.57
Dollars spent on TV promotion	0.49
Proportion of promotional budget spent on TV	0.41
Proportion of promotional budget spent on printed matter	−0.39
Overall promotional budget	0.38

Table 2. Summary of regression analysis; factors significantly related to checkoff revenue yield.

Variable	F ratio	Probability level
Number of refund tax returns filed	54.48	0.0001
State area	27.53	0.0001
Radio promotional budget	21.61	0.0001
Funds for nongame only	6.76	0.01
Competing tax checkoff	5.63	0.02

in the population (r=0.31). Significant regression models could be obtained using other combinations of these two factors, but the best two-variable model generated from the available 41 observations was obtained using the number of refund returns filed and state area.

One variable involving promotional effort added significantly to the predictive capacity of the regression model. The best fit was obtained using the amount of money spent on radio promotion, which was positively related to checkoff revenue. Radio budget was also related to the following promotional variables: overall promotional budget (r=0.51), proportion of budget spent on radio (r=0.83), TV budget (r=0.46) and proportion of budget spent on printed material (r=−0.34).

Two variables related to format of the tax checkoff added signficantly to the predictive value of a regression model. The first variable considered whether the revenue was specifically designated for nongame and endangered species, and the second whether there was a competing checkoff on the tax form. States designating money for nongame received additional revenue, and states with competing checkoffs received a lower amount of revenue.

The five-variable model that provides the best prediction of checkoff revenue accounted for 86 percent of variation in revenue, and is as follows:

$$Y = -217.6 + 0.24 X_1 + 2.56 X_2 + 23.7 X_3 + 83.0 X_4 - 96.4 X_5$$

where: Y = checkoff revenue ($1000)

X_1 = Number of refund tax returns filed (1000)

X_2 = State Area (1000 mi^2)

X_3 = Dollars spent in radio promotion ($1000)

X_4 = 1 if revenue is designated for nongame, 0 if it is not

X_5 = 1 if there is a competing checkoff, 0 if there is not

Applying this model to the two states that were deleted from the analysis showed a predicted value of $1,531,000 for New York, which is only 13 percent different from the observed value of $1,756,000: and a predicted value of $466,000 for Indiana, which is more than three times greater than the $133,000 that they received. The department of taxation error in that state apparently had a major effect on checkoff revenue.

An examination of residual values (difference between revenue predicted by this model and revenue actually collected) showed that several states with multiple years of checkoff revenue were consistently well above or below the level of revenue predicted by the model. Specifically, West Virginia received more revenue than predicted and Kansas and Minnesota received less revenue than predicted. Colorado was well below its predicted level during the first year of collection (1977) and well above the predicted level during 1980 and 1981. Further research into attributes of these specific states might prove helpful in developing a more complete understanding of factors related to checkoff revenue.

The proportion of all taxpayers who contributed to the wildlife checkoff averaged 4.7 percent for all states and varied from a minimum of 0.6 percent (Kentucky in 1981) to a maximum of 10.7 percent (Utah in 1980). Since this variable was highly correlated with checkoff revenue (r=0.56), the results of correlation and regression analysis are somewhat similar for these two response variables. Correlation results (Table 3) are presented to provide additional evidence of the positive relationship between checkoff participation and activity in wildlife-related recreation and checkoff promotion efforts of the state wildlife agency—especially in radio and TV.

Discussion

The findings of this study must be considered as preliminary, despite the inclusion of data from all states that have ever received revenue from tax checkoffs. The total number of cases in the analysis is small (41) and further studies, as more states begin to collect checkoff dollars, will certainly provide a more definitive understanding of the subject. Nonetheless, since tax checkoffs have become the most general method of expanding the funding base for nongame wildlife management at the state level, it is important to consider the experiences of existing checkoff states at this very early stage for any insight that may affect the future of these programs.

Based on this preliminary analysis of existing checkoff programs, the following conclusions are suggested:

1. Most variation in checkoff revenue appears to be related to factors that are outside the control of state wildlife agencies. The most important factor in predicting revenue was the number of refund tax returns filed in a state during a tax year. Thus, Pennsylvania received only $224,000 in its first checkoff year (compared to the average of $322,000 for all states) despite being second only to New York in having the highest number of taxpayers; since only 19 percent of Pennsylvania's taxpayers were eligible for a refund, compared to an average of 67 percent for all states.

Table 3. Factors significantly (α=0.05) correlated with participation (percent of total taxpayers making a contribution) in checkoff programs.

Sociodemographic variables	r
State area	0.56
Proportion of hunters or fisherman in population	0.54
Proportion of appreciative wildlife users in population	0.48
State population	−0.39
Promotional variables	
Proportion of promotional budget spent on radio	0.63
Dollars spent on radio advertising	0.49
Dollars spent on TV advertising	0.45
Proportion of promotional budget spent on printed matter	−0.37
Proportion of promotional budget spent on TV	0.35

It also appears that large states, with a relatively high proportion of citizens who actively participate in wildlife-related recreation, can expect above average checkoff revenues. This factor, too, is not likely to be affected by a wildlife agency in the short run, although expanded opportunities provided by checkoff-funded programs may increase participation in the long run.

2. Promotional efforts on behalf of the checkoff appear to increase both revenues and the proportion of taxpayers who make a contribution. Also, the data suggest that radio might be the most effective medium for advertising the checkoff, followed closely by TV. A literal interpretation of the corresponding coefficient in the regression model suggests that promotional dollars invested in radio are returned twenty-fold in checkoff revenue. It is interesting that Colorado's revenue increased steadily from $350,000 in 1977 to $741,000 in 1980 as their promotional budget increased, was highest during the 3 years that they spent most on advertising, and dropped by $140,000 in 1982 when their promotional budget was reduced from $25,000 to $10,000.
3. Competing tax checkoffs appear to reduce wildlife checkoff revenue. The regression coefficient suggests that a competing checkoff will reduce revenue by about $100,000. When Oregon's citizens were given the opportunity to contribute to the arts through a checkoff in 1981, wildlife revenue declined about $90,000 from the previous year when there was no competition, and declined even further in 1982. Through 1982, only 3 of the 20 checkoff states had other programs competing for checkoff dollars, but competition is on the horizon in other states. Arizona and Alabama have added checkoffs to combat child abuse for their 1983 tax year, and similar legislation is pending in South Carolina.
4. Finally, the specific designation of revenues for nongame and endangered species management may be more attractive to a taxpayer than a wildlife checkoff with a more general purpose. The regression coefficient indicates that the magnitude of this effect is on the order of $80,000. Overall, the 8 states in which checkoff dollars were not designated for nongame received an average of $165,000 per year, with 2.6 percent of taxpayers making a contribution. In the 33 remaining states (New York and Indiana excluded) checkoff revenue averaged $323,000, with 5.2 percent of taxpayers contributing. This must be regarded as the most tentative conclusion, however, since comparisons can only be made between states rather than within a state over several years, so that other unmeasured factors may confound the issue.

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The North Carolina Wildlife Endowment Fund: An Investment in the Future

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Introduction

From establishment of the Wildlife Resources Commission (WRC) in 1947 until 1980 the agency operated totally on receipts. License and permit fees, federal aid, and receipts from magazine and timber sales comprised the bulk of revenue used for operating costs.

With the successes of deer and wild turkey restoration projects, expanded trout stocking programs, introductions of striped bass and muskie into lakes and rivers, and the initiation of endangered species recovery projects, the cost of agency operations rapidly increased. Inflation became a significant factor during the 1970s as expenses, such as the cost of gasoline, increased by 500 percent. From 1970 through 1980 the state's general budget grew 217 percent, but the WRC's budget only increased 131 percent.

Realizing that the agency's ability to adequately fund programs and provide service had been shrinking to critical levels, a special nine-member Finance Study Committee was created by the General Assembly in 1979. The Committee developed a seven-point plan for broadening the funding base. The plan included the following:

1. Establish a system of annual reimbursement from the General Fund for the cost of outstanding statutory lifetime licenses. These reimbursements are to be used by the WRC in its hunting and fishing programs. Return the proceeds earned on all funds collected for wildlife resources to the WRC to support wildlife conservation programs.
2. Reimburse the WRC from the General Fund for the actual cost of activities unrelated to hunting and fishing but mandated by State and Federal government.
3. Establish an Endowment Fund and/or Foundation to support programs of the WRC; the principal of such Endowment and/or Foundation to be derived from but not limited to tax exempt contributions by persons and corporations interested in wildlife conservation, from lifetime licenses that may be authorized, and from lifetime subscriptions to *Wildlife In North Carolina*; the earnings of such endowment and foundation funds to be available to the WRC to support appropriate wildlife conservation programs.
4. Exempt the WRC from payment of state sales tax on expenditures and receipts.
5. Qualify the WRC for Law Enforcement Assistance Administration (LEAA) Funds and insure that the agency receives its fair share of such funds.
6. Establish a State waterfowl stamp.
7. Establish a Foundation to receive tax exempt contributions to fund the construction of a WRC building.

While not all of the points in the plan have been implemented, the Endowment Fund has.

The North Carolina Wildlife Endowment Fund

In January 1981, the Governor's Legislative Package included a bill to enact the North Carolina Wildlife Endowment Fund. All proceeds from the sale of six types of lifetime hunting and fishing licenses, a lifetime magazine subscription, as well as tax deductible gifts are placed in a special Fund handled by the State Treasurer, with only the interest earned by the Fund being available for use by the WRC. Interest earned from most state revenues, including regular sales of annual licenses accrue interest to the State General Fund. Thus, the Endowment Fund's features are unique in that the principal is protected and the interest earned through its investment by the State Treasurer is the only portion available for expenditure to support wildlife programs.

The WRC acts as the Board of Trustees for the Fund and must act in official session to request that available earnings be budgeted to agency accounts in accordance with the provisions of the Executive Budget Act. Income from the Fund will be used to supplement program costs and is not meant to replace any other types of funds derived by the agency.

Success of the Endowment Fund

As is the case with most new programs, communicating to the public the availability of this new concept has been slow. Even though the agency has a coordinated plan for increasing public awareness, there are still many people who do not know that they can purchase a lifetime license or make contributions. Table 1 lists the types and numbers of

Table 1. 1983 schedule of Wildlife Endowment Fund promotions.

Month	Type of publicity
January	Radio program; news release
February	Magazine feature article highlighting achievement of one million-dollar level
March	Distribution of brochures at six shows/exhibits
April	Distribution of brochures at four shows/exhibits
May	Brochure inserted in magazine
June	Four television programs
July	Three personal appearance programs featuring Endowment Fund slide program; two exhibits
August	Special news release encouraging purchase of lifetime hunting and fishing licenses; two television programs; two personal appearance programs featuring Endowment Fund slide show
September	One exhibit
October	Special display at State Fair; newspaper column; special magazine promotion on Christmas gift-giving
November	Magazine article highlighting memorial gifts
December	Television program featuring Christmas gift-giving
Each month	Magazine bind-in featuring information and order blank; magazine inside back cover featuring large full-color photograph and slogan; financial statement insert in magazine
Other	Endowment Fund information included in Regulations Digest, Wildlife Calendar, and public hearings' booklet

coordinated public contacts that are pursued annually. In addition to the structured program, our field employees, wildlife clubs, and individuals who hold lifetime licenses are helping promote the program. By June 1983 awareness of the lifetime license had grown to a point that daily sales through September 1983 averaged some 27 per day. Table 2 outlines the various categories of licenses available and provides a breakdown of sales and receipts. Interest earned by revenue source is included in each dollar amount shown.

From the Fund's creation in July 1981, it took about 17 months to reach the first million-dollar mark. The second million-dollar plateau was achieved in only 11 months. Governor Hunt has awarded a plaque to the individuals whose contributions helped the fund surpass each million-dollar plateau. Recently, a mother and father's gift of a lifetime subscription to our *Wildlife In North Carolina* magazine to their three-year-old daughter was honored by the Governor for helping the Fund attain the two million-dollar mark (Figure 1).

The Infant Sportsman Lifetime License category has been especially popular for parents and grandparents as a gift. By the time an infant reaches our license-buying age of 16 years, the value of the license will be about $417.68 based on an annual interest rate of 10 percent. The annual Sportsman's License currently costs $30, making the Adult Lifetime Sportsman License cost ten times the amount of the current annual fee. To date, the actual interest rate earned has averaged over 11 percent through the Treasurer's involvement.

Figure 1. A beautiful plaque was presented to the parents and their daughter recognizing the plateau of $2 million for the Wildlife Endowment Fund. The presentation was made by the Governor of North Carolina with the Commission's Executive Director and two Commissioners in attendance.

Table 2. A summary of the types of revenue and sources generated by the N. C. Wildlife Endowment Fund from July 1981 through December 1983.

License or revenue type	Cost of licenses/ subscriptions	Number sold	Dollar amounts[a]	Percent of fund
Adult Sportsman	$300	4,594	$1,552,093	81.4
Nonresident Sportsman	500[b]	87	43,567	2.3
Youth Sportsman	200	370	82,018	4.3
Infant Sportsman	100	1,114	123,185	6.5
Hunting License	150	68	11,586	0.5
Fishing License	150	267	43,240	2.3
Wildlife In North Carolina Magazine	100	198	21,991	1.1
Contributions	N/A	—	26,689	1.6

[a] Dollar amounts by source includes accrued interest.
[b] The Nonresident Sportsman category was added in July of 1983.

Lifetime Sportsman Licenses include all activities except trapping and special device fishing privileges. The basic lifetime hunting and fishing licenses do not include special privileges that big game, trout, or primitive weapons licenses offer.

An annual subscription to *Wildlife In North Carolina* is $5.00, thus the interest earned by the $100 lifetime subscription generates over twice the annual amount. Contributions to the Fund have largely been in the form of small donations, but there have been several donations in excess of $2,000. As word of this Fund has spread, a number of interested people have had codicils added to their wills, and many others have given memoriums in memory of friends and relatives.

Youth Involvement Program

With interest earned from the Endowment Fund, we are initiating a broad-based youth program. This program will include expanding youth opportunities in fishing and hunting and in nongame projects such as developing backyard projects and promoting development of urban wildlife areas.

Youth programs are a wise investment of these funds because they have the potential to greatly expand our constituency. Youth programs will provide more opportunities to involve adults in volunteer roles such as teaching bird identification, forest ecology, and firearms safety. Perhaps, most important of all, youth programs will begin the process of imprinting tomorrow's adults with better outdoor ethics and environmental awareness than today's adults.

Through Endowment Fund sponsored youth programs, we will enhance public involvement and understanding of our entire program. Increased awareness will lead to greater contributions to this Fund and to other programs such as our Income Tax Refund Check-Off Program, which is in its first year of implementation.

The North Carolina Wildlife Resources Foundation, Inc.

To enhance the Endowment Fund's contribution option, a Foundation was incorporated recently by a group of interested citizens. This non-membership foundation is working in cooperation with our agency in much the same way as a college foundation assists the universities in acquiring gifts, grants, and bequests. The two Commissioners who are the elected Chairman and Vice-Chairman automatically serve as members of the Foundation Board throughout their tenure as Commission officers. By providing Commission recognition on the Foundation Board, the agency and the Foundation will maintain a close working relationship. The Foundation has a paid executive officer charged with development of fund-raising projects designed to assist in the development of expanded program funding, with special emphasis on the Endowment Fund.

Conclusion

An Endowment Fund Program can be very useful to any wildlife agency. It can be especially useful in states where a nongame funding program like the Income Tax Check-Off is not possible because of no state income tax. By protecting the principal and using only earned interest, the Fund will have perpetual application. A lifetime license holder or contributor never "dies;" their principal is maintained in perpetuity. It is true that interest rates could drastically fall and earnings could decline but, frankly, who really believes that the days of 7 percent interest are just around the corner? The North Carolina Wildlife Endowment Fund will probably surpass the $3-million mark by September 1984 and can provide in excess of $300,000 in interest during the 1984–85 fiscal year in support of our wildlife programs.

By 1990 we expect the Endowment Fund to be in the range of $10–15 million and be providing about 7 percent of our funding needs. Most importantly, the very nature of this unique funding mechanism will help us broaden and strengthen our constituency.

Idaho's Modular Nongame Plan

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Introduction

There were several reasons why the Idaho Department of Fish and Game developed a nongame plan to supplement its primary planning document "The Policy Plan." We wanted to get the Idaho Fish and Game Commission committed to the Nongame Program. We needed a working document to provide direction and improve the operating efficiency of the Department statewide in the management of nongame wildlife. There was a need to clearly identify which wildlife species constituted "nongame wildlife" for everyone concerned. We wanted to display the management goals for nongame for other entities whose proposed or ongoing land management activities, projects, and programs may affect nongame wildlife and its habitat. Lastly, we wanted to increase public awareness concerning the current status of the nongame resource and solicit public support for a nongame program. With these goals in mind, the planning process was initiated.

Original Funding

The development of a nongame plan for Idaho, in a sense, began with the passage of Public law 96–366, the Fish and Wildlife Conservation Act of 1980. As with a lot of the states, we decided to try for legislation on a nongame check-off on the State Income Tax form. We wanted matching funds to be eligible for the Federal monies that would eventually become available under the 1980 Act. We have a population just short of a million, scattered over 53 million acres (21.5 million ha), and felt the check-off was the most feasible and economical way to obtain funding for the nongame program. In selling the proposed legislation, we found ourselves talking about wildlife species that previously had limited or no visibility either with the Department or the public. However,the citizenry responded through their legislative representatives, and a nongame check-off on the State Income Tax became law in 1981. It was estimated the check-off would yield $50,000 the first year; we actually grossed $106,000. There were 400,000 income tax returns filed, with about 6 percent participation in the nongame check-off. The Department of Revenue and Taxation took $16,200 off the top for administrative costs, but we had to accept this to get the legislation passed. We are still negotiating with the Department of Revenue and Taxation over the amount of the administrative fee.

Department Organizational Setup

Contributions from the first check-off were budgeted effective July 1, 1982, and the program was off and running. The Act directed the Idaho Fish and Game Commission "to establish a nongame management and protection program for which monies so set aside shall be spent." A State Nongame Manager was assigned to the Bureau of Wildlife, effective the same date, to coordinate the nongame program. Next, we needed an internal staffing structure to coordinate the nongame program throughout the state. We did not have sufficient funding to hire additional personnel so we used existing staff.

The Regional Conservation Educator in each of the Department's six regions was assigned the duties of a Regional Nongame Coordinator. It is his or her responsibility to keep the nongame program highly visible through media contact; coordinate with regional staff biologists on the implementation of nongame projects at the regional level; and work closely with the regional citizen nongame advisory committee on all nongame matters. The regional advisory committees are an integral part of the regional nongame programs. Each regional staff was charged with the responsibility of selecting six or more informed and interested citizens for appointment to the regional citizen nongame advisory committees. We cannot overemphasize the importance of these regional committees in the implementation of this state's nongame program. They provide expertise and counsel to the Department, add status to the program, and are a strong communication link with the public.

A statewide citizen advisory committee meets twice yearly to critique and review the status of the statewide nongame program. This committee is composed of one member from each of the six regional committees. With this organizational framework in place, we began the actual planning process.

Identification of Nongame

The very first order of business was to develop a complete listing of nongame wildlife found in the state. This was a very important step in the planning process. We wanted to identify clearly for all concerned which species are classed as nongame wildlife. There was even some confusion in the Department, let alone among the public, on this score. By definition, nongame wildlife includes all wild mammals, birds, reptiles and amphibians not classified as game animals, game birds or furbearing animals. Idaho law is silent on invertebrate species. Individual species were listed when practicable in order to familiarize the public with nongame. Nongame fish are addressed in the Department's Fisheries Management Plan 1981–85. It was the collective judgment of the Department that nongame fish would most generally be affected by game fish management programs. We did retain the option to fund specific nongame fish projects. We did list them with the other nongame species to complete the full complement of vertebrate nongame wildlife.

For Planning Purposes

The 280+ species ultimately identified were segregated into 10 groupings based on classification and definitions in the Idaho Code, taxonomical considerations, habitat similarity, and arbitrary decision. The groups included hooved mammals, carnivorous mammals, noncarnivorous mammals, reptiles, amphibians, raptors, water birds, passerine birds, miscellaneous birds (which arbitrarily includes the turkey vulture, woodpeckers, cuckoos, hummingbirds, swifts, and goatsuckers), and lastly a category classified as species of special concern. This group includes species that have restricted range, specific habitat requirements, and/or low numbers which may make them vulnerable to elimination from the state. The most difficult group on which to establish a complete listing were the passerines, which were arbitrarily limited to in-state breeders. In the case of noncarnivorous mammals, we did not attempt to list individual species of unprotected ground squirrels, bats, shrews, moles, rats, mice or pocket gophers. It was the first time in the history of the Department that we had listed the nongame species in a single document.

Data Base

Our next concern was to get a feel for the existing data and general knowledge available on nongame wildlife species in the state. This was no small undertaking as there were no central data sources or repositories of nongame information, it was everywhere. We concentrated mostly on the state's professional wildlife community. This included biologists with the Fish and Game Department, United States Forest Service, Bureau of Land Management, Bureau of Reclamation, United States Fish and Wildlife Service, private industry and the biology departments of the principal universities and colleges. Audubon members helped significantly in identifying nongame bird breeding populations and general distributions.

Plan Format

The statewide assessment of nongame resources provided the basic information to rough out a pre-draft plan. It was our intent to get the available information in plan form early on to provide a vehicle for public reaction.

The plan format was modeled, in part, after the Department's parent Policy Plan. This plan outlines the broad goals, objectives, and policies of the Department from 1975 to 1990. Under this plan, fish and wildlife are segregated into major programs, one of which is nongame. The nongame wildlife major program addresses broad policy guidelines, general goals and objectives, and problems and strategies for each species or species group. In the model nongame plan, we added an overview section and identified common problems and programs as viewed from the statewide perspective. It was at this juncture (January 1983) the Department signed a cooperative agreement with the United States Fish and Wildlife Service to develop a model nongame plan. Concurrent with the plan development, we were addressing another real concern—how to maintain public interest in the nongame program.

Public Involvement

In the interim, prior to the completion of a nongame plan, the Department wanted to expand public interest and involvement in the State's nongame program. We did not want to lose the momentum generated by public participation in the first year of contributing to the nongame fund via the State Income Tax check-off. This called for the immediate implementation of high visibility action programs. We were fast approaching the next check-off cycle and were facing a competing check-off, the Olympic Fund. It was decided to go with a choice of projects that we felt would be very visible and, where possible, involve species with restricted range, specific habitat requirements and/or low populations that needed attention.

Nineteen potential projects were identified during the initial round of public contacts when we were assembling the data base and identifying problems. The projects were discussed at statewide public meetings held in each of the six Department regions. Attendees were asked to comment on these projects and any others that may have been overlooked. The same proposals were also reviewed by the six regional citizen nongame advisory committees that had been previously appointed by the Director. It should be emphasized again that the citizen advisory committee concept has been invaluable throughout the entire planning process. The collective thrust of the public comments were incorporated into the action projects ultimately submitted to the Fish and Game Commission for its consideration and approval.

In January, 1983, the Commission selected nine projects to formally initiate the nongame program. The projects were chosen to dovetail into the goals and objectives of the plan and, at the same time, maintain a high degree of public interest. These projects included determining the distribution of the Idaho ground squirrel, indigenous only to Idaho and found only in parts of four counties; translocating the relatively rare shoshone sculpin into vacant habitats; investigating woodland caribou ecology; expanding ferruginous hawk nesting opportunity through the strategic placement of nest platforms; approving a bald eagle-osprey cross-fostering research project; developing an urban wildlife pamphlet tailored for Idaho; initiating a bluebird recovery program; establishing a statewide raptor rehabilitation program; and, finally, cooperating with The Nature Conservancy to establish an Idaho natural heritage program. This involves inventorying unique natural areas and nongame wildlife associated with such areas. All of these projects are in some phase of completion and continue to keep the program before the public eye. The process was repeated again in January 1984, with the addition of other projects.

The Plan

Meanwhile, back to the actual planning process. As previously indicated, we wanted public involvement early on in the development of the plan. Therefore, a pre-draft plan was distributed to our six citizen advisory committees and also our regional Fish and Game staffs for their review and critique. This exercise turned out to be most beneficial in disclosing missing, incomplete, or inaccurate data and identifying problems and recommending programs. It definitely enabled us to submit a much-improved draft nongame plan to the agencies and to the general public for their scrutiny and comment.

Over 350 copies of the draft plan were recently distributed, primarily to those individuals, organizations, universities and agencies that were previously contacted regarding nongame data. The plans were also made available for general public review utilizing the "open house" technique. Regional offices remained open throughout an entire day and into the evening hours.

Response to the Plan

We wanted to see how much interest we could actually generate using this approach. It was generally felt the Idaho public had been virtually burned out by the agencies continually submitting plans and other documents for their consideration. This concern was borne out by the level of participation. The attendance was light, to say the least; no more than three individuals showed up at any one open house.

Response from the agencies, organizations, and academic institutions is yet to be determined. We will be interested in any further gaps in the existing data base and reactions to the problems identified and the programs recommended. Particular emphasis will be placed on comments indicating trends regarding public concern. Hopefully, this will aid in the refinement of plan goals and objectives.

Summary

In summary, the Department has obvious reasons for developing a nongame plan. It was our intent to get the Commission committed; improve the operating efficiency of the Department; clearly identify nongame wildlife; display management goals for all interested entities; and increase public awareness regarding nongame.

A Nongame Income Tax Check-off was the most feasible means of funding a nongame program and was accomplished on our first attempt at check-off legislation in 1981. An internal organization structure was devised to implement the nongame program and facilitate the planning process. The appointment of interested citizens to regional nongame advisory committees has been a most successful program.

The state's professional wildlife community provided most of the data base on nongame wildlife. This data was translated into pre-draft plan form early on to encourage public participation. Public interest in the nongame program has been sustained during the planning period by initiating highly visible nongame action programs throughout the state. The draft nongame plan drew minimal interest from the public on "open house" review. The draft plan has been sent out to agencies, wildlife organizations, academic institutions, and private citizens. As of this writing, the rate of return of comments and critiques indicates we will have substantial reaction. Hopefully, any gaps in the plan will be revealed, and we should complete a good plan.

Comprehensive Wildlife Management: An Approach for Developing a Nongame Program in Connecticut

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Introduction

An encouraging and dramatic increase in state nongame wildlife programs has been noted in recent years. Johnson et al. (1982) indicated the percentage of wildlife agencies with nongame programs has increased from 67 percent to 91 percent between 1972–1982. The development of most of these programs was significantly assisted by the passage of the Endangered Species Act of 1973 and the Fish and Wildlife Conservation Act of 1980. Both acts either promised or provided substantial new revenues for the purpose of managing and protecting nongame wildlife. This dependence has not been without its problems, however, as many nongame programs based on Federal endangered species funds have been highly vulnerable to the political shifts associated with Federal appropriations, and most have been narrowly species-oriented. Perhaps relatedly, Johnson reported only 14 percent of state agencies devoted more than 3 percent of their budgets to the nongame area.

The fundamental contention of this paper is that adequately funded and sufficiently broad nongame efforts will be difficult to establish until the artificial and negative distinction between game and nongame species is replaced by an emphasis on comprehensive wildlife management. This alternative approach will be explored by identifying and describing 11 elements of a comprehensive wildlife management program that includes a balanced and equitable consideration of game and nongame wildlife.

This comprehensive wildlife management proposal was the collective conclusion of a citizens advisory committee established in Connecticut in 1982 to examine nongame wildlife program needs in this state. This 11-member committee consisted of a wide diversity of Connecticut residents with expertise in the wildlife field; most members were unaffiliated with special interest groups that could impede their ability to consider various management alternatives. Committee members included Dr. Roger Tory Peterson, the eminent artist and author; Dr. S. Dillon Ripley, Secretary of the Smithsonian Institution; Dr. Noble Proctor, one of the country's foremost field ornithologists; Roland Clement, past vice-president of the National Audubon Society; Albert Gilbert, President of the Society of Animal Artists and a past Duck Stamp award winner; Dan Lufkin, former Commissioner of Connecticut's Department of Environmental Protection; Professor James Slater, an entomologist at the University of Connecticut; Kent Olsen, Executive Director of the Connecticut chapter of The Nature Conservancy. The committee also included Paul Herig, the present Director of Connecticut's Wildlife Bureau; and Dennis DeCarli, Deputy Commissioner of Natural Resources in Connecticut's Department of Environmental Protection, and a previous director of the Wildlife Bureau. The committee has nearly completed its preliminary report, although no funding recommendations have yet been made. As chairman of the committee, I have written this report to summarize some of the committee's major conclusions.

As indicated, the committee concluded—as did Jackson (1982) and Bury et al. (1980)—that the term "nongame" is both negative and taxonomically without meaning. We decided, instead, to seek to identify a number of generically-related program aspects of wildlife management which encompass all wildlife, game and nongame included. This "comprehensive" approach to wildlife management focused on conserving and protecting all wildlife, as well as the habitats and ecosystems necessary to their maintenance and survival. This approach hopefully avoided the relegation of most nongame species (according to Bury et al. (1980), more than 85 percent of all nonfish vertebrate species) to a "non" category.

The committee additionally assumed that comprehensive wildlife management should seek to provide for the broadest spectrum of wildlife-related outdoor recreational opportunities; foster, through scientific data collection, an understanding of the biological and social aspects of wildlife; and, endeavor to promote public knowledge and awareness of wildlife and related ecosystems.

The entire public was deemed to be the potential beneficiary of comprehensive wildlife management. We assumed that any program of sufficient scope should strive to enhance opportunities for the appreciation, enjoyment and conservation of wildlife among all citizens. The committee proceeded with the conviction that in designing a comprehensive wildlife management program, it was necessary to address the broadest range of values people associate with wildlife—recreational, utilitarian, scientific, ecological, ethical, aesthetic, symbolic, educational, cultural, and historic. The maintenance and enhancement of these wildlife values was interpreted as the trust invested by the public in wildlife management agencies. For these reasons, the entire public was regarded as the appropriate constituency of wildlife management.

Goals of a Comprehensive Wildlife Management Program

Eleven elements of a comprehensive wildlife management program were identified, recognizing that many state agencies, including Connecticut's, have already established commendable and effective efforts in a variety of these areas. These eleven elements included: resource inventorying, habitat conservation, monitoring of environmental impacts, endangered and rare species protection, recreational management, conservation education, technical and private landowner assistance, urban wildlife, problem animal management, scientific research, and future planning and budget. The remainder of this paper will briefly describe these program areas.

1. Resource Inventorying

Wildlife species and habitat management should be based on an adequate knowledge of the natural resource base, including geological, soil, and wetland characteristics; as well as related information on the abundance, vulnerability, and population trends of key plant and animal species. This information might optimally be computerized and be accessible through a system of maps for spatially identifying this data.The utility of this information would be enhanced by integrating this data with the planning activities of various state agencies and private developers. The creation of this comprehensive biological inventory could have great scientific value, be used to help assess and mitigate adverse environmental impacts, and assist in developing land protection priorities.

2. *Habitat Conservation*

Sound wildlife conservation depends on the maintenance of adequate wildlands and aquatic systems to perpetuate biological diversity and healthy ecosystem functioning. The insidious pressures of an increasingly urban and technological society, and the associated trend toward greater land consumption for various development purposes, represent major threats to wildlife habitat today. An adequate habitat conservation program requires the identification of natural areas of importance to the conservation of valuable plant and animal species, particularly the rarer forms. These land areas should be described in terms of their biological uniqueness, habitat fragility, vulnerability to change, degree of imminent threat, and the practicality of their maintenance and protection.

The conservation of these natural areas will necessitate various strategies depending on funding, the extent of public and private ownership, landowners attitudes, as well as diverse biological factors. Conservation options can include land acquisition, easements, incentive programs, cooperative agreements, and the monitoring of uses and impacts. Conservation of wildlife habitat, thus, necessitates an adequate information base, cooperation among public and private parties, and adequate financial resources.

3. *Monitoring of Critical Activities*

Comprehensive wildlife management should include an effective monitoring program for assessing potentially damaging human impacts. This information could assist public and private developers in avoiding, minimizing, or mitigating potentially harmful activities on wildlife. Experience has repeatedly demonstrated the cost-effectiveness, and the likelihood of eliminating nonproductive and divisive conflict, of early recognition and avoidance of adverse environmental impacts.

An adequate monitoring program will require consideration of direct habitat impacts, as well as the indirect but damaging effects of external activities that disturb protected areas. Deterioration of ground and surface water, air quality, and the harmful affects of toxic waste products all represent potentially adverse indirect impacts.

Effective monitoring will also require coordinating efforts among diverse public agencies, the development of procedures to assess potentially adverse impacts, and methodologies for consultation with private developers. These review procedures can at times become onerous and result in unacceptable costs and delays. These administrative difficulties can hopefully be avoided by vigilance to the problem, awareness of the trend toward burdensome bureaucracy, and organizational efficiency.

4. *Rare, Threatened, and Endangered Species*

This wildlife management focus shifts our attention from particular habitats and ecosystems to the precarious and threatened status of specific wildlife species. In Connecticut, approximately 35 vertebrate species are currently regarded as seriously declining, and many more are rare despite stable populations. In addition, among the much larger group of invertebrate species, a number of rare and endangered species can be identified.

The management and protection of rare and endangered species should include efforts to assess potentially harmful impacts on important habitats such as wetlands, mature forests, barrier beaches, sand plains, and other biologically fragile areas. Additionally, an adequate computerized data base should be established on the status of threatened wildlife. This assessment could include information on present numbers, existing and historic ranges, current threats, and key population characteristics. To enhance public awareness and planning efforts, this information should be made readily available to concerned scientists, agency administrators, and private developers.

5. *Wildlife Recreation*

Wildlife agencies have historically devoted much of their resources toward providing recreational opportunities for sportsmen, and hunting and fishing activities should continue to be a major wildlife program objective. The number of citizens broadly interested in natural history and nonhuntable wildlife has grown substantially, however, and recent surveys suggest this group may now exceed the number of sportsmen (USDI 1982). Meeting this diversity of wildlife-related outdoor recreational demands represents a challenging but necessary objective of contemporary wildlife management.

These varied recreational interests can be partially addressed by managing diverse land types including wetlands, mature forests, fields, woodlands at various successional stages, tidal marshes, littoral environments, beaches, etc.. Relatedly, new lands will need to be acquired for wildlife recreation purposes, particularly if important habitats and desired species are presently inaccessible to large segments of the public. In meeting this challenge, it may be necessary to obtain a better understanding of the wildlife recreation interests of the state's citizenry. Information on the concerns and preferences of sportsmen, birders, naturalists, and other groups can assist in designing programs more effectively tailored to the particular needs and desires of these various "consumer" groups.

6. *Education*

Our long-term ability to maintain wildlife diversity and abundance will depend on the collective attitudes, values, and beliefs of the public. No degree of funding or professional expertise can substitute for the knowledge among the general citizenry that a rich and rewarding life is to a degree dependent on an aesthetically satisfying and ecologically sound natural environment.

People tend to be most appreciative of wildlife and the natural world when they have opportunities for direct contact with it; typically, in the context of enjoyable outdoor experiences. Wildlife education programs should promote direct contact with wildlife as a means of enhancing public appreciation and awareness. Relatedly, Aldo Leopold remarked (1968: 174), a generation ago, "to promote perception is the only truly creative part of recreational engineering . . . . Let no man jump to the conclusion that [the average person] must take a Ph.D. in ecology before he can 'see' his country . . . . The weeds in a city lot [can] convey the same lesson as the redwoods."

Wildlife education should stress the renewable character of wildlife and the potential, if managed wisely, to yield many, and continuing, practical and aesthetic benefits. The primary task of wildlife education should not be merely to instill an affection for animals so much as a sense of awe, respect, and appreciation for the role of species in relation to their natural communities. A sense of the beauty and the aesthetic qualities of animals will be less important to communicate than a knowledge of the immense complexity and intricacy of the ecological enterprise, and the importance of healthy ecosystem functioning as the basis for the survival of all creatures, humans included. Wildlife education should promote an understanding of animals, not justified on the basis of "being kind to animals," but from a conviction that the long-term well-being of wild animals is inextricably related to the eventual condition of human beings.

The elements of a wildlife education program will need to be varied. Important products could include high quality and widely distributed publications, teacher-training workshops, environmental education centers, school programs, and various demonstration efforts designed to reach diverse segments of the public. Mass media programming—including radio, television, and newspapers—should be implemented as a means of communicating with a larger fraction of society than is typically the case in most current wildlife programs.

7. *Technical and Private Landowner Assistance*

Technical assistance to private landowners can foster a greater realization of the wide diversity of social values derived from wildlife and the natural world. These programs should seek to promote a broad spectrum of land and resource benefits associated with wildlife such as watershed protection, outdoor recreation, ecological preservation, or even timber and other practical resource production. Private landowner assistance can include professional land management information, seeds and plantings to enrich wildlife habitat, the establishment of demonstration woodlots, and assistance for orphaned and injured wildlife. All of these efforts can enhance an appreciation among landowners of the diversity, aesthetic quality, and productivity of wildlife and the ecological environment.

8. *Urban Wildlife*

The management and conservation of wildlife in urban settings should be a logical component of any of the wildlife programs thus far described. Urban wildlife programs are so unusual for most states, however, that this area deserves special emphasis in the development of comprehensive wildlife management.

The existence of an ecologically healthy and recreationally enjoyable wildlife resource is a benefit of potential value for all citizens. Urban residents have the right and need to experience the pleasures and responsibilities of conserving wildlife and the natural environment. Wildlife education, recreation, and technical assistance programs should be provided for city residents in an accessible, adequate, and convenient fashion.

9. *Problem Animals*

Situations inevitably arise where particular wildlife species conflict with human needs and activities. These problems can often be eliminated or minimized by judicious adjustments of existing land use practices, including relatively minor modifications of agricultural and forestry methods. Circumstances will occur, however, where certain species inflict intolerable damage to crops, buildings, trees, and other objects of material importance to society. Professional assistance will be needed to minimize or eliminate these impacts, although such relief should be provided, whenever possible, in ways that are humane, cost-effective, and least environmentally harmful.

10. *Scientific Research*

Effective wildlife programs depend on accurate and efficient use of scientific data. Programs involving the utilization of wildlife, for example, should be based on an accurate knowledge of the population sizes and distribution of target species; programs for managing rare and threatened species should include sufficient data on habitat needs, breeding characteristics, and levels of risk; or adequate habitat conservation efforts should include a thorough knowledge of the biotic and abiotic resources of diverse natural areas. Additionally, the collection of needed scientific information should be possible in timely response to changing biological and socioeconomic circumstances.

The ability to generate this data will depend on an adequate technological capacity and qualified staff. A high level of scientific competence should help to enhance public confidence in wildlife management as a professional endeavor governed by standards of objectivity and impartiality.

11. Planning and Budget

The capacity to provide equitable wildlife management services in changing times is considerably enhanced by professional planning and budgetary allocation activities. The growing complexity of contemporary wildlife management, as well as the constraints of limited financial resources, emphasize the need to establish clear departmental priorities, and to plan for future developments. Additionally, a wildlife agency's ability to address the needs and demands of diverse constituencies suggests the importance of an adequate understanding of the concerns and characteristics of various wildlife clienteles. This information should foster a "multiple use" approach to wildlife management where the needs of various consumer groups become the direct product of agency activities. This planning function will require an accurate understanding of the complex interrelationship between the wildlife resource, the public, and the availability of management revenues.

The implementation of these recommendations will undoubtedly require many new and imaginative efforts, considerable interagency coordination, and the development of procedures for private and public consultation and review. Additional monetary resources will be a necessary accompaniment of any effort toward establishing this level of comprehensive wildlife management. The most desirable revenue sources appear to be either special excise taxes on wildlife-related equipment and supplies, limited increases in sales tax charges, or income tax checkoff programs.

The task of comprehensive wildlife management may seem formidable, perhaps utopian, and its practical realization, at best, a long-term prospect. The chances of achieving comprehensive management may be enhanced if we strive to convince society's leaders and decision makers that our interest is not just with wildlife but, more broadly, with the quality of human life. Wildlife is merely the tip of the environmental iceberg, representing but the most visible expression of a highly enjoyable or degraded and impoverished natural landscape. If we can maintain a healthy natural environment for wild animals, then we have preserved options essential to the maintenance of a rich and rewarding human life as well. An evolutionary opportunity in wildlife and resource management confronts our society, and the wisdom of its choice will reflect on our capacity to build a world characterized by natural beauty, diversity, and quality.

Acknowledgements

Many thanks to Roland Clement, and the State of Connecticut's Wildlife Bureau, for their excellent editorial assistance, as well as Carl Wagenar of the Connecticut Audubon Society for his invaluable staff assistance.

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Budgeting Wildlife Checkoff Funds: Twenty States' Priorities, Problems and Prospects

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State income tax checkoff programs constitute a unique innovation in collecting and earmarking revenues. State agencies receive funds from taxpayers, who donate to wildlife management a portion of their tax refund by checking a box on their state income tax form. Since the checkoff was introduced in Colorado in 1977, similar programs have been adopted in 32 states. Twenty states have now collected revenues for at least one tax year.[1] Seven of the remaining 19 states have no state income tax (U.S. Bureau of the Census 1982:290).

Checkoff funds have provided a boost for underfunded nongame programs, supported new management initiatives, increased public awareness of wildlife, and provided expanded employment opportunities for wildlife professionals. Consequently, some have viewed the checkoff as a panacea for solving difficulties in funding nongame management programs.

But fundraising is only part of the story. How have checkoff monies been spent? How are allocation decisions made? Records on income have been widely reported (Newhouse 1981, Nongame Wildlife Association of North America 1982, Wildlife Management Institute 1982, 1983), but little study has been made of patterns of budget outlays.

Analysis of state agency budgets for expenditure of wildlife checkoff funds—especially programmatic and project budgets—provides a rough indication of agency priorities among broad program categories and individual species. Experiences of the first states to use this funding mechanism are instructive in identifying problems and assessing prospects for the future of checkoffs. With this goal in mind, we surveyed the first 20 states to collect wildlife checkoff funds.

Methods

Budget data on wildlife checkoff programs were obtained through a brief, written questionnaire mailed to 20 state wildlife agencies in August 1982, and follow-up telephone interviews with each agency through February 1984. Our survey asked respondents to estimate the percentage of checkoff funds budgeted in each of seven broad program categories: threatened and endangered species, nongame species, game species, urban wildlife, public information and education, law enforcement, and a catch-all category labeled "other."

[1] These are shown in Table 1. Twelve states which have not yet collected revenues for a full tax year are: Arkansas, California, Delaware, Illinois, Maine, Massachusetts, Michigan, Montana, Nebraska, North Carolina, Ohio and Wisconsin.

Heavy reliance was placed on the perception and judgement of wildlife professionals to characterize checkoff budgets in terms of the categories provided. Examples of projects in each category were requested, and examination of them suggests agency personnel were reasonably consistent in categorization of projects, given the variability in status of particular species from state to state. The data describe both actual and planned expenditures, depending on the status of checkoff programs in each state at the time of the survey.

Results

Total funds collected in the years for which budgeting information was reported by 20 states are presented in Table 1. Because the previous year's budget often forms the basis for preparation of the following year's budget (Wildavsky 1979), we were particularly interested in budget priorities established during the *first* year of checkoff funding. Checkoff budgets were reported for the first year by seven states for the 1982 tax year (taxes actually collected in 1983), by seven states for 1981, and by one state for 1980, giving a total of 15 first-year states. Collections for the remaining five states are shown for the 1981 tax year. Due to variation in economic conditions and disposable income of contributors, funds collected for years shown are not comparable across all states. Budgeting data are comparable for all first-year states.

The range of total dollars collected was broad, from a high of $1,748,449 in New York (1982) to a low of $74,500 in Alabama (1982). While it is not evident in Table 1, we estimate total wildlife checkoff funds collected in 20 states for the 1982 tax year at about $6.4 million. With the addition of collections in 11 other states, total wildlife checkoff donations for the 1983 tax year will likely exceed $13 million, for 31 states (Nebraska will begin collections for the 1984 tax year).

The average contribution in 19 states (Louisiana not reported) was $5.39, with New Mexico receiving the highest at $10.68, and Minnesota the lowest at $3.23. Ranking states by average contribution and comparing them to a ranking of the same states by per capita personal income in 1981 (U.S. Bureau of the Census 1982:427), shows no significant correlation between average contribution and per capita income in checkoff states. People in less affluent checkoff states often donate more for wildlife than people in more affluent states, but not predictably so.

Contributors in 19 states represent on average 6.2 percent of taxpayers receiving refunds in these states. Contributions by refund recipients ranged from 13.9 percent in Utah to 1.3 percent in Kentucky. Such low participation rates suggest that there is much room for improvement in checkoff publicity and public education efforts.

Ten of twenty states placed more than 10 percent of their checkoff funds in a reserve fund for expenditure at year's end, or in a later fiscal year, some as required by state law. Nine were states in their first year of checkoff collections; five of these reserved more than 55 percent of funds collected, with one, Louisiana, reserving 100 percent of such funds. It is noteworthy that in four of five states for which a year other than the first year's budget was reported, less than 10 percent of funds collected were reserved. States with citizen advisory committees tend to reserve less of their annual collections than states without these committees.

Several states were unprepared for the influx of funding and did not begin planning expenditures until after funds were collected. For example, New Mexico established criteria for allocating its checkoff funds and secured approval of its Game Commission for a budget in August 1982, for funds collected in April 1982, under legislation enacted

Table 1. Wildlife income tax checkoff funds collected in 20 states.

State	Tax year	Year checkoff started	Total $[a] collected	Total $ budgeted	Reserve fund (%)	Average contribution[b] ($)	% of refund recipients participating	Citizen advisory committee? (yes or no)
Alabama	1982	1982	74,500	74,500	0	3.44	2.4	Yes
Arizona	1982	1982	300,156	130,000	56.7	9.95	5.0	No
Colorado	1981	1977	720,972	720,972	0	5.36	11.9	Yes
Idaho	1981	1981	106,245	98,200	7.6	4.43	9.0	Yes
Indiana	1982	1982	133,490	57,500	56.9	3.79	2,4	No
Iowa	1982	1982	238,643	238,643	0	5.28	7.0	No
Kansas	1981	1980	137,474	110,000	20.0	6.00	3.5	Yes
Kentucky	1980	1980	84,988	31,446	63.0	7.20	1.3	NA
Louisiana	1981	1981	300,000	0	100.0	NA	NA	No
Minnesota	1981	1980	532,994	480,761	9.8	3.23	13.3	No
New Jersey	1981	1981	410,000	350,000	14.6	4.11	4.8	Yes
New Mexico	1981	1981	265,600	226,557	14.7	10.68	4.6	No
New York	1982	1982	1,748,449	800,000	54.2	5.58	6.1	No
Oklahoma	1982	1982	204,515	80,000	60.9	6.34	4.2	No
Oregon	1981	1979	272,152	272,152	0	4.13	8.1	Yes
Pennsylvania	1982	1982	211,660	232,591[c]	0	4.16	5.5	No
South Carolina	1981	1981	100,217	85,000	15.2	4.10	2.5	No
Utah	1981	1980	208,000	208,000	0	4.27	13.9	Yes
Virginia	1981	1981	369,793	341,250	7.7	5.95	3.7	NA
West Virginia	1981	1981	164,649	150,000	8.9	4.41	7.8	Yes

[a] From: Harpmann (1984), except Louisiana and Indiana, from telephone contacts with state agency personnel. Indiana figure does not include donations returned to contributors by mistake.
[b] Information for Kansas, Kentucky, Oregon, South Carolina, and Virginia from Nongame Wildlife Association of North America (1982).
[c] Includes $8,000 interest plus $12,931 in non-refund donations.
NA = Not Available

in April 1981 (New Mexico Department of Game and Fish 1982). Louisiana, which collected about $300,000 in both 1981 and 1982, expects to have a total of $1 million by July 1984, when it plans to begin spending these funds ($158,660) on equipment and four staff members—including the first nongame professionals hired by that agency. Their first task will be to develop a program and budget for checkoff funds. Such delay is unnecessary and may lead to public criticism of the agency. To avoid this, states developing new programs should list and prioritize desired projects well before funds are available, using public input to do so.

Eight of the twenty states have established citizen advisory committees to obtain input on preferences for allocation of checkoff funds, while reserving budgetary decisions to the agency or a state commission. Participation on these committees by representatives of local conservation groups and wildlife professionals in state universities has reportedly been of assistance in identifying both nongame research and management projects, and in providing high visibility and support for checkoff programs.

This has led to somewhat more open decision making in these agencies, and has made life for wildlife professionals more like living in a "goldfish bowl," requiring some adaptation of professional attitudes and behavior. Agency personnel in several other states expressed deep reservations about establishing such committees, probably because they are unfamiliar: few wildlife professionals have been trained in the requisite skills to deal with them effectively.

Public involvement in checkoff program development and budget preparation provides wildlife agencies with a valuable public relations tool. Citizens often contribute useful information, listen and learn as they participate, and tend to be more supportive of decisions made with their input (Erickson 1980). Recognition that the nonconsumptive wildlife user has tremendous undeveloped potential as a constituent who will support agency programs, and use of citizen committees to cultivate that potential, is still in its infancy in most states. The financial success of checkoffs provides a "quantitative" indication of this potential.

Priorities: Program Categories

There is substantial variation from state to state in the percentages of checkoff funds allocated between broad program categories, shown in Table 2. Average percentages for 19 states obscure these variations, but show that checkoff money has been allocated in the aggregate as follows: threatened and endangered species, 19.5 percent; other nongame species, 27.8 percent; game species, 2.1 percent; urban wildlife habitat, 4.0 percent; public information and education, 17.4 percent; law enforcement, 2.0 percent; other (primarily habitat acquisition), 27.2 percent.

Funds budgeted for game species and law enforcement were considered supplemental funding for traditional fish and game agency programs, and all other categories were aggregated and considered to be funding for new or expanded nongame management programs. We found that 95.9 percent of checkoff funds were budgeted for nongame programs. Only three states budgeted checkoff funds for law enforcement—which may include enforcement of endangered species laws. While some states are legally bound to spend checkoff funds only on nongame programs, this is not so in all states. Nonetheless, it is apparent most wildlife checkoff funds are being budgeted for nonconsumptive and nontraditional wildlife programs.

Examples of projects which fit into these broad program categories but which do not

Table 2. Wildlife checkoff funds budgeted by twenty states, 1981 or 1982.

State	Tax year	Year checkoff started	Program category estimates (%)							
			Endangered species	Nongame species	Game species	Urban wildlife	Public information	Law enforcement	Other	Total nongame[a]
Alabama	1982	1982	0	70	0	10	20	0	0	100
Arizona	1982	1982	20	30	0	0	0	0	50	100
Colorado	1981	1977	50	30	0	10	10	0	0	100
Idaho	1981	1981	14.8	67.7	0	0.5	0.5	0	16.5	100
Indiana	1982	1982	40	50	0	0	10	0	0	100
Iowa	1982	1982	7.5	40	0	15	7.5	0	30	100
Kansas	1981	1980	5	31	10	8	20	6	20	84
Kentucky	1980	1980	5	10	0	0	2	20	63	80
Louisiana	1981	1981	0	0	0	0	0	0	0	0
Minnesota	1981	1980	21.3	16.5	9	10	13.9	0	29.3	91
New Jersey	1981	1981	30	30	0	5	30	5	0	95
New Mexico	1981	1981	22.1	7.8	20.6	0	0.7	1.4	47.4	78
New York	1982	1982	17	2	0	2	20	5	54	95
Oklahoma	1982	1982	12.5	13.8	0	0	15	0	58.7	100
Oregon	1981	1979	24.7	24.7	0	0	0	0	50.6	100
Pennsylvania	1982	1982	10.8	6.2	0	0	38	1.5	43.5	98.5
South Carolina	1981	1981	30	35	0	5	10	0	20	100
Utah	1981	1980	30	45	0	10	15	0	0	100
Virginia	1981	1981	18.9	8.8	0	0	68.1	0	4.2	100
West Virginia	1981	1981	10	10	0	0	50	0	30	100
19-state average			19.5	27.8	2.1	4.0	17.4	2.0	27.2	95.9

[a] Total nongame = sum of percentages for endangered species, nongame species, urban wildlife, public information, and other.

have a species-specific focus are: development of urban wildlife areas; promotion of landscaping beneficial to urban wildlife through distribution of plant seeds, shrubs and instructional brochures; placement of plantings and birdfeeders at retirement homes; and support for Project WILD environmental education projects.

Priorities: Species

Projects listed by survey respondents as examples for each category of budgeted checkoff funds were assumed to be the highest priority projects. Lists of species-specific projects were separated from species-group projects. Examples of species-specific projects include nesting studies and lead-poisoning research on bald eagles, acquisition of heronries, and placement of nesting boxes for bluebirds. Species-group projects include raptor rehabilitation programs, publications on reptiles and amphibians, and shorebird surveys.

Checkoff funds were budgeted for 68 priority species in 19 states. Species listed as the subject of funded projects three or more times are listed in rank order with frequencies as follows: bald eagle, 12; peregrine falcon, 8; osprey, 6; river otter, 5; barn owl, bobcat, Indiana bat, and gray bat, 3 each. In terms of public preferences for wildlife, as described by Kellert and Berry (1980:34), state wildlife agencies budget checkoff funds for species which are preferred by citizens, like eagles and owls, and also for those people dislike, such as bats.

When examples of funded projects were aggregated by class of species, they accounted for the following percentages of total projects funded: birds, 55 percent; mammals, 23 percent; reptiles and amphibians, 11 percent; fish, 9 percent; plants, 2 percent; insects and mollusks, each less than 1 percent. In order to compare these findings with Kellert and Berry's (1980:36) ranking of classes of wildlife preferred by the American public, we combined fish, reptiles and amphibians into one category, and omitted plants, as they did; we considered insects and mollusks together as approximating their category of invertebrates. Comparing these results, and assuming percentage of projects per class is an indicator of priority, we found state wildlife agencies budget checkoff funds for classes of species in the same order of priority as the general public ranks them.

This is fortuitous, rather than a matter of design. Few state wildlife agencies have surveyed public attitudes to develop management-relevant information on uses of wildlife by state residents, preferences among funding alternatives, or approval of agency programs. Probably it reflects congruence between the underlying preferences of wildlife professionals and those of the public at large.

Fifty-five percent of the projects funded in 19 states were directed toward endangered or threatened species, which received 19.5 percent of checkoff funds. Urban wildlife programs received only 4.0 percent of checkoff funds, although 10 states allocated funds for this category.

Raptors received the most management attention of any species-group, with 30 percent of all projects. Eleven of the 68 species identified (16 percent) were raptors. By comparison, the species-group receiving the next most attention is comprised of 3 species of bats, with about 6 percent of all projects.

What is Nongame?

Responses of wildlife professionals to the broad, familiar categories of program activities used in this survey revealed considerable conceptual confusion over distinctions between nongame species, urban wildlife, endangered species and game species. Part of this confusion may stem from the diversity of legal definitions attached to the term "nongame" in several state and federal statutes.

In New Mexico, nongame species include all species "that are not legally hunted, trapped, or fished, regardless of whether or not state law defines the particular species as game. Endangered species are a subset under nongame, but endangered species may include those defined by state law as game" (letter dated 13 Sept. 1982 from N. Ames, New Mexico Game and Fish Dept., Santa Fe). Thus, checkoff funds may be spent on desert bighorn, a game species that is endangered in New Mexico, until it reaches huntable population strength and is therefore no longer endangered. Under Kansas law, however, species legally classified as game species, furbearers, threatened species or endangered species are *not* considered nongame species (Schwilling 1981).

Some states, such as Alabama, limit nongame species to vertebrate wildlife not commonly pursued, killed or consumed for sport or profit. But Minnesota includes crustaceans, mollusks, butterflies and all designated endangered and threatened species (except the timber wolf) in its definition of nongame species (Minnesota Division of Fish and Wildlife 1983:2). Pennsylvania also provides nongame checkoff funding for management projects concerning endangered plants.

The U.S. Congress further complicated matters when it enacted the Fish and Wildlife Conservation Act of 1980 with a definition of nongame fish and wildlife which includes:

> all unconfined, wild vertebrates which are not ordinarily taken for sport, fur, food, or commerce, are not listed as endangered or threatened under the Endangered Species Act of 1973, are not marine mammals under the Marine Mammal Protection Act of 1972, and are not domesticated species reverted to feral existence. (U.S. Fish and Wildlife Service 1983).

At a minimum this definition excludes endangered and threatened species, marine mammals, all invertebrates, all feral horses, burros and parakeets, and all confined wild vertebrates found in wildlife rehabilitation programs currently supported by states through nongame checkoff funds.

If the national government is to provide some sort of permanent funding mechanism for state nongame programs in future years, greater conceptual clarity concerning what constitutes nongame species will be necessary to avoid friction in state-federal relations over how this funding is to be spent.

Another source of conceptual fuzziness is inherent in the nature of the word "nongame," which conjures up a distinctive image or impression for the listener of *nothing*. At this conference two years ago, Jackson (1982) pointed out the problems with such a non-descriptive term. There is apparently no generally accepted definition for nongame. State checkoffs do not define nongame in any uniform fashion.

This is not just a matter of semantics, and is of more than academic interest if one contemplates the possibility that some wildlife species for which management is needed may be considered ineligible for checkoff funds because of this confusion. For example, under current state laws, endangered invertebrates would be ineligible for nongame management in Kansas, Alabama and perhaps other states, while species with lesser management needs would be eligible.

Problems and Prospects

Some of the greatest difficulties encountered by wildlife agencies developing checkoff programs stem from the pluralistic nature of American politics. Competition between many groups with diverse goals often focuses on state legislatures, where wildlife checkoff programs continue to be entangled in political struggles after they are enacted.

Checkoff Proliferation

It is ironic that the most serious threat to wildlife checkoff programs is their tremendous success. Their ability to raise money without raising taxes has caught the imagination of other interest groups, who would like to establish similar checkoffs. Some which have already been added to state tax forms are checkoffs for the U.S. Olympic Committee (Colorado and Idaho), for domestic abuse programs (Colorado), and for drug abuse programs (Idaho). A proposed political party checkoff in Indiana was killed in committee in 1982.

Competing checkoffs appear to reduce donations to wildlife checkoffs. Checkoff revenues for 1982 declined in four out of five states with competing checkoffs, but also in four other states which have no competing checkoffs (Harpmann 1984). This seems unusual, because checkoff income in previous years has tended to increase from year to year. Perhaps the initial popularity of wildlife checkoffs is eroding in the face of hard economic times. Checkoff proliferation may be expected to reduce donations proportional to the number of checkoffs on the form.

Language in the Pennsylvania nongame checkoff statute prohibits the placement of additional checkoffs on state tax forms. However, a legislature can easily amend such a prohibition by authorizing another checkoff in subsequent legislation.

Legislative proposals for non-wildlife checkoffs are likely to increase in coming years. No doubt some will be enacted, and more proposals will be made. Eventually state legislatures will decide tax forms are too long and cluttered with too many checkoffs. Yet they will likely prove unwilling or unable to say no to one without saying no to all, for purely political reasons. At this point, a legislature will probably abolish all income tax checkoffs. Such a move is already under consideration by some legislators in Colorado (Colorado Chapter of the Wildlife Society 1983), which now has three checkoff programs.

There is no assurance replacement revenues will be provided from other sources. Declining revenues and the possibility that wildlife checkoffs might be abolished lend a sense of urgency to the study of permanent nongame funding alternatives.

Raids on Checkoff Funds

On occasion, other state agencies and their constituents have attempted to convince legislators to allocate wildlife checkoff funds for another agency's use. In 1981, the Colorado Parks and Recreation Department promoted a bill to split nongame checkoff revenue equally between wildlife and parks programs (High Country News 1981). Although the bill was killed in committee, it was enough to make wildlife managers nervous over the security of checkoff funds.

Reduced General Funding

In some states, nongame programs were established and financed at a minimal level with general fund appropriations before checkoffs were adopted. After checkoffs began producing revenue, however, attempts were made to reduce general fund appropriations—in spite of language in the checkoff statute to the effect that checkoff revenue was not intended to replace general fund revenue. This has occurred in Colorado, and may yet in other states.

Public Support

Opening the checkoff treasure box has also opened a Pandora's box of public relations problems. Checkoff states are finding they must *earn* voluntary contributions by paying increased attention to donors.

Accommodating public preferences for fund allocation, while remaining within the bounds of sound biological science, is a major challenge of checkoff programs. Legally, one must usually pay a license fee before engaging in hunting, trapping, or fishing, but nonconsumptive uses of wildlife require payment of no such fee: checkoff contributions are voluntary and may be withheld by the dissatisfied contributor, unlike the unlucky fisherman. Pleasing the public is fundamental to a checkoff's continued success.

Funding a few high-visibility projects for wildlife which are preferred by the public may be a useful strategy in maintaining checkoff contributions. These projects must also have a sound basis in biological research and management practice, as in the case of river otter reintroduction in Colorado and peregrine falcon restoration in eight states.

Wildlife public relations have previously had to contend with explaining wildlife programs while others collected revenues. But checkoffs require a much heightened level of publicity if contributions are to be maintained. Minnesota provides an outstanding example of checkoff public relations, devoting considerable time and effort to public education, which is a major part of fundraising.

Traditional wildlife public relations and management skills are quite different from those required for successful fundraising, which are more akin to skills required for membership drives and product marketing. Agencies which do not employ persons with this expertise would do well to acquire it in two ways. First, they might seek the advice of organizations which rely on these skills to sustain their own activities, such as state conservation groups. Second, they might secure additional training for public information specialists in fundraising skills, in cooperation with local civic groups, charitable organizations or universities.

Conclusion

As with most research, hindsight reveals ways in which it might have been better done and areas where further research is needed. It remains for further research to ascertain whether categorization of budgets by wildlife professionals is consistent with categorization done by an independent budget analyst.

In 1984, 11 more states will complete their first year of checkoff program development. Have they benefited from experiences of the 20 states in this study? Accumulation of comparable data on the first year of state checkoff program experience in those states will help to answer this question.

Checkoff programs are so new there is as yet inadequate data to plot changes in budget priorities over several years, so time-series data have not been considered systematically. Verification is needed on the impact of checkoff proliferation within single states on wildlife checkoff contributions.

Responsiveness to public preferences, and the ability to educate those preferences, will become increasingly important as the novelty of the wildlife checkoff begins to wear off. Development of a capacity to ascertain wildlife preferences of state residents, to evaluate the effectiveness of publicity in reaching potential contributors, and to gauge public approval of checkoff programs would be helpful in sustaining checkoff contributions.

Some national data is available concerning public attitudes toward wildlife (Kellert and Berry 1980, U.S. Fish and Wildlife Service and U.S. Bureau of the Census 1982), but it is not disaggregated to the state level, and is not useful in evaluating specific state agency programs.

State agencies can secure this expertise on a contract basis and can learn how to incorporate its insights into program planning. Information obtained will prove useful to that portion of wildlife management which involves people management. For example, a demographic profile of contributors in a state would be useful in identifying the primary and secondary audiences for checkoff publicity, thereby helping to refine and make fundraising efforts more effective.

Finally, the search for relatively stable, long-term funding for state nongame programs must continue in earnest. An extensive list of funding alternatives, ranging from commodity taxes and mineral severance taxes to off-road vehicle registration fees was discussed at this conference a year ago by Whitehead (1983). Also, Minnesota utilizes a property tax checkoff in addition to its income tax checkoff.

The U.S. Fish and Wildlife Service is currently studying 18 potential revenue sources for federal funding of state nongame programs, with recommendations to be submitted to Congress by the end of 1984 (U.S. Fish and Wildlife Service 1983). Commodity taxes on birdseed, bird feeders, camping equipment, binoculars, field guides, recreational diving equipment, photographic equipment and film seem the most promising of alternatives under consideration.

Fortunately, most of the alternatives currently being studied by the U.S. Fish and Wildlife Service are also available to individual states, who have a proven record of innovation and independent initiative in funding nongame programs. Hopefully they will not be lulled to complacency by the temporal success of checkoff programs, but will look realistically at diversified long-term funding for state wildlife programs.

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The Status of Urban Wildlife Programs

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Introduction

In April 1982, Dale A. Jones, President, The Wildlife Society (TWS), charged his Urban Wildlife Committee[1] with (1) preparing a policy statement concerning urban wildlife and urban wildlife management responsibilities and opportunities, and (2) evaluating the extent to which major state and federal conservation agencies are meeting urban wildlife management needs in their respective spheres of responsibility. The latter charge included determining trends in emphasis, the use of new funding sources, and information on relevant research. Committee member Larry VanDruff took the lead role in developing The Wildlife Society's (TWS) position statement on Urban Wildlife. It was adopted by TWS Council on 11 October 1983 and published in *The Wildlifer*, Issue No. 210 for November-December 1983. On behalf of the entire Committee, we are pleased to present and share with you our findings from the second Committee project concerning the present status of state, federal, and provincial agency urban wildlife programs.

Traditionally, state and federal fish and wildlife programs have been largely concerned with fish and wildlife resources on public and private lands in rural or wild areas rather than in cities, suburbs, and small towns where about three-fourths of our human population now live. The major reasons for lack of attention to wildlife in developed areas are two-fold. First, there has been a general impression on the part of the public and many fish and wildlife agencies that urbanized areas can be written off as unsuited for wildlife or wildlife management, except for controlling nuisance or injurious animals. Second, state, and to a somewhat lesser extent federal agencies, have primarily depended upon hunting and fishing license fees and waterfowl stamps, rather than general appropriations, to finance their operations. It is understandable, therefore, that most of the fish and wildlife programs have focused on the management of game species, including control of species injurious to livestock and property or potentially hazardous to humans, e.g., rabid raccoons, skunks, and foxes. Research and management of game species and their habitat has benefited nongame species as has the acquisition or leasing of valuable refuge and wildlife production areas financed primarily by license and duck stamp purchasers.

We do not wish to give the impression that nongame and urban wildlife have been entirely neglected in the past 50 years. Aldo Leopold (1933) asked, "Is it not probable that landowners who now proudly exhibit their bird baths or feeding stations will be equally enthusiastic about the diversity of bird environments which they can build up?

[1] A major portion of this paper is based on a project of the Wildlife Society's Urban Wildlife Committee which, under Lyons' initiative, polled state and federal fish and wildlife agencies for information on their respective urban wildlife programs. Members of the Urban Wildlife Committee are Lowell Adams, Jonathan Andrew, James Applegate, Al Geis, Paul Gorenzel, James Lyons, David Manski, Gary San Julian, David Tylka, Larry VanDruff, Joe Werner, and Daniel Leedy, Chairman.

Should not public parks be 'landscaped' with an eye to the variety of their bird life, as well as to the beauty of their scenery?" But in summarizing the North American Wildlife Conference 13 years later, Rudolph Bennitt (1946) of the University of Missouri stated, ". . .I still look forward to the day when we shall hear men discuss the management of songbirds, wildflowers, and the biota of a city. . . ."

A review of all the North American Conference proceedings would show that these topics have gained increasing recognition. In addition, in 1968, the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, sponsored a symposium, "Man and Nature in the City", to "explore the role of nature in the urban environment." Subsequently, several other symposia dealing with urban wildlife have been held—one at the University of Massachusetts in 1973 (Noyes and Progulske 1974), one at the University of Guelph, Ontario in 1975 (Euler et al. 1975), and a conference entitled "Wildlife and People" at Purdue University in 1978 (Kirkpatrick 1978), among others.

The National Environmental Policy Act of 1969 and similar state laws requiring preparation of environmental impact statements or assessments prior to certain types of development resulted in increased attention to fish and wildlife, both game and nongame, as an important component of the environment. The Endangered Species Act of 1973 was designed to assure better protection and management of threatened and endangered species and their critical habitats. To fully implement this Act, it was necessary that states also have nongame and endangered species programs. Because there are so many more nongame fish and wildlife species than game and because most of the threatened or endangered species are nongame, attention given by the states to the nongame component of the wild fauna has markedly increased. The Fish and Wildlife Conservation Act of 1980—the Nongame Act—brought added focus to nongame fish and wildlife. Federal funds for its implementation have not been appropriated, but the U.S. Fish and Wildlife Service is investigating possible sources of revenue for this purpose.

Meanwhile, the ranks of those biologists devoting some time to both game and nongame fish and wildlife in urban areas, to urban fishing, and to planning and public education designed to enhance enjoyment of wildlife by city, suburban, and town residents has been increasing. The nonprofit Urban Wildlife Research Center, now the National Institute for Urban Wildlife, at Columbia, Maryland, was established in 1973. Obtaining adequate funding has been a problem throughout its existence, but the Institute has made some progress in research and in publishing planning and management guides for urban wildlife. Through its quarterly *Urban Wildlife News* it lists current and recently completed urban wildlife research projects and, through the cooperation of the Wildlife Management Institute, it has sponsored or co-sponsored Urban Wildlife Open Exchange sessions at the North American Wildlife and Natural Resources Conferences for the last 10 years.

Researchers in federal and state agencies, at universities, and in private conservation organizations have found that despite the commonly held belief that wildlife in urbanized areas consists mostly of house sparrows, pigeons, starlings, rats, and mice, some developed areas have more wildlife than was present prior to development. They have documented the fact that the money expended by urban residents for bird seed, bird feeders, nesting boxes, binoculars, and natural history literature is a multi-million dollar industry. Also they have discovered that a majority of urban residents like to have wildlife around their homes and that there are many opportunities for improved planning and management which would permit wildlife and people to live more in harmony with each other.

About three-fifths of the states have been able to supplement their funds for fish and wildlife management through various income tax check-off systems or other means. The extent to which state and federal agencies are currently engaged in urban wildlife programs is the main thrust of this paper. As you will see, attention to ***urban***, as opposed to ***nongame*** fish and wildlife, has been relatively slight; yet, because wildlife belongs to the people, urban residents are the primary constituents of state and federal wildlife agencies.

Methodology

A seven-page questionnaire was developed to gather data on the status; administration; funding; and achievements, problems and potential of current state and provincial urban wildlife programs. Additional, limited information was also collected on other public and private urban wildlife programs.

A draft of the questionnaire was reviewed by the members of the Urban Wildlife Committee of The Wildlife Society in late 1982. Additional comments were sought from participants in an urban wildlife meeting at the 1983 North American Wildlife and Natural Resources Conference.

Based on this review, a final questionnaire was prepared for distribution to the state and provincial fish and wildlife agencies in cooperation with the Nongame Committee of the International Association of Fish and Wildlife Agencies. The survey was first distributed to the agency directors in June, 1983. A follow-up mailing was made to nonrespondents in August.

In December, 1983, the original urban wildlife survey questionnaire was modified for distribution to a number of federal natural resource management agencies. In January, 1984, the chief administrators of the Department of Energy; Environmental Protection Agency; USDA Forest Service and Soil Conservation Service; the Army Corps of Engineers; and the Park Service, Office of Surface Mining, Fish and Wildlife Service, Bureau of Land Management, and Bureau of Reclamation in the Department of Interior were sent the revised questionnaires.

Results

Forty-two states and Puerto Rico responded to the urban wildlife survey. In addition, three Canadian provinces returned completed questionnaires. All the federal agencies contacted last December responded to the survey, either by mail or by telephone.

The status of state, federal, and provincial urban wildlife programs is summarized in Table 1. Only six states reported that an urban program existed in their state in 1983. Iowa reported that an urban wildlife program was proposed. Urban wildlife programs were defined as those specifically intended to address the research and management of non-domestic vertebrate and invertebrate species, both game and nongame, and feral animals that inhabit the ecosystems of cities and suburbs, and the interests and needs of the residents of cities and suburbs who may be affected by these species. A program was deemed to exist if at least one employee and funding were specifically allocated to urban wildlife.

Eleven of the responding states reported that urban wildlife was currently addressed as a component of some other state wildlife program or management activities. Connecticut and Oklahoma planned to address urban issues through their nongame programs in 1983–1984. Most often this was the nongame program. Florida, Georgia, and South Carolina reported that urban wildlife was addressed through their game management programs.

Table 1. Status of state, federal and provincial urban wildlife programs—1983.

State, province, or agency	An urban wildlife program exists[a]	Urban wildlife part of other agency activities	Urban wildlife *not* an agency function
States			
Alabama		●	
Alaska			●
Arizona		non-respondent	
Arkansas		non-respondent	
California		non-respondent	
Colorado		●	
Connecticut		● (proposed)	
Delaware			●
Florida		●	
Georgia		●	
Hawaii		●	
Idaho		●	
Illinois		●	
Indiana			●
Iowa	● (proposed)		
Kansas	●		
Kentucky			●
Louisiana			●
Maryland			●
Massachusetts			●
Michigan		non-respondent	
Minnesota		●	
Mississippi			●
Missouri	●		
Montana			●
Nebraska			●
Nevada		●	
New Hampshire			●
New Jersey	●		
New Mexico			●
New York		●	
North Carolina			●
North Dakota			●
Ohio		non-respondent	
Oklahoma		● (proposed)	
Oregon		non-respondent	
Pennsylvania			●
Rhode Island			●
South Carolina		●	
South Dakota			●
Tennessee	●		
Texas			●
Utah	●		
Vermont		non-respondent	
Virginia			●

[a] Funding and staff have been allocated specifically to urban wildlife activities.

Table 1. (Cont.)

State, province, or agency	An urban wildlife program exists	Urban wildlife part of other agency activities	Urban wildlife *not* an agency function
States			
Washington	●		
West Virginia			●
Wisconsin			●
Wyoming		non-respondent	
Puerto Rico			●
Provinces			
British Columbia		●	
Ontario			●
Saskatchewan			●
Federal Departments or Agencies			
Army Corp of Engineers			●
Bureau of Reclamation			●
Department of Energy			●
Environmental Protection Agency			●
Fish and Wildlife Service	●		
Forest Service			●
National Park Service		●	
Office of Surface Mining			●
Soil Conservation Service			●

Twenty-one states and Puerto Rico indicated that urban wildlife was not addressed by the fish and wildlife agency. States in this category not only included those with relatively small urban populations, such as West Virginia, but also states with high urban populations, like Massachusetts and Maryland (see Figure 1).

Of the federal agencies contacted, only the Fish and Wildlife Service reported an urban wildlife program with specific staff and funding. The National Park Service indicted that urban animal management activities occur in at least 10 units of the National Park System, though no central program exists. Urban wildlife management activities are conducted as needed in each unit.

Of the Canadian provinces, Ontario and Saskatchewan reported no urban wildlife activities in their agencies. British Columbia indicated that urban wildlife was addressed in conjunction with other program activities.

Characteristics of Urban Wildlife Programs

State urban wildlife programs first appeared in 1978. In that year, Kansas, Missouri, and Tennessee established programs—all by agency initiative. In 1979, Utah launched a program, followed by Washington in 1980. New Jersey established an urban wildlife program in 1983. When surveyed, Iowa was planning to initiate a program.

Funding and staff support for existing state urban wildlife programs varied widely. In 1983, New Jersey proposed to allocate $10,000 to support a part-time urban wildlife

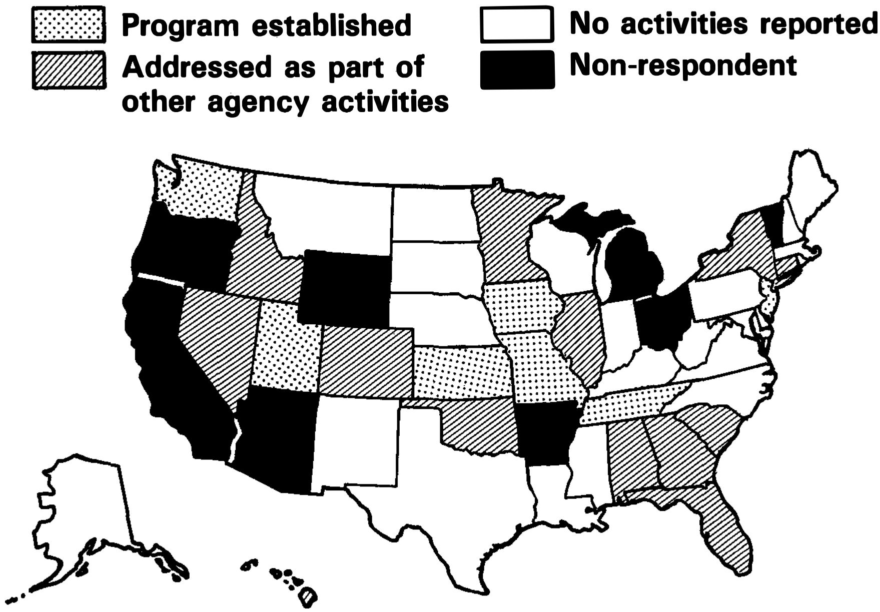

Figure 1. A summary of urban wildlife management activities.

person. Iowa proposed a budget of $30,000 and one full-time employee. Most programs supported one or two urban wildlife employees. The exceptions were Kansas and Missouri. Kansas reported an urban wildlife budget of $148,000 and 10 urban wildlife staff members—5 full-time and 5 seasonal or part-time. Missouri allocated 10 full-time positions to urban wildlife programs with a budget of $758,000 in 1983.

Program emphasis was evaluated in two ways. First, the respondent was asked to indicate what percentage of the total program was allocated to management, research, extension, education, and other urban wildlife activities. The responses to this question are summarized in Table 2. Extension and public education, followed by management, were the principal functions of most urban wildlife programs.

Next, respondents were to indicate the types of projects that had been addressed by the urban wildlife program. Ten project alternatives and the category, "other", were provided. When asked which of these had been of *primary focus* for the urban wildlife program, landowner/homeowner assistance, adult education, and habitat management and planning were most often noted. Animal damage/nuisance control and community assistance were also mentioned as focal projects for urban programs.

One segment of the questionnaire dealt with urban wildlife program achievements, problems, and potential. Respondents were asked to state, in their own words, the primary objectives of their urban wildlife program. Their answers fell into the following categories: (1) to encourage habitat management in urban environments to preserve wildlife, (2) to provide opportunities for wildlife enjoyment, and (3) to help urbanites gain an appreciation of wildlife and the work of the wildlife agency.

Major accomplishments cited by the states with urban wildlife programs included

Table 2. Characteristics of existing state urban wildlife programs[a].

State	Year established	Fiscal year 1983 funding ($000)	Personnel		Program activities (% of time expended)				
			Full-time	Part-time	Management	Research	Extension	Education	Other
Iowa	1983	30 (proposed)	1				50	50	
Kansas	1978	148	5	3/2[b]	40	10	10	40	
Missouri	1978	758	10		27		20	24	29[c]
New Jersey	1983	10		1			50	50	
Tennessee	1978	40	1	4	5		85	10	
Utah	1979	35	2		50	12		38	
Washington	1980	37	1		80	1	5	10	4[d]

[a] An urban wildlife program exists if staff (at least one employee) and funding are allocated specifically to urban wildlife management.
[b] Seasonal employees.
[c] Remaining effort in liaison, public relations, and land acquisition.
[d] Remaining effort in enforcement and program coordination.

preparation of urban wildlife publications, educational programs for city residents and land developers, resource inventories, and habitat acquisition. Problems most often noted by respondents were inadequate program funding and a lack of public support for urban wildlife programs. Despite the problem of inadequate funding, five of the seven states with programs noted that, "Once people are informed, they are likely to support our program. Support is growing day by day."

Urban Wildlife Activities in Other States

The nature and extent of urban wildlife activities in states with no formal urban wildlife program varied widely. This variation made interpretation of agency responses difficult. For example, though many states addressed urban wildlife through their nongame programs, others did not identify a specific unit or program of the agency that dealt with urban wildlife. Instead, a respondent would state, "all our biologists have urban wildlife responsibilities." Other respondents simply noted that they did not have an urban wildlife program by our definition.

Urban wildlife activities in states where no formal urban wildlife program exists are summarized in Table 3. Seventy-five percent of the states that address urban wildlife do so principally through their nongame wildlife units. Of the states with established urban wildlife programs, all but two supported their urban work principally through a nongame checkoff or some funding source other than hunting license fees or general appropriations.

Program emphasis differed slightly between states with formal urban programs and those who addressed urban issues by some other means. Animal damage control was stated by five states as a primary focus of their urban program. Of the states with established programs, only one noted this as a primary concern. Education and habitat management and planning were also projects of primary focus in states with no formal urban wildlife programs.

Urban Wildlife Activities of the Federal Agencies and Canadian Provinces

Though several federal agencies have programs related in some way to urban wildlife, only the U.S. Fish and Wildlife Service reported a current urban wildlife program. The program was established in 1972 and is currently staffed by two individuals. Eighty percent of the program's focus is research on birds. The fiscal year 1983 budget for urban wildlife was $70,000, less than one percent of the agency's total budget. Program funding has steadily declined since 1980. When asked to assess the program's future, the respondent indicated that it was uncertain, due to the lack of a secure funding base.

National Park Service urban wildlife activities were estimated to be 75 percent management, 20 percent extension and education, and 5 percent research. Eighty percent of the management effort was directed toward the control of pest species and another 15 percent to feral animals. Funding was approximately $200,000 in fiscal year 1983, less than 0.5 percent of the agency budget. The Park Service cited reducing the impacts of urban wildlife on natural and cultural resources as their major urban wildlife program accomplishment.

The Forest Service noted that it plays a limited role in urban wildlife assistance through the State and Private Forestry Program. Urban forestry positions in the Washington, D.C. office were terminated in fiscal year 1983, and only mimimal assistance is provided in the southeastern region of the United States. Urban wildlife research, in which the Forest Service pioneered at the Amherst, Massachusetts research unit during the mid-1970s, has

Table 3. Characteristics of urban wildlife activities in states without a formal urban wildlife program[a].

		Primary Focus					
State	Urban wildlife activities assoc. with	Animal damage/ nuisance control	Habitat/ wildlife inventory	Habitat mngt./ planning	Adult education	Primary/secondary school education	Landowner/home-owner assistance
Alabama	nongame						
Colorado	nongame						
Connecticut[b]	nongame		●	●		●	
Florida	technical guidance	●		●	●		
Georgia	game	●			●	●	
Hawaii	nongame & aquatic resources	●		●			●
Idaho	nongame		●		●		●
Illinois	fish & wildlife	●			●		●
Minnesota	nongame & fish and wildlife			●			
Nevada	nongame & game	●			●	●	
New York	nongame		●	●		●	
Oklahoma[b]	nongame						
South Carolina	game						

[a] See definition, Table 1.
[b] Responses reflect a program proposed for 1983/1984.

been eliminated. The respondent summarized the current status of the Forest Service's urban wildlife efforts by stating, "in essence, we have no program."

British Columbia reported that urban wildlife is currently addressed through their nongame program. Seventy-five percent of their efforts are expended in management, 10 percent in research, and 15 percent in extension. The fiscal year 1983 urban wildlife budget was approximately $50,000, less than one percent of the agency's budget. The respondent indicated that lack of administrative support and funding would likely result in future program reductions. Interestingly, a primary objective of urban wildlife efforts in British Columbia is to provide recreational hunting opportunities through maintenance of upland bird and waterfowl habitat near urban areas.

Related Urban Wildlife Programs

Additional information was sought from all state and provincial agencies regarding other public and private urban wildlife programs occurring in their state or province.

Eighteen of the responding states and provinces indicated that they were not aware of any other public or private urban wildlife programs in their state or province. Four of these—Iowa, Nevada, South Carolina, and Ontario—reported that their fish and wildlife agency was addressing urban wildlife. The remainder indicated no agency involvement in urban wildlife programs.

In states and provinces where other urban wildlife programs were reported, both public and private activities occurred. Several states and provinces reported that local, state, and federal programs to benefit urban widlife were being implemented. Local organizations involved in urban wildlife included park commissions, county organizations, and regional authorities. State agencies involved in urban wildlife included forestry departments and extension agents associated with state universities. Several states noted the actions of federal agencies in their states as they related to urban wildlife. The Soil Conservation Service and Fish and Wildlife Service were among the federal agencies mentioned.

Private actions related to urban wildlife included the activities of non-profit organizations such as civic groups, wildlife organizations like local Audubon Society units, and other conservation organizations. However, some states noted that private commercial interests were also concerned with urban wildlife in their state. These included recreation interests, residential and commercial development interests, as well as animal nuisance control and landscape design firms. The urban wildlife activities of other public and private organizations in the states and provinces are summarized in Table 4.

Funding for Urban Wildlife Programs

Limited data on the sources and amounts of funding for urban wildlife programs were gathered. In addition, information on program funding trends and budget allocations were recorded. These data are summarized in Table 5.

Fourteen states, British Columbia, the Fish and Wildlife Service and National Park Service reported urban wildlife program funding in 1983. Two states, Connecticut and Iowa, reported proposed fiscal year 1983 funding levels. Except for Florida, Hawaii, Kansas, and Minnesota, no state allocated more than one percent of their total fish and wildlife budget to urban wildlife.

Principal sources of urban funding were nongame checkoffs or other non-traditional revenue sources. Overall, however, a relatively small proportion of state nongame monies

Table 4. Status of other public and private urban wildlife programs in the states and provinces[a].

State/Province	Other public programs			Private Programs						
				For profit				Not for profit		
	Local[b]	State	Federal	Recreation	Residential development	Commercial development	Other	Civic groups	Wildlife organizations	Other conservation organizations
Colorado										●
Delaware										●
Florida		●	●	●					●	●
Georgia	●									
Idaho									●	
Illinois	●	●								
Kansas	●									
Maryland			●		●					
Minnesota	●		●							●
Missouri	●						●		●	●
New Hampshire									●	
New Jersey	●						●			
New York		●						●	●	●
Oklahoma	●									
Rhode Island			●	●	●	●	●			
Tennessee							●		●	
Texas	●				●					
Utah		●				●			●	●
Washington	●									●
Wisconsin	●			●					●	
Puerto Rico	●								●	●
British Columbia	●	●	●	●						
Saskatchewan	●									

[a] States reporting no other public or private urban wildlife activities included: Alaska, Georgia, Indiana, Iowa, Kentucky, Maine, Massachusetts, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, South Carolina, and West Virginia, and the province of Ontario. Connecticut, Hawaii, North Carolina, Pennsylvania, South Dakota, and Virginia responded "Don't know".

[b] Includes city, township, and county governments and public agencies.

Table 5. Urban wildlife program funding.

State, province, or agency	Fiscal year 1983 funding: Amount ($000)	Fiscal year 1983 funding: Percentage of total fish & wildlife budget	Funding sources (percent from each): Nongame checkoff (percent of all nongame funding)	General appropriations	Pittman-Robertson	Dingell-Johnson	License sales	Other	Budget Allocation (percent for): Management	Research	Extension	Education	Land acquistion	Other	Funding Trends (+ increasing − decreasing)
States															
Alabama	not available														
Colorado	not available														
Connecticut[a]	30			100										100[b]	not applicable
Florida[c]	104	25			75				50		20	30			+
Georgia	50	1			100				10		60	30			not available
Hawaii	8	3		100					5	2				93[d]	+
Idaho	1	1	100(1)									100			+
Illinois	not available														
Iowa[a]	30	<1	100(14)								50	50			not applicable
Kansas	148	2	25(27)				75		15	5		10		70[e]	+
Minnesota[f]	400	2	8(5)		13	32	47		80	4	6	3			+
Missouri	758	1						100[g]	25		10	13	39	13[h]	+
New Jersey	10	<1	100(3)								50	50			not applicable
Nevada	not available														
New York[i]	46	<1					100		10	30	30	30			+
Oklahoma	not available														
South Carolina	not available														
Tennessee	40	<1			100				5		85	10			−
Utah	35	<1	75(14)		25				40	25		35			not available
Washington	37	<1						100[j]	80	1	5	10		4[k]	+
Provinces															
British Columbia	50	<1		90			10		80	5	15				−

Federal agencies				Data not collected from federal agencies
Fish & Wildlife Service	70	<1	100	
National Park Service	200	<1		not available

[a] Responses based on proposed 1983 program.
[b] Allocated to planning.
[c] For technical guidance activities which include urban wildlife.
[d] For nuisance animal control.
[e] Salaries and administrative costs.
[f] Figures represent fisheries, wildlife, and nongame costs in seven county region surrounding Minneapolis-St. Paul.
[g] Funding source is a ⅛ cent sales tax.
[h] Allocated to fish stocking and public relations.
[i] Reflects total nongame unit funding.
[j] Funding source is the sale of personalized motor vehicle license plates.
[k] Funding for enforcement and program coordination.

was allocated to urban wildlife. As of August, 1983, 11 of 28 states with a nongame checkoff had no urban wildlife activities underway (see Figure 2).

Georgia, New York, and Tennessee reported that Pittman-Robertson funds or license receipts were the sole funding sources for their urban programs. Seventy-five percent of Kansas' program and 47 percent of Minnesota's urban wildlife efforts were supported by license sales.

Most urban wildlife funding was allocated to management and extension and education efforts. Connecticut planned to fund only planning activities in fiscal year 1983. Hawaii's budget was primarily for animal damage and nuisance control efforts. Only Missouri had budgeted for land acquisition in their 1983 budget. Funding for urban wildlife research was minimal.

Trend data for urban wildlife funding revealed that most programs received increased support in current dollars in recent years. However, Tennessee, British Columbia, the Fish and Wildlife Service, and the Forest Service budgets for urban wildlife have decreased during the same period.

Urban Fishing

Heaton Underhill of the Cooperative National Park Resources Study Unit, University of Arizona, obtained information on urban fishing from the fisheries' agencies of all 50 states. His findings were reported in a poster session presentation for the Urban Fishing Symposium held in Grand Rapids, Michigan, October 1983. With his permission, the following information from his unpublished report, "A Survey of State Urban and Fishing

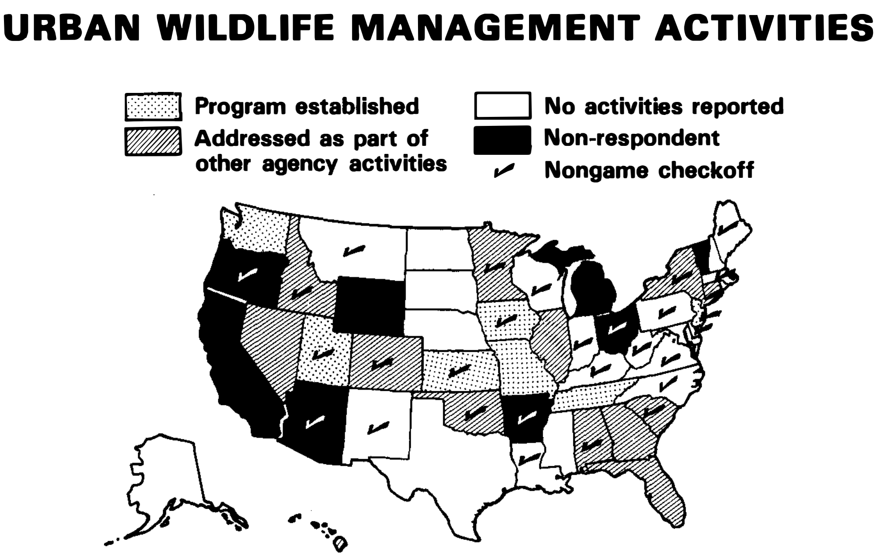

Figure 2. Urban wildlife management activities and nongame checkoffs.

Programs," supplements data obtained by the Wildlife Society's Urban Wildlife Committee. According to Underhill, of the 50 states, 20 reported that they had a distinct, recognizable urban fishing program. Of the other 30 states, most indicated that they did provide fishing opportunities in urban areas. Sixteen managed urban waters in the same manner as other fishing programs; 6 cited budget limitations; 3 stated they had "kid" and "old-timer" programs; and one reported it had discontinued an urban fishing program.

With respect to the 20 states having identifiable urban fishing programs, 19 furnished fish for stocking; 16 provided education and promoted urban fishing; 14 provided biological support and habitat management; 9 provided law enforcement; and 5 provided other services like coordination, training of volunteer instructors, and technical advice. Annual expenditures by states for urban fishing programs varied from $3,000 to $600,000. Some states like Washington, Oregon, Michigan, and New York have good natural fishing in urban areas. Many urban centers must settle for marginal waters and "put and take fishing." The majority of the states felt that their regular funds should go to managing natural waters and resisted stocking urban waters unless someone else footed the bill. Underhill stated that seeking other financial support is understandable but asked, "Why single out the disadvantaged (in terms of fishing opportunities) urbanite?" He concluded that most state fish and wildlife agencies can and should provide better urban fishing programs. By doing so he believed there would be more anglers and a greater understanding of and support for all natural resource management programs.

Discussion

Nearly 75 percent of all Americans lived in metropolitan areas in 1983 (U.S. Bureau of the Census 1983). The attitudes, interests, and concerns of the urban public are a dominant influence in American society. Urban residents' knowledge of and attitudes toward wildlife can have a profound influence on wildlife management practices and programs. For example, Kellert (1978, 1979), Applegate (1973), and others have indicated that anti-hunters tend more often to live in densely populated areas. Urban residents have an indirect influence on wildlife programs by virtue of the dominant role of their representatives in state legislatures and the U.S. Congress. Urban legislators dominate decision-making bodies that control legislation and appropriations affecting state, federal, and provincial wildlife agencies.

Recent studies have indicated that urban residents have a strong interest in wildlife. As reported in the *1980 National Survey of Fishing, Hunting, and Wildlife-Association Recreation*, 35 percent of all big city residents and more that 50 percent of all small city residents engaged in some form of primary nonconsumptive wildlife-related recreation. Residential activities, such as observation, photography, and feeding were dominant forms of wildlife enjoyment. Sixty-five percent of all those who participated in residential activities were urban residents. Of those who took trips primarily to observe, photograph, or feed wildlife, over 62 percent resided in urban areas. Overall, more than two-thirds of those who participated in nonconsumptive wildlife-related recreation were urban residents (U.S. Fish and Wildlife Service 1982).

A recent report of the Canadian Wildlife Service, "The Importance of Wildlife to Canadians—Highlights of the 1981 National Survey," reflected similar interest in wildlife among urban residents in Canada. Seventy and 71 percent of all participants in residential and nonresidential wildlife-related recreation, respectively, were residents of urban areas. Fifty percent of all Canadian hunters resided in urban areas (Filion et al. 1983).

It is difficult to characterize the current status of urban wildlife programs in general terms. Some states have made a commitment to urban wildlife and established separate urban wildlife programs, other states have become involved in urban wildlife management in conjunction with their usual management activities. Many have used new sources of funding for nongame as an entree to urban wildlife management.

Fifty percent of the states that participated in this survey had no involvement in urban wildlife management although many of them are highly urbanized. Though most states cited that inadequate funding was their primary impediment to developing an urban wildlife program, 11 of these had wildlife income tax checkoff programs to supplement traditional sources of program funding. There appears to be little correlation between total fish and wildlife agency budgets, new sources of program funding, the degree to which a state has become urbanized, and the establishment of an urban wildlife program. However, it does appear that additional fish and wildlife program funding generated by income tax checkoffs and other sources of funding can provide the capital needed to initiate an urban wildlife program.

Existing state, federal, and provincial urban wildlife programs are limited in size and scope. The majority have relatively small staffs—usually one or two professionals—and extremely small budgets. A rough estimate of total funding for all urban wildlife activities in United States and Canada for fiscal year 1983 is slightly more than $2 million.

Most urban programs emphasized extension and public education. But this is a mammoth task for the few personnel in existing programs. Animal damage and nuisance control also appears to be a principal program thrust. Urban wildlife research efforts are negligible.

Are the interests and needs of urban residents well-served by current fish and wildlife programs? The fact that urban residents do engage in large numbers in wildlife-related recreational activities, including fishing and hunting, indicates that, to some degree, their interests are addressed. Certainly, protecting endangered species, preserving wetlands, and other wildlife program accomplishments benefit urban, and suburban, as well as rural residents, but this survey indicates that programs primarily directed to the interests of urban residents and the needs of their environments are at present, extremely limited. In this context, the interests and needs of urban residents are not well-served.

Why are urban programs so limited in size and scope? Most survey respondents indicated that funding was their limiting factor. Yet the states that have established new funding sources—principally nongame checkoffs—have allocated only a small share of their revenues to urban wildlife activities. A 1981 survey of state agencies by Johnson et. al. (1982) indicated that only 6 percent of the state and provincial wildlife agencies included urban wildlife projects in their nongame programs. Nongame research, wildlife inventories, and habitat management and protection were the most popular projects. Most efforts were directed toward endangered species. Eleven of the 28 states with nongame checkoffs when this survey was conducted, including some with high urban populations, reported no urban wildlife programs or projects.

Perhaps another reason for the lack of strong urban wildlife efforts lies in the education and training of wildlife professionals. Our training is primarily ecologically-oriented and biologically-based. Too often, it is devoid of a basis for understanding wildlife management in a social context—for dealing with people as well as wildlife and habitats.

Our apparent limited attention to urban wildlife and urban environments may result from the way in which fish and wildlife management programs have developed. Wildlife agencies have strongly benefited from the "user pay" principle. In promoting the use of license fees and user-based taxes like the Pittman-Robertson and Dingell-Johnson programs, we have sought the security of relatively stable and dedicated sources of program funding. However, in so doing, we have cemented the link between program and funding source. It is this linkage that has driven programs oriented to the paying customer—primarily the consumptive user. And as budgets have driven programs, they have molded a myopic philosophy that appears to be too narrowly-sighted to benefit the full range of publics interested in wildlife. In stating this we are not recommending reductions in current programs, but are urging that as additional funds become available, greater consideration be given to programs concerned with wildlife in urban areas.

Public agencies have a responsibility to serve the interests and needs of those they represent. Urban residents are an important segment of the constituencies of fish and wildlife agencies. As one respondent stated, "We sometimes think of [urbanites] as being nontraditional wildlife clientele. But are they? They may really be the broad base of traditional support."

The public needs to understand the benefit of wildlife management and importance of a clean and healthy environment. And the wildlife profession needs to recognize the importance of addressing the needs of its urban constituency. Urban residents are an important segment of the profession's clientele. Simply by virtue of their numbers, they can have the greatest influence on wildlife management programs in the decades to come. Yet, urban residents' knowledge of animals is low in contrast to rural residents. Their "moralistic" concern for animal rights and opposition to "utilitarian" views of animals as reported by Kellert and Berry (1980), "reflect fundamental distinctions in outlook regarding the appropriate human use and treatment of animals."

Urban wildlife management is a relatively new field for the wildlife profession. Most programs reported in this study were initiated in the last 3 to 5 years. Since this survey, new programs have been established and existing programs substantially expanded. For example, New York has allocated $110,000 to fund fish and wildlife staff in New York City, using revenues generated by their "Return a Gift to Wildlife" program (New York Department of Environmental Conservation 1983). Funding for most state urban wildlife activities has nominally increased in recent years.

Federal support for state nongame wildlife programs will commence with the development of a funding base for the Fish and Wildlife Conservation Act of 1980. Perhaps additional funding will be the catalyst for state urban wildlife programs. Urban wildlife was one of the most frequently mentioned programs that would be initiated by states if no financial or personnel restraints limited their nongame efforts, according to a 1980 survey of state fish and wildlife agencies (Howard et al. 1980). Though funding and staff will never be unconstrained, the new nongame monies will permit the state agencies to get on with the work they said they would like to do. We hope that care is taken in selecting the funding source for the federal Nongame Program, so that it does not restrict new state nongame program initiatives.

Conclusions

Urban wildlife management efforts are mostly a new initiative among state fish and wildlife agencies. Current programs are small in size (i.e., funding and personnel) and scope, though their funding has increased slightly in recent years. Federal urban wildlife efforts are declining. There are opportunities for state, federal, and private initiatives in this area, and universities, too.

Current programs have stressed extension, education, habitat management, and animal damage control. Urban wildlife research is extremely limited.

Though funding is most often cited as limiting program establishment or growth, a number of fish and wildlife agencies have established modest urban programs without substantial new sources of revenue. Other states have used new nongame monies to initiate urban wildlife programs or activities. New revenue from a federal nongame program can be the catalyst for new and expanded urban wildlife programs.

Urban residents are the single greatest potential source of support for fish and wildlife management. Programs which address the interests and needs of urban residents can improve the quality of urban environments, reduce human pressure on adjacent land areas and wildlife resources, and create a more informed constituency to support all fish and wildlife programs.

Gene Grey (1984), in a recent editorial on urban forestry stated, "Urban forestry has two basic problems: it is not clearly understood, and people, particularly foresters, are uncomfortable with it . . . . The result is the urban forestry child seeking legitimacy." The same can be said for urban wildlife.

Nearly two decades ago at another North American Conference, John Gottschalk, then Director of the U.S. Bureau of Sport Fisheries and Wildlife stated, "The problems besetting wildlife conservation in 1966 are reasonably clear and have scarcely changed in fundamentals in recent decades . . . We need habitats . . . We need access . . . We need know-how . . . And we need public support . . . ." He went on to say that public support is what is required to get more healthy habitat, access to it, and the scientific know-how (Gottschalk 1966). If we are to gain the public support of which Gottschalk spoke in the 1960s then we must embrace the illegimate child—urban wildlife.

At the beginning of this decade Kellert and Berry (1980) noted that "urban/rural challenge may represent one of the most difficult and important problems confronting the wildlife management field in the 1980's." We can use new sources of wildlife program funding to deal with this problem or we can ignore it and lose the opportunity to gain additional public support for wildlife management. The need for public support has not diminished since 1966. The opportunity to develop urban wildlife programs has never been greater.

Acknowledgements

The authors acknowledge the assistance of other members of the Wildlife Society's Urban Wildlife Committee in preparing the questionnaire used in this study. Thanks are due Larry Jahn, Chairman of the Nongame Committee of the International Association of Fish and Wildlife Agencies for encouragement, and Jack Berryman, Executive Director of IAFWA for distributing questionnaires to the state fish and wildlife agencies. Heaton Underhill, Cooperative National Park Resources Study Unit, University of Arizona kindly gave us permission to use unpublished data he had gathered on state urban fishing programs.

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Advances in Wetland Research and Management

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Introduction

Present wetland management has been developed largely on a trial and error basis (Figure 1). The effects of many important environmental variables on wetland productivity are not known, consequently management results have not been predictable with a high degree of accuracy (Weller 1981). Many marsh management techniques have been described; however, consistently successful marsh management requires a more comprehensive understanding of the structure and function of wetland systems. Although there have been numerous observational studies, major advances in our understanding will result from tightly controlled experimentation which permits the integration of simultaneous research efforts by a number of different scientific disciplines (Reichle 1975, Weller 1978). Because wetlands are temporally dynamic, this type of multi-disciplinary ecosystem analysis must also span a number of years to document the annual and long-term variability within the system. By better understanding the structure and function of wetlands, managers will be better able to design management techniques and strategies suited to their particular situation and therefore realize greater success in manipulating the productivity of these systems (Figure 1).

In response to the need for long-term multi-disciplinary research in freshwater wetlands, the Delta Waterfowl Research Station and Ducks Unlimited Canada embarked on their joint Marsh Ecology Research Program (MERP) in 1979 (Batt et al. 1983). A scientific team from a variety of disciplines (hydrology, plant ecology, invertebrate ecology, vertebrate ecology, nutrient dynamics, marsh management) was assembled to design and oversee a long-term experiment on the effect of water level manipulations on northern prairie marshes. MERP has three general program objectives: (1) to understand the ecological processes affecting the distribution and abundance of wildlife and plant species in northern prairie marshes (Development of New Information); (2) to improve practical management of wetlands by providing managers with a better understanding of the structure and function of wetland systems (Communication); and (3) to encourage students to seek training and careers related to wetland research and management (People).

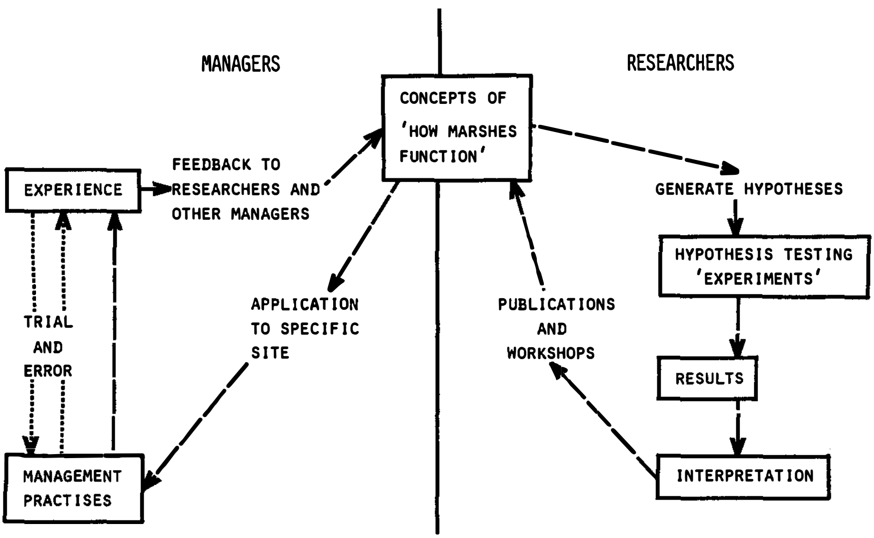

Figure 1. Hypothetical model of the interaction between researchers and managers in the development of successful marsh management practices.

Development of New Information

The MERP Scientific team (authors of this paper) is responsible for the development and supervision of the overall research program. Each team member oversees the field procedures, data collection, analyses, and publication of results in their area of responsibility.

The primary research objective of MERP is to develop new information on the structure and function of northern prairie marshes. These marshes exhibit changes in productivity which correspond to the wet-dry cycles characteristic to the northern prairie environment (Weller and Frederickson 1974, van der Valk and Davis 1978). The wet-dry cycle is the fluctuation between drought (dry) and flooded (wet) conditions resulting from variation in annual precipitation. The changes in wetland productivity during this wet-dry cycle have been described by van der Valk and Davis (1978). Two early MERP contributions (van der Valk 1981, 1982) have presented models and discussions of the vegetation response to the wet-dry cycle.

Without understanding the mechanisms involved, marsh managers have long used water level manipulations to manage the productivity of prairie marshes (Kadlec 1962, Harris and Marshall 1963, Meeks 1969). Because water regime appears to be the dominant factor regulating the productivity of these systems and one which can be practically manipulated by managers, the MERP Scientific Team decided that early investigations would concentrate on the effect of varying water levels on overall wetland productivity. The movement and storage of the three crucial macro-nutrients (nitrogen, phosphorus, and carbon) will be monitored at all levels of the ecosystem. In many wetlands, either nitrogen or phosphorus are often thought to be limiting productivity, hence this effort should lead to a better understanding of the underlying relationships regulating the productivity of prairie wetlands (Kadlec 1979). The general research objective is to quantify the movement and storage of nitrogen, phosphorus and carbon in the marsh ecosystem during various stages of the wet-dry cycle.

The more specific research objectives are:

1. Hydrology—to estimate the terms of the water budget during all phases of the wet-dry cycle: surface water in, surface water out, ground water in, ground water out, change in storage, precipitation, and evapotranspiration.
2. Water chemistry—to estimate the concentrations of carbon, nitrogen, phosphorus, and chloride in both surface and interstitial water and to monitor the movement of these nutrients in the water budget throughout the wet-dry cycle.
3. Invertebrates—to calculate production of aquatic invertebrates (nekton and benthos) during the wet-dry cycle through estimation of standing crops and turn-over rates.
4. Macrophytes—(a) to estimate net annual above and below ground macrophyte production through estimates of biomass; (b) to estimate annual uptake and release of nitrogen and phosphorus by living macrophytes.
5. Macrophyte litter—(a) to estimate annual production of standing emergent, standing submersed, and detached macrophyte litter; (b) to estimate the annual net loss and/or uptake of nitrogen and phosphorus in the standing emergent, standing submersed, and detached litter.
6. Vertebrates—to calculate the transfer of carbon, nitrogen, and phosphorus by vertebrates.

Experimental Design

The MERP study area is located on the Delta Marsh in south-central Manitoba. The actual experimental site consists of 10 contiguous 4–6 ha (10–15 acre) marsh units created by building a series of dikes along the north side of the marsh (Figure 2). Besides the diked cells, two undiked areas of similar size within the Delta Marsh are monitored as controls. Due to the long-term nature of the experiment, the dikes are designed to last at least 20 years with annual maintenance to control erosion and muskrat damage. Each experimental marsh is equipped with a water control structure and electric pump to manipulate and maintain water levels.

The experimental marshes were randomly assigned the schedule of water levels shown in Table 1. Following a year of baseline data collection (1980) all cells were subjected to a 2-year "conditioning" period. Conditioning involved flooding the marshes to a depth of one meter within the cattail (*Typha* spp.) stands. This prolonged flooding was intended to set all marshes to the "lake marsh" stage described by van der Valk and Davis (1978). Setting all experimental marshes to the lake marsh stage during conditioning was an attempt to reduce the variability between the marshes prior to the main experiment beginning with drawdown. The conditioning period was also a unique opportunity to study the marsh response to prolonged above-normal flooding (for example see Murkin 1983a). Conditioning levels killed most of the emergent and submersed vegetation and resulted in the decompostion of much of the original plant litter. These levels also similate the natural high water levels that occurred in the Delta Marsh prior to the 1960s.

Following drawdown the cells will be reflooded to three different levels (Table 2). The exact levels of reflooding in 1985 will be determined following a detailed analysis of the contour levels and other data from the conditioning period. Under natural conditions northern prairie marshes cycle through varying stages of productivity depending on water levels (van der Valk and Davis 1978). It is hypothesized that the rate of cycle or change in productivity is determined in large by the water depth within the marsh basin. Reflooding the experimental marshes to a variety of water depths (Table 2) should result in a variety of cycling rates within the study area. Monitoring the movement and storage of nutrients of marshes cycling at different rates will provide important insights into the factors controlling wetland productivity.

Long-term Monitoring Program

The scientific team has designed a program of standardized methods to monitor the system throughout the period of study. These techniques are detailed in a procedures manual (Murkin 1983b). Most of the procedures used have been adopted from other investigators, but all have been fully field-tested and modified to suit the needs for efficiency, economy, and practicality required in long-term, large scale replicated research (for examples see Murkin et al. 1983, Wrubleski and Rosenburg 1984). Publication of the MERP procedures manual (Murkin 1983b) will aid in the standardization of techniques used in marsh ecology research and will also allow critical evaluation of MERP procedures by other scientists in the field. As experience is gained, improvements in sampling techniques and schedules are incorporated into the long-term monitoring program as needed. Progress in marsh research will be more rapid if techniques used by various investigators are comparable. We offer our techniques in this format to encourage others to use them and thereby make all of our work more comparable and therefore more valuable.

Data obtained through a program of standardized techniques on a series of marshes

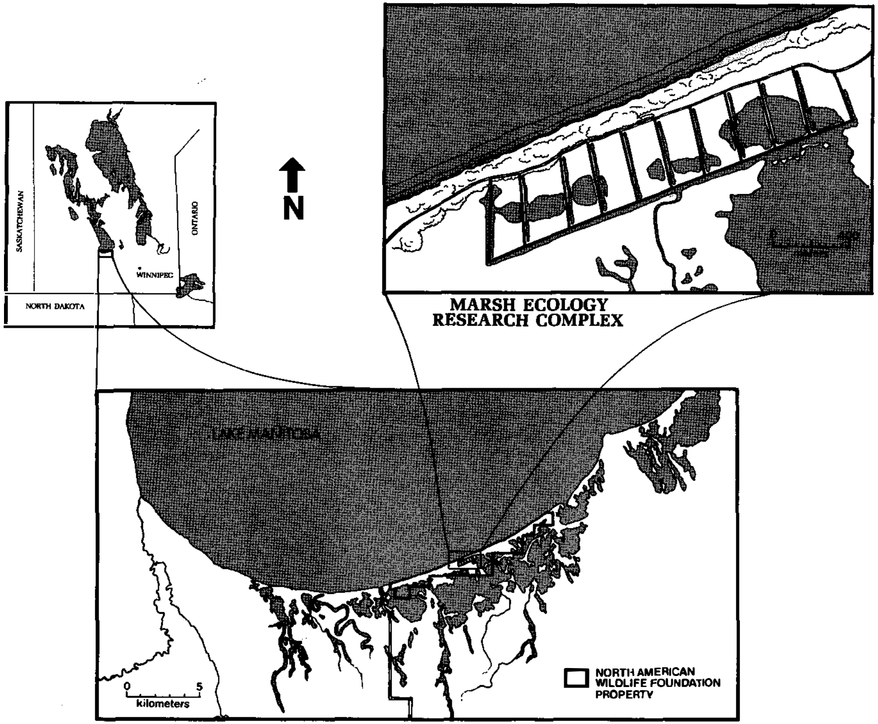

Figure 2. The March Ecology Research Program experimental marshes on the Delta Marsh in southcentral Manitoba.

Table 1. Schedule of water levels for MERP experimental marshes.

Year	Water levels
1980	All 10 marshes normal levels of Delta Marsh (baseline monitoring of all marshes)
1981	8 marshes flooded to "conditioning" level 2 marshes normal levels of Delta Marsh
1982	10 marshes at "conditioning" level
1983	8 marshes drawn down 2 marshes remain at "conditioning" level
1984	10 marshes drawn down
1984–89	3 marshes reflooded to shallow level 4 marshes reflooded to medium level 3 marshes reflooded to deep level

Table 2. Number of experimental marshes within each of proposed water levels following drawdown.

Drawdown duration (years)	Water level after drawdown		
	Shallow	Medium	Deep
1	—	2	—
2	3	2	3

undergoing simultaneous experimental manipulations will provide systematic information on the response of the ecosystem to water level manipulations. Items monitored for this long-term study correspond to the seven research objectives mentioned earlier. The list of long-term monitoring items is detailed in Batt et al. (1983) and Murkin (1983b). The basic strategy is to collect a comparable data set from year to year in each experimental marsh for each of the major components being monitored.

Short-term Studies

Besides the long-term monitoring, an important aspect of MERP are the short-term studies. As the long-term program proceeds, many hypotheses are generated that are suitable for short-term studies. Short-term studies are normally conducted and funded through the graduate research program of the Delta Waterfowl Research Station. To this point in time, graduate studies have dealt with the following topics: the role of seed banks in the vegetation development on drawdown surfaces (Pederson 1981, 1983), effects of nutrient litter quality on macroinvertebrate production (Nelson 1982), macroinvertebrate response to prolonged flooding of marsh habitat (Murkin 1983a), the effect of habitat type on the emergence of Chironomidae (Wrubleski 1984), the effects of invertebrates on macrophyte litter decomposition, the effect of water level fluctuations on productivity and biomass of algae assemblages, waterfowl and plant production in marshes dominated by whitetop grass (*Scholochloa festucacea*), reestablishment of perennial emergent macrophytes during drawdown of a lacustrine marsh, and chironomid recolonization of marsh drawdown surfaces following reflooding. Other short-term studies are anticipated as more questions are generated by the long-term monitoring program. There are also opportunities for new investigators to develop affiliations with MERP as the overall program develops.

Communication

One hindrance to successful wetland management has been the lack of communication between the management and research communities. An important objective of MERP is to bridge this gap and to make researchers aware of the information needs of managers and to ensure that the information produced by MERP and other related studies leads to a better understanding of the dynamics of wetlands by both managers and the research community. While the value of published information to other researchers is obvious, managers often do not use or understand the information generated by research. This problem stems from lack of training, lack of access to the information, job descriptions that do not allow time for review of the literature, and-so-on. MERP generated information will appear in the scientific literature but also as management publications geared to field personnel (see Pederson 1981). Seminars and workshops between MERP researchers and wetland managers have been held and more are planned. MERP itself will not generate many specific management techniques; however, by increasing the understanding of wetland managers, they will be better able to develop management techniques suitable to the specific marshes with which they work (Figure 1).

This is an important change from previous management-oriented research where the results of a single management technique are monitored. Each wetland system is different based on its geographic location and resulting environmental variables. A technique may work in one region and not in another. Rather than monitoring the results of a single technique in a specific geographic area, researchers should channel their efforts to achieve a general understanding of the structure and function of marshes and then ensure that their work leads to a better understanding of wetland processes by the management community. Managers are most aware of the environmental conditions and unique physical characteristics of their regions, so with improved understanding of their system would be better equipped than anyone to develop successful marsh management programs (Figure 1).

People

MERP will also expose students to training in basic wetland ecology. To date over 90 students from the U.S. and Canada have gained wetland experience on MERP. Some of these people will become managers and be much better prepared to take advantage of the information available on prairie wetlands and therefore realize greater success in the management of their systems. Others will be involved in wetland research and will be more aware of the need to better understand the dynamics of freshwater wetlands in general and to communicate their results to managers to ensure successful management of our wetland resources. While many of the students will not be wetland specialists in their professional careers, most will be employed somewhere in the field of conservation. Wetlands are the focal points for many conservation decisions and all of these people will be better prepared to influence proper decisions based on insight gained at this stage of their professional careers.

The Future

MERP is entering the most important phase yet because the data accumulated to date are being analyzed, published, and made available to the research and management communities. Early major achievements such as the development of a model detailing the vegetation response to the wet-dry cycle (van der Valk 1981) or the first replicated water budgets for small prairie marshes (Kadlec 1982) show that this process is well underway, and the rate of production of both scientific and management contributions should escalate markedly during the next few years. There are numerous indications that MERP is on a productive course and achieving near its potential even at this early stage.

Acknowledgements

A program the size and scope of MERP requires a broad base of financial support. The following individuals, companies, and foundations have provided major financial support: Amoco Canada Petroleum, James F. Bell Foundation, Devonian Group of Charitable Foundations, Donner Foundation, Ducks Unlimited Canada, Ducks Unlimited Foundation, Edson I. Gaylord, Richard Ivey Foundation, Laidlaw Foundation, John M.S. Lecky, Molson Foundation, Murphy Foundation, McLean Foundation, Senator Norman Patterson Foundation, Richardson Century Fund, and R. Howard Webster. This is Paper Number 10 of the Marsh Ecology Research Program, Delta Waterfowl Research Station, Delta, Manitoba, Canada.

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A Conceptual Approach to Relating Habitat Structure and Macroinvertebrate Production in Freshwater Wetlands

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Introduction

Annual fluctuations in continental waterfowl populations are a result of relative changes in population reproductive and survival rates. These rates may be affected by factors operating across seasons and geographic regions. Heitmeyer and Fredrickson (1981) pointed to potential cross-seasonal influences of habitat suitability on subsequent mallard recruitment rates. Wintering ground conditions may affect survival rates and population distributions (Nichols et al. 1983). However, breeding ground habitat suitability ultimately determines reproductive effort and success by breeding waterfowl (Boyd 1981, Leitch and Kaminski in press, Nudds 1983).

Our paper focuses on the breeding season and provides a functional basis for structural cues potentially used by female waterfowl to assess invertebrate food resource suitability. We have purposely limited our discussion to freshwater wetland systems of the prairie pothole region (Kantrud and Stewart 1977). However, many of the concepts are general and may well apply to other geographic regions.

Background

Several studies have indicated a preference by breeding waterfowl for wetlands interspersed with an equal mixture of emergent vegetation and flooded openings. Preference for such wetlands has been related in part to increased accessibility of nesting cover to breeding birds (Weller and Spatcher 1965), increased diversity of vegetative types (Weller and Fredrickson 1974), and increased macroinvertebrate production (Voigts 1976). Management of breeding marshes is commonly directed at maintaining emergent vegetation in an interspersed pattern throughout wetland basins. Marshes in this condition are viewed by waterfowl biologists as being highly suitable for breeding waterfowl (Weller 1981).

Two experimental studies have tested dabbling duck response to artificially interspersed marshes of 3 cover: water ratios (Kaminski and Prince 1981, Murkin et al. 1982). In both studies, birds selected intermediate cover to water ratios (50 percent each) in preference to other cover to water mixtures. Presumably because the openings were recent and artificially established, neither study showed differences in invertebrate abundance or diversity among treatments. Both studies concluded that waterfowl were responding to habitat structure instead of food resource abundance within these experimental areas.

However, Kaminski and Prince (1981) suggested that in natural settings habitat structure may provide a proximate cue to wetlands rich in macroinvertebrates, basing their conjecture on Voigts' (1976) observations.

Conceptual Functions of Emergents

To conceptually relate wetland structure to function we initially discuss two processes by which macrophytes might influence macroinvertebrate production in freshwater marshes. The conceptual framework outlined below has been developed largely from the literature.

Conceptual development follows a logical progression of ideas outlined as follows. Inundated emergent litter accumulations are structurally similar to submersed vegetation and may be important invertebrate production sites early in the ice-free season. As rates of litter decomposition increase with water temperature, these same accumulations are expected to become important sources of fine particulate organic matter (FPOM) (defined in Cummins et al. 1980) for communities of macroinvertebrates established in adjacent flooded openings. Thus, inundated litter accumulations potentially affect macroinvertebrates throughout the waterfowl breeding season (Figure 1). For this reason the distribution and pattern of emergent vegetation within wetland basins may be an important structural component influencing habitat suitability and determining reproductive effort by breeding waterfowl.

Spring—Substrate for Epiphyton

The water column structure of flooded wetland openings is relatively simple during spring because submersed plant communities have not yet become established (Figure 1). Lack of habitat structure in these openings may limit macroinvertebrate production during spring (Street and Titmus 1982).

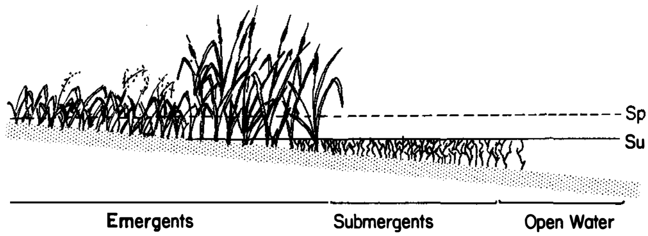
In contrast, flooded litter accumulations surrounding flooded openings provide a highly heterogenous habitat for macroinvertebrate populations. Epiphytic algae colonizes such flooded accumulations of litter (e.g., Jenkerson and Hickman 1983) and physical conditions remain relatively benign in these areas (Kairesalo 1980). Flooding permits rapid water interchange with adjacent openings due to wind-driven water currents (de la Cruz 1979, Polunin 1982).

Because many macroinvertebrates are opportunistic feeders (Anderson and Sedell 1979, Minshall 1978) and physical conditions are tolerable, productive communities of grazers and associated predators may colonize such litter accumulations and feed on growths of epiphyton available in these areas during spring (Cattaneo and Kalff 1980). By colonizing flooded emergent litter accumulations, macroinvertebrates gain access to a structurally complex habitat supporting nutritious algal food resources.

Summer—FPOM Production

Decomposition rates of litter substrates increase as water temperatures rise (e.g., Davis and van der Valk 1978). An interaction of microbial and fungal colonization, macroinvertebrate feeding activity, and physical abrasion of emergent leaf litter during decomposition produces FPOM (Anderson and Sedell 1979) which can be transported in suspension by low velocity wind-induced water currents (de la Cruz 1979).

Through the summer, physical conditions within litter accumulations become severe



Characteristic		Shallow Marsh	Deep Marsh emergent phase	Deep Marsh open water phase	Open Water
Water Column	Sp[1]	Complex	Complex	Simple	Simple
Structure	Su	-[2]	Complex	Complex	Simple
Trophic Status	Sp	= 1·0	>1·0	= 1·0	= 1·0
(P:R ratio)	Su	-	<<1·0	>>1·0	= 1·0
Diel Fluctuation	Sp	Moderate	Weak	Weak	Weak
(°C and O_2)	Su	-	Strong	Moderate	Weak
Water Current	Sp	Low	Moderate	High	High
Velocity	Su	-	Moderate	Moderate	High
Macroinverte-	Sp	Moderate/High	High	Low	Low
brate Production	Su	-	Low/Moderate	High	Low

Figure 1. Summary diagram of important components affecting macroinvertebrate production in freshwater prairie pothole wetlands. Spring and summer water levels are shown in relation to vegetative zones (Stewart and Kantrud 1972). [1]Sp=spring conditions, Su=summer conditions. [2]The shallow marsh zone is usually dry during summer.

for many macroinvertebrates. We expect conditions within litter accumulations to rapidly shift from autotrophy ($P{:}R>1.0$) toward heterotrophy ($P{:}R<1.0$) once overhead emergent foliage is established (Figure 1)[1]. Murkin (1983) and Kairesalo (1980) provided evidence that severe environmental conditions can affect macroinvertebrate distributions. Macroinvertebrates probably respond to adverse environmental conditions through adaptive life histories (e.g. Anostraca, Cladocera) and physical adaptations (e.g., air tubes) in temporary and seasonal wetlands, and shifts in spatial distributions in more permanent wetlands (Pennak 1978).

Once submersed plants become established in open water areas during early summer, macroinvertebrates are afforded areas of complex substrates (Krull 1970) (Figure 1) with

[1] *P:R* refers to the community production:respiration ratio. *P:R* ratios less than one are indicative of areas where decomposition rates are high and oxygen levels are depressed. These conditions are referred to as being heterotrophic (Wetzel 1975). When production is high relative to respiration, the *P:R* ratio is greater than one. These conditions are termed autotrophic and oxygen is generally abundant.

benign physical environments (Driver 1977, Murkin 1983). Submersed plants support productive assemblages of algal epiphytes (Allanson 1973, Cattaneo and Kalff 1980) which continue to be important food resources for invertebrates. Additionally, communities of collector invertebrates within submergent communities may filter FPOM transported in suspension from adjacent emergent litter accumulations (e.g., Wallace and Merritt 1980).

In summary, we believe emergent litter accumulations shift in function along a time gradient in response to changing water levels and temperatures. During initial flooding they provide a structurally complex and productive habitat for macroinvertebrate communities. Environmental conditions progressively deteriorate in these areas causing spatial shifts in invertebrate distributions. However, these litter accumulations continue to be a source of nutrition for invertebrate communities because FPOM released during microbial decomposition is transported to populations established in adjacent flooded openings. These openings are dominated by submersed macrophytes, providing a complex structural habitat, abundant food resources, and favorable environmental conditions.

Opening Sizes—Horizontal Structure

Within emergent stands, we believe that flooded litter accumulations which are adjacent to openings are functionally most important because they directly impact macroinvertebrate production. These areas provide the most accessible substrates to invertebrates during spring because physical conditions deteriorate as water depth decreases away from openings. Also most of the FPOM in transport should be produced during summer from litter accumulations nearest openings because water current velocity which affects transport potential declines with distance into an emergent stand (Knutson et al. 1982).

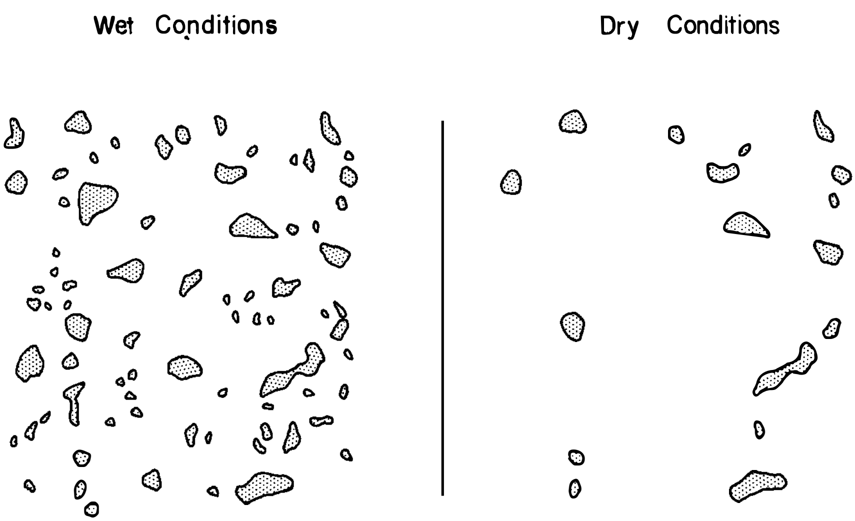


Figure 2. Changes in land-water interspersion in response to availability of water in a typical prairie pothole section (1 square mile or 2.6 km^2).

The horizontal structure of an individual wetland is determined to a large extent by patterns and ratios of flooded openings and emergent vegetation. By analogy we argue that horizontal structure of a wetland complex is also a function of patterns and ratios of flooded openings (i.e., individual wetlands) and surrounding uplands (Figure 2). Potential for FPOM transport and for submersed plant establishment is a function of opening size whether the opening is a wetland surrounded by a fringe of emergent vegetation or an opening within a matrix of emergent vegetation.

Macroinvertebrate communities should be least productive in large unprotected openings. Large wind-swept openings are characterized by low invertebrate abundance and survival (Jonasson and Lindegaard 1979). Submersed plants which provide important macroinvertebrate production areas during summer are also negatively impacted by wind action and the turbid conditions (e.g., Wetzel 1979, Anderson 1978) associated with large shallow wetlands. Generally, submersed macrophytes are most productive in openings sheltered from excessive wind; i.e., sheltered by emergent communities or surrounding uplands.

Conditions in small shallow sheltered openings may also negatively impact macroinvertebrate populations. Although small openings may be colonized by submersed plants, physical conditions fluctuate widely on a diel basis (see Swanson 1977) and quantities of FPOM in transport are probably reduced because of insufficient wind and wave action.

Wetland Quality—Flooding Depth

Hypothetically, emergent litter accumulations must be flooded during early spring to allow the establishment of epiphytic algae and colonization by macroinvertebrate communities. The processes of litter decomposition and transport also require that emergent stands be flooded. When litter accumulations are shallowly flooded or stranded during years of low precipitation and little spring runoff, macroinvertebrate production should decline.

Wetland Basins—Drawdowns

Yearly changes in spring water conditions are closely tracked by changes in wetland vegetative structure. During drought years when water levels decline, emergent vegetation stands expand vegetatively and by seedling recruitment onto exposed mudflats which were formerly flooded openings (van der Valk and Davis 1978, van der Valk 1981).

Shallowly flooded and dry semi-permanent basins are often overgrown with extensive areas of emergent vegetation interspersed with a few remnant small openings (e.g., Weller 1981). Under these conditions, macroinvertebrate production declines when communities are not adapted to strongly heterotrophic conditions (Swanson and Meyer 1977). As the size and number of flooded openings expand following reflooding, macroinvertebrate production increases (Voigts 1976) and reproduction effort by waterfowl increases (Weller and Fredrickson 1974, Weller and Spatcher 1965).

Wetland Complexes—Droughts

In wetland complexes, habitat structure changes with yearly variation in wetland numbers. Virtually all the annual variation in pond numbers within wetland complexes in the prairie pothole region is due to variation in numbers of flooded temporary and seasonal wetland basins (Kantrud and Steward 1977, Stoudt 1971) (Figure 2). Varying levels of water/land interspersion are achieved according to how wet or dry conditions are within any wetland complex. During droughts, only permanent wetlands hold water and the highly productive temporary basins remain dry (Swanson and Meyer 1977)[2]. Water levels in permanent wetlands are low, stranding emergent stands and diminishing macroinvertebrate production in these wetlands as discussed in the previous section.

During years of abundant precipitation and runoff, good interspersion of water and uplands results as the temporary basins fill. Productive feeding areas are available to pairs and broods because litter accumulations in both temporary and permanent wetlands are flooded (Krapu 1979, Swanson and Meyer 1977). When temporary basins are flooded, macroinvertebrate populations are extremely productive. Production is compressed into a few weeks because these basins dry through the summer. Invertebrate life cycles are adapted to the ephemeral nature of these wetlands (Krapu and Swanson 1975). Water conditions in many temporary and permanent basins often remain good following wet springs, making abundant brood-rearing habitat available (Talent et al. 1982).

Summary—Waterfowl Habitat Selection

Bailey (1981) presented a conceptual framework linking breeding ground habitat suitability to reproductive effort and success. Waterfowl returning to breeding areas of high suitability are expected to exhibit high reproductive effort and success. Conversely, those returning to areas of low suitability are expected to withhold reproductive effort unless the probability of surviving to the next breeding season is low. By adopting these reproductive strategies in relation to variation in habitat suitability, costs of reproduction are minimized relative to potential benefits (i.e., inclusive fitness is maximized).

Macroinvertebrates are an important source of nutrition for breeding hens and young broods of most species of waterfowl. Renesting effort has been positively associated with increased food availability (Swanson and Meyer 1977, Krapu 1979), and to improved summer wetland conditions (Pospahala et al. 1974). Krapu (1979) and Bengtson (1971) have related smaller clutch sizes to reduced food availability and quality. Many have demonstrated the importance of invertebrates in the diet of young ducklings (e.g., Collias and Collias 1963, Chura 1961, Sugden 1973, Swanson 1977, Talent et al. 1983). Thus, we contend that the suitability of waterfowl breeding habitat may be in part determined by its potential for supporting productive macroinvertebrate communities.

Our conceptual framework provides a functional basis for the importance of interspersion during habitat selection by breeding waterfowl which depend on macroinvertebrate food resources. Conditions should be optimal for macroinvertebrate production when protected openings, large enough to allow FPOM transport, are fringed by emergent vegetation and interspersed within a wetland basin. Similarly, when both temporary and more permanent basins are flooded in a wetland complex, macroinvertebrate production should be high. Interspersion or horizontal structure can therefore be functionally related to macroinvertebrate production both within wetlands and across wetland complexes. Habitat structure should generally index habitat suitability for breeding waterfowl which depend on macroinvertebrates for successful reproduction.

Although we provide a conceptual basis for habitat selection operating on the basis of structural cues to potential food resources, these cues may also be associated with other

[2] For simplicity, we define permanent basins to include Type IV and V wetlands and temporary basins to include Type I, II, and III wetlands. Original classification follows Stewart and Kantrud (1972).

factors which also affect habitat suitability for breeding waterfowl. (e.g., pair spacing, nesting cover). However, because macroinvertebrate production can be directly related to factors which are known to affect reproductive effort by waterfowl, food should be an important component of habitat suitability.

Seasonal and temporary wetlands are important components of wetland complexes and conceptually play a major role in determining habitat suitability for breeding waterfowl. These same wetlands face the most pressure from agricultural drainage (Swanson and Meyer 1977) and are being destroyed at an increasing rate (Kiel et al. 1972). Understanding how habitat structure affects habitat suitability has important implications for wetland protection programs. Like Talent et al. (1983), we emphasize that entire complexes of wetlands need to be set aside as opposed to individual basins.

Acknowledgements

The Delta Waterfowl Research Station provided the facilities and atmosphere necessary for the development of this paper. We acknowledge those who saw to it to publish the studies on which our ideas are based. C. Hawkins, M. Heitmeyer, R. Kaminski, H. Murkin, F. Reid, and A. van der Valk have provided helpful suggestions on earlier drafts and during various discussions. The study during which these ideas were conceived was part of the Marsh Ecology Research Project and was funded by Ducks Unlimited Canada and the Delta Station. This is paper Number 11 of the Marsh Ecology Research Project, Delta Waterfowl Research Station, Delta, Manitoba, Canada.

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Vegetation Change and Seed Banks in Marshes: Ecological and Management Implications

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Introduction

"Natural" waterfowl habitat management (Weller 1981) involves the use of natural forces (e.g., water levels, muskrat activity) to develop a mosaic of native plant communities, i.e., a habitat complex. Such a complex is designed to provide the nutritional and structural requirements for not only waterfowl, but also for a large variety of migratory bird and nongame species (Fredrickson and Taylor 1982). Natural management is less costly, more permanent, more esthetically pleasing, and provides more resources for wildlife than do standard agronomic practices (Fredrickson and Taylor 1982). Because natural marsh management is primarily the application of ecological principles, the successful development of a habitat complex requires a conceptual grasp of vegetation dynamics and a detailed understanding of the biological and physical factors that produce vegetation changes in wetlands.

Vegetation Dynamics in Wetlands

Plant communities in wetlands are typically described as distinct zones or bands of vegetation that follow shoreline contours (Stewart and Kantrud 1972, Cowardin et al. 1979). Actually, individuals of different plant species are distributed independently along environmental gradients, with each species surviving under a specific set of environmental conditions (Swindale and Curtis 1957, Mandossian and McIntosh 1960, Beschel and Weber 1962, Raup 1975, van der Valk and Davis 1976a).

As environmental conditions change, plant species are redistributed as some populations are eliminated and others become established along the new environmental gradient. This "resorting" of vegetation is a function of recruitment from buried seed reserves (van der Valk and Davis 1978), buried vegetative propagules (Lieffers and Shay 1982), and the dispersal of propagules (Hall et al. 1946).

Once established, wetland vegetation can change both qualitatively, i.e., floristically, and quantitatively, i.e., species' abundance and physical structure. For these reasons, van der Valk (1984) has separated vegetation change into three separate phenomena: succession (the establishment of new populations or the extirpation of existing populations), maturation (the growth of individuals in established populations), and fluctuation (the year-to-year changes in density or size of individuals within established populations).

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All attributes of vegetation change (i.e., succession, maturation, fluctuation) are the result of changes within individual populations of the species which make up the wetland community. Therefore, the key to understanding and predicting vegetation change is a knowledge of the life-history characteristics of the species in the vegetation, since life-history features determine how each population will respond to the physical-chemical environment, competition, herbivory, and disease.

Life history characteristics that are potentially important for predicting vegetation change include: seed production, dispersal, longevity, and germination requirements; growth form and life span; and growth rate under different environmental conditions. When life-history information is combined with information about the biological and physical factors that cause vegetation change (for reviews, see Kadlec and Wentz 1974, Hutchinson 1975, Davis and Brinson 1980, Olson 1981, Ogaard et al. 1981), more reliable predictions about vegetation dynamics can be made.

This approach was first demonstrated by Hall et al. (1946) who used information on seed germination, seed dispersal, and water tolerance of wetland species to devise management regimes to control vegetation in Tennessee reservoirs. Other studies of wetland successions (Kadlec 1962, Harris and Marshall 1963, Weller and Spatcher 1965, Meeks 1969, Weller and Fredrickson 1974, van der Valk and Davis 1978, 1979) have also documented the importance of characterizing life-history features. The utility and predictive power of this approach make it a powerful tool for wetland managers.

To predict vegetation change for a particular wetland, two sets of information are needed: (1) the potential flora of the wetland, and (2) the life-history type of each species. The potential flora includes all species found growing in the wetland, plus all additional species represented as seeds and propagules in the soil. Life-history information may be gleaned from the literature (Sculthorpe 1967, Kadlec and Wentz 1974, Hutchinson 1975, Herner and Co. 1980, see also the Information and Retrieval Service of the Aquatic Weed Program, University of Florida, Gainesville, FL 32611), or from long-term field studies (Hall et al. 1946, Connelly 1979, Fredrickson and Taylor 1982). However, much of the information needed for a particular wetland can be obtained by examining its' seed bank.

Seed Bank Studies

Seed bank studies involve collecting surface sediment samples from the marsh and exposing subsamples of each sample to conditions similar to those of an exposed mud flat and to those of a flooded wetland. The number of seedlings of each species (whose seeds germinated under the simulated drawdown and submersed conditions) are recorded after a suitable amount of time has passed, usually several months. Further information on the collection, preparation, and treatment of seed bank samples can be found in a review by Roberts (1981), and papers by van der Valk and Davis (1978) and Pederson (1981).

Van der Valk (1981) used seed bank information to develop a qualitative model for predicting wetland succession. Plant species were classified into life-history types on the basis of: (1) life span, (2) propagule longevity, and (3) propagule establishment requirements. This information was used to construct successional sequences (under different environmental regimes) for prairie glacial marshes and a fringe papyrus swamp (van der Valk 1981) and for a shallow southern lake (van der Valk 1980). In all cases, the model predicted changes which did actually occur in the field.

Although van der Valk's model is qualitative (it only predicts which species will be present and does not predict their relative abundance), additional insight into potential vegetation response can be obtained by a more detailed analysis of seed dispersal and the spatial variation in the composition of the seed bank.

Seed Banks of Wetlands

In prairie pothole marshes, there is relatively little within-marsh variation in the composition of the seed banks (van der Valk and Davis 1976b). However, in other types of wetlands, there is considerable spatial variation in the location, size, and composition of buried seed reserves.

Seed Distribution in the Delta Marsh

Figure 1 summarizes data from a seed bank study (Pederson 1983) of the Delta Marsh (a large lacustrine wetland) located on the southern end of Lake Manitoba in Manitoba, Canada. The distribution of buried germinable seeds (calculated from numbers of seedlings which grew from substrate samples) is plotted against elevation in Figure 1 (species are grouped according to life-history types). The transition zone between aquatic and terrestrial habitats is located between elevations 247.4 m to 247.7 m.

Regardless of dispersal or life-history type, highest seed concentrations were located in soil samples from the shoreline zone and very few seeds were located in samples from open water areas. This seed bank distribution resembles that of seed banks of lake shores (Keddy and Reznicek 1982), lake basins (Haag 1983), and saline wetlands (Smith and Kadlec 1983), and reflects the fact that the Delta Marsh is a littoral wetland not subject to extreme fluctuations in water levels; i.e., open water areas are always flooded even during periods of low water, and a seed bank is never developed.

Seed Dispersal in the Delta Marsh

Shoreline seed accumulations are caused by water movement depositing seeds along drift lines. This is illustrated in Figure 2, which shows the elevational distribution of seed rain for one year. Seed rain for all emergent species (whether they produced large seeds or light wind-dispersed seeds) and from submergent species was highest in shallow water areas of the shoreline zone. Few seeds were collected in seed traps located in deeper water. Similar dispersal patterns in other wetlands were documented by Hanson (1918), Hall et al. (1946), and Smith and Kadlec (1978), who observed that shoreline emergent communities (e.g., cattails and bulrushes) effectively trap both water- and wind-dispersed seeds.

Annual species contributed very little to the seed rain (Figure 2). This reflects the low occurance of these species in the present vegetation (Table 1). However, annuals and other "disturbance" species (e.g., *Scirpus validus* and *Scirpus maritimus*) are well-represented as viable seeds in the seed bank (Table 1). This implies that a quite different environment once occurred in the marsh.

Vegetation History in the Delta Marsh

Since seed banks contain a historical record (in the form of viable seeds) of past vegetation change (van der Valk and Davis 1979), additional insights about vegetation dynamics of a wetland can be gained by examining the composition of seeds at different depths in the substrate.

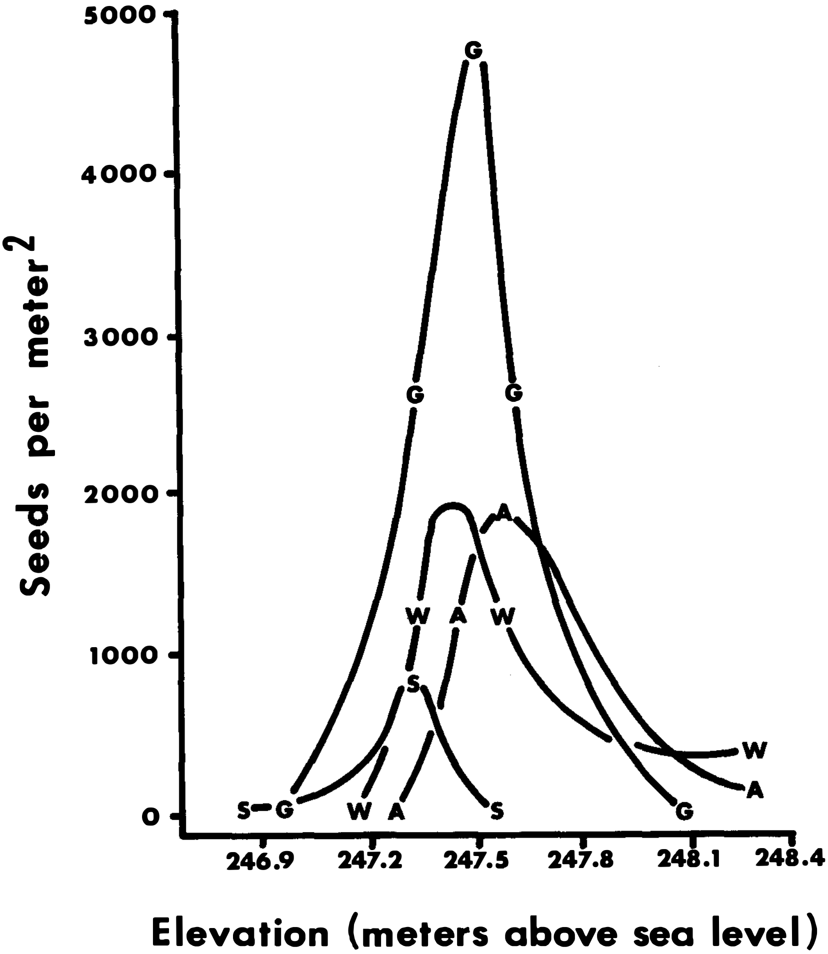

Figure 1. Distribution of buried seed populations along an elevational gradient in the Delta Marsh, Manitoba.

G = Seeds of emergent perennials (*Carex atherodes*, *Scirpus* spp., *Scolochloa festucacea*) which produce large seeds (achenes or grains).

W = Seeds of emergent perennials (*Phragmites communis*, *Typha* spp.) which produce small wind-dispersed seeds.

A = Seeds of annuals (*Aster brachyactis*, *Atriplex patula*, *Chenopodium rubrum*, *Ranunculus sceleratus*, *Rumex maritimus*).

S = Seeds of submergent aquatics (*Potamogeton pectinatus*, *Utricularia vulgaris*, *Zannichellia palustris*).

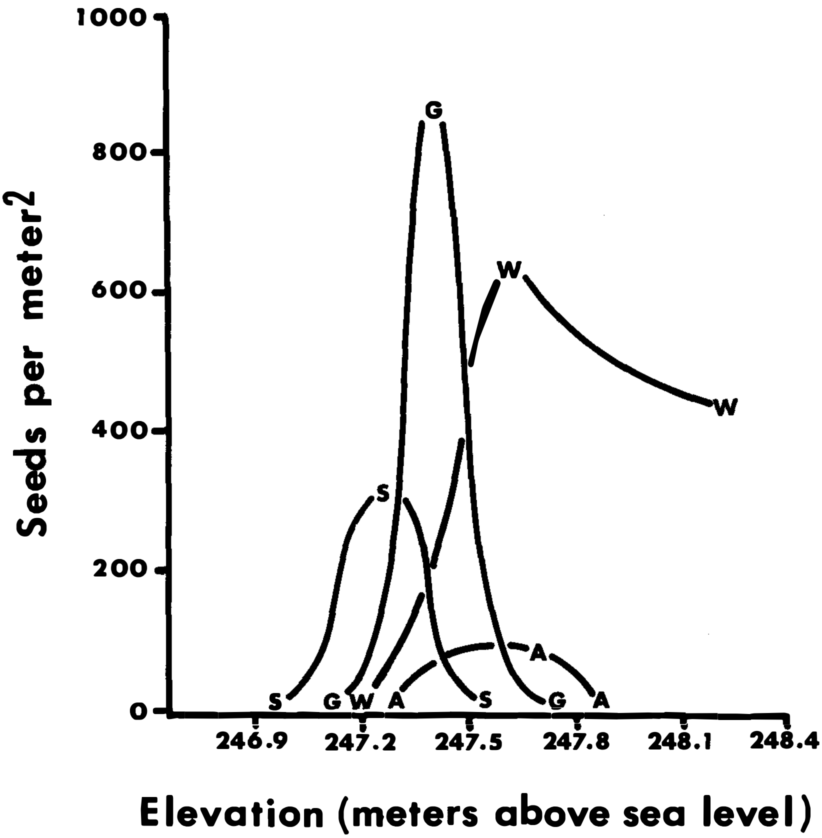

Figure 2. Distribution of seed rain (calculated from seeds collected in seed traps over a period of one year) along an elevational gradient in the Delta Marsh, Manitoba.

G = Seeds of emergent perennials (*Carex atherodes, Scirpus* spp., *Scolochloa festucacea*) which produce large seeds (achenes or grains).

W = Seeds of emergent perennials (*Phragmites communis, Typha* spp.) which produce small wind-dispersed seeds.

A = Seeds of annuals (*Aster brachyactis, Atriplex patula, Chenopodium rubrum, Ranunculus sceleratus, Rumex maritimus*).

S = Seeds of submergent aquatics (*Potamogeton pectinatus, Utricularia vulgaris, Zannichellia palustris*).

Table 1. Relative frequency ($n = 250$ points) of representative species in the Delta Marsh vegetation and in soil samples (seed bank). Data taken from Pederson 1983.

Species	% Frequency in existing vegetation (1979)	% Frequency in the seed bank (1980)
Annuals		
Aster brachyactis	0	25
Atriplex patula	1	23
Chenopodium rubrum	11	65
Ranunculus sceleratus	18	53
Rumex maritimus	1	25
Emergent Perennials		
Carex atherodes	15	28
Phragmites communis	43	38
Scirpus acutus	26	8
Scirpus maritimus	0	22
Scirpus validus	0	74
Scholochloa festucacea	24	28
Typha spp.	34	91

Table 2 illustrates seed profiles of soil cores taken from a *Typha glauca* community in the Delta Marsh. Annuals *(Chenopodium rubrum, Ranunculus sceleratus, Rumex maritimus)* and certain perennials *(Scirpus validus, Scirpus maritimus)* all exhibited their highest seed densities in the lower sections (4–8 centimeter depth) of the soil cores. Conversely, largest seed accumulations of *Typha* spp. and *Zannichellia palustris* occurred in the upper 4 centimeters of the soil core. This seed distribution profile suggests the site was once much drier (large seed accumulations from annual species), then became wetter and was dominated by *Scirpus* spp. In recent history, there has been a diminished seed input from annuals, and *Typha* has replaced *Scirpus* as the dominant vegetation on the site. The sequence of seed accumulation in the upper soil profile suggests a recent period of relatively stable water levels in the Delta Marsh, which in fact has occurred.

Since 1961 water levels in Lake Manitoba (and the Delta Marsh) have been stabilized by water control structures (Manitoba Department of Mines, Resources, and Environmental Management 1974). Stable water levels for the last two decades have resulted in a decrease in plant diversity in the marsh (which is reflected in the seed banks—Tables 1 and 2), and an increase in the importance of certain perennials (particularly *Phragmites communis*, which now covers 75 percent of the marsh area occupied by emergent vegetation—Bossenmaier 1968).

Seed Banks and Marsh Management

Smith and Kadlec (1983) used seed bank data in conjunction with soil data to recommend management options for saline wetlands in Utah. They noticed that when seed bank samples were covered with a few centimeters of water, soil salinities were much lower than in the drawdown samples. The lower salinity permitted seeds of more species to germinate in the submersed samples than the drawdown samples. This information

Table 2. Mean number (m^{-2}) of seeds found in 2 cm layers of soil (4 depths) from soil cores of *Typha glauca* communities in the Delta Marsh, Manitoba. Data adapted from Table 1–5 in Pederson (1983).

Species	Soil Core Section (depth from surface)			
	0–2 cm	2–4 cm	4–6 cm	6–8 cm
Chenopodium rubrum	25	0	475	775
Ranunculus sceleratus	0	250	1650	300
Rumex maritimus	0	0	950	25
Scirpus maritimus	12	122	585	95
Scirpus validus	606	6125	29250	4762
Typha spp.	625	125	63	0
Zannichellia palustris	1775	812	737	0
Total number of seeds	3068	7446	33710	5957

prompted Smith and Kadlec to recommend drawdowns which maintained very shallow water levels. This type of drawdown would still provide food resources for waterfowl and shore birds, permit submerged species to be retained, and discourage establishment of nuisance vegetation such as *Tamarix pentandra* (Smith and Kadlec 1983).

Management implications (derived from seed bank information) for the Delta Marsh indicate that the restoration of fluctuating water levels in the marsh would allow a diverse flora to develop from the seed bank. Table 3 outlines several predicted successional sequences for an open water community in the Delta Marsh. Although these predictions were made from seed bank data, similar vegetation sequences (Walker 1959, 1965) occurred during the last "natural" fluctuation of water levels (1954—1964).

In addition, the absence of large numbers of seeds in soil samples from the large bays indicates these areas may remain unvegetated if completely drained for management purposes. The location of large seed banks in the shoreline zone implies that partial drawdowns are probably the best option for promoting emergent vegetation.

The relationship of fluctuating water levels to vegetation diversity has been well recognized for the Delta Marsh (Bossenmaier 1968, Ducks Unlimited 1981), however, to date, efforts to instigate a management plan whereby water levels in the marsh can be controlled independently of Lake Manitoba have been fruitless. This situation is especially unfortunate, considering the tremendous importance of the marsh for wildlife (Bossenmaier 1968) and the potential of management for creating diverse habitats for a variety of wildlife (Fredrickson and Taylor 1982).

Summary

This paper has shown that seed bank studies can be used to provide information on plant life-histories, the potential flora, the distribution of buried seeds, the recent vegetation history, and the nature of seed dispersal. This information can be used by marsh managers to devise suitable management regimes (e.g., water level changes, irrigation schedules) for different types of wetlands (e.g., palustrine, lacustrine, riverine, saline) to develop the vegetation potential of seed reserves.

Table 3. Predicted successional sequences under different environmental regimes in a shallow, open water community in the Delta Marsh, Manitoba. Adapted from seed bank data in Table I-1 of Pederson (1983).

Dominant genera[a] in seed bank	Genera present in vegetation under different environmental regimes			
	After prolonged flooding and muskrat activity	After drawdown	Reflooding after drawdown	After prolonged flooding
Aster	—	*Aster*	—	—
Atriplex	—	*Atriplex*	—	—
Chenopodium	—	*Chenopodium*	—	—
Utricularia	*Utricularia*	—	*Utricularia*	*Utricularia*
Zannichellia	*Zannichellia*	—	*Zannichellia*	*Zannichellia*
Scirpus	—	*Scirpus*	*Scirpus*	—
Scolochloa	—	*Scolochloa*	*Scolochloa*	—
Typha	—	*Typha*	*Typha*	*Typha*

[a] *Aster, Atriplex,* and *Chenopodium* are mud flat annuals; *Utricularia* and *Zannichellia* are submerged aquatics; *Scirpus* and *Scolochloa* are perennial emergents intolerant of prolonged flooding; *Typha* is a perennial emergent tolerant of prolonged flooding.

Acknowledgements

Data used in this paper are derived from a Ph.D dissertation (Iowa State University) by the senior author. Financial support for that research from the Delta Waterfowl Research Station and Ducks Unlimited-Canada is gratefully acknowledged. We would like to thank Craig Davis, Charles Welling, Jeff Nelson, and John Kadlec for reviewing the manuscript and providing constructive comments. Paper No. 12 of the Marsh Ecology Research Program, Delta Waterfowl Research Station, Delta, Manitoba, Canada.

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Systems Evaluation of Okefenokee Swamp

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Introduction

This paper[1] considers the possibility of providing a formal basis in systems theory for research and management of wetlands and their wildlife. The approach has been used in theoretical ecology (Patten et al. 1976, Patten 1978, 1982, Patten and Auble 1981) to better understand the organism-environment relationship, and in ecosystem research to organize integrated studies of wetlands (Patten 1984a, 1984b).

Sciences like ecology, and their more applied counterparts such as wildlife management, cannot be said to be as advanced or rigorous as the "hard" sciences of mathematics, physics and chemistry. The latter, which define their own systems (mathematics), or study simpler systems than those involving organisms (physics, chemistry), have discovered laws of logic and nature which provide the bedrock foundation for all science. The laws of algebra and calculus, thermodynamics and mechanics, and chemical kinetics have familiar applications in many sciences. In the "soft" sciences, there seemingly are no laws discovered or discoverable, only phenomena to be described. Such laws as are articulated, like Liebig's law of the minimum and Gause's law of competitive niche separation in ecology, lack the standing of those from mathematics, physics, and chemistry. "Laws" from the social sciences are inclined to be facetious, such as Parkinson's and "Murphy's" well enjoyed principles.

This paper argues that the sciences of complex systems, roughly anything containing at least one organism, in fact deal routinely with lawful phenomena and have, in principle, the capacity to present their findings as laws which can take their place with those of chemistry, physics, and mathematics. The laws in question are systems principles, many of which have already been discovered in general and mathematical systems theory, and only await application in applied systems sciences. One of these laws is the causal principle, a sometimes difficult topic (e.g., Bunge 1959, Heise 1975, Brand 1976) that nevertheless has been formalized in modern system theory. The purpose of this paper will be to state the essence of causality in systems terms, and apply the resultant model to phenomena of wetlands to illustrate how readily behavioral features of these complex ecological systems can become explained and expressed in formal terms. This goal reflects a penchant of the author to see rigor and formalism enter ecology and guide its development to a higher kind of science than now exists. This paper will not achieve this, of course, but it should show that meaningful natural history and formal system theory are not so far apart that they cannot be usefully joined. The examples will be taken from Okefenokee Swamp, where an ecosystem study of almost 10 years' duration has been attempting to establish a system theory basis for ecological understanding.

[1] University of Georgia, *Contributions in Systems Ecology*, No. 60, and *Okefenokee Ecosystem Investigations*, Paper No. 48.

Okefenokee Swamp

The Okefenokee, situated on the lower Atlantic coastal plain of southeastern Georgia, is one of the major wildernesses remaining in the continental United States. It is large, 1754 km^2 in a 3781 km^2 watershed, and most is protected as a National Wildlife Refuge, and somewhat less as a National Wilderness Area. General elevation of the swamp is 37 m, and the watershed rises to 56 m on the western side (Figure 1). The climate of the region is humid subtropical, and the soils, which support Southeastern Evergreen Forest prevented by fire from becoming Southern Mixed Hardwoods (Monk 1968), are well

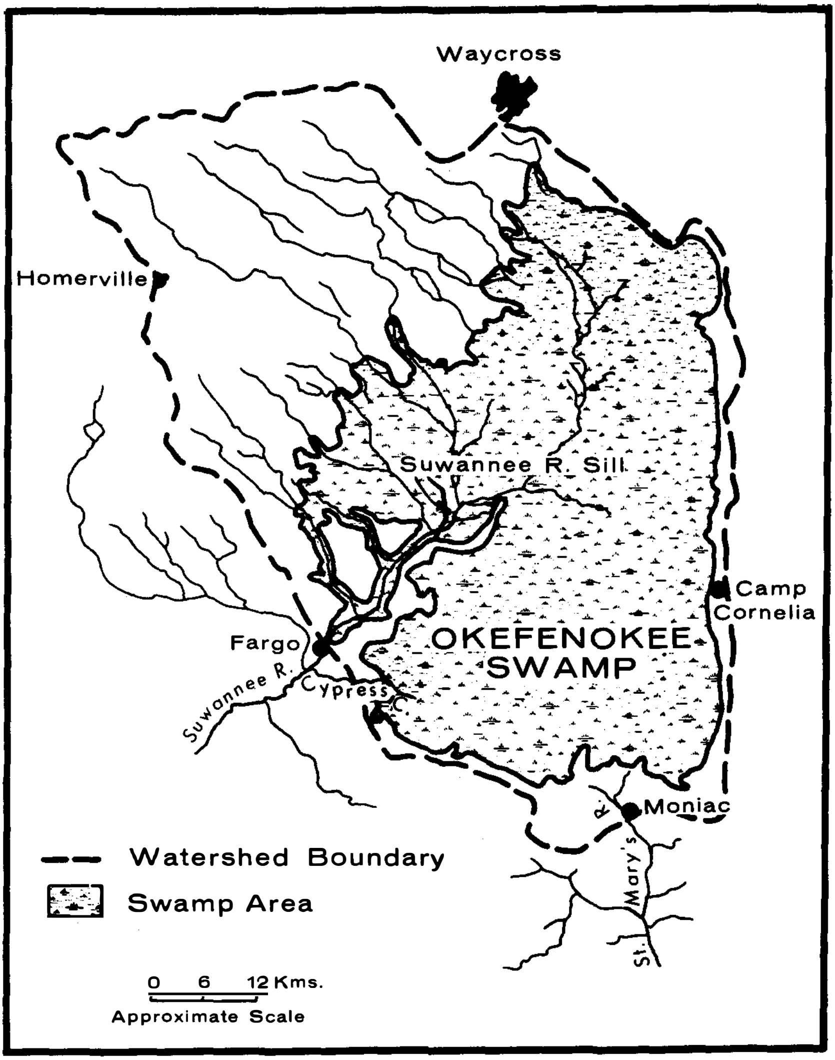

Figure 1.

leached sandy loams with shallow water tables, low pH, and low concentrations of plant nutrients. The swamp is a peat forming system, the basis for a detritus-based trophodynamics. Peat covers most of the geological substrate and isolates water and biota from soil minerals. Nutritionally, the Okefenokee is ombrotrophic, receiving most of its nutrients from rainfall (Beck et al. 1974, Rykiel 1977). Dissolved elements are lower than in world average lakes and rivers, e.g., in 1977 major cation ranges in $\mu g\ l^{-1}$ were: K=0.07–0.89, Na=2.67–7.00, Ca=0.69–1.98 and Mg=0.27–0.91 (Bosserman 1981). Sodium is the dominant cation in swamp water and precipitation (Rykiel 1977, Bosserman and Hagner 1981) due to proximity to the sea. Water chemistry and biology are influenced by low pH, in the range of 3.8–4.2 (Bosserman 1981).

Water levels and its fluctuations are major factors in nutrient dynamics, peat decomposition, productivity, and plant succession. This variable, together with fire and several anthropogenic influences, are major determinants of community types within the swamp. All major kinds of wetlands appearing in the classification by Cowardin et al. (1976) are represented in the Okefenokee: lakes, aquatic macrophyte marshes, *Sphagnum* beds, shrub swamps, and swamp forests of several different types. Shrubs (*Lyonia, Cyrilla*) occupy 34 percent of the palustrine area, cypress (*Taxodium*) forests 23 percent, aquatic macrophyte, (*Utricularia, Nymphaea, Orontium*) and grass-sedge (*Panicum, Carex*), marshes 21 percent and bay forests (*Gordonia, Persea, Magnolia*) 6 percent (Hamilton 1977). Most precipitation falling on the uplands is lost as evapotranspiration, whereas only 54 percent of swamp rainfall exits the watershed by this means (Patten and Matis 1982). Twenty-two percent of upland precipitation flows to the swamp as surface streamflow. Two streams flow out of the watershed, the Suwannee (88 percent) and St. Mary's (12 percent) Rivers (Patten and Matis 1982). A man-made structure, the Suwannee River sill (Figure 1), was installed in 1960 in response to major fires in 1954–55 to retard burning. This sill has raised the water level measurably all the way to the vicinity of Camp Cornelia on the eastern side (Figure 1) and also has damped historical water level fluctuations (Finn and Rykiel 1979). Heavy logging occurred during the first quarter of the present century (Izlar 1972), removing more than 90 percent of the merchantable cypress timber, routinely consisting of 900 year old specimens. The oldest tree recorded in recent times in 587 years (Duever and Riopelle 1983). Prominant vertebrates in the swamp include alligators (*Alligator*), sandhill cranes (*Grus*), wood storks (*Mycteria*), white ibis (*Eudocimus*) and wood ducks (*Aix*).

The State Space Dynamical System

In system theory, a *system* is defined as a partially interconnected set of components. "Partially" means some of the components interact some of the time while others do not. The components are various objects or groups of objects, or possibly processes or sets of processes, and their interconnection is achieved by a variety of interactions between them. Competition and predation are the two kinds of interactions given most attention in ecological literature. Ecological components usually fall into five categories: organisms, resources, intraspecific populations, interspecific communities, and ecosystems which include both biota and abiotic categories. Interconnections include: binary interactions between two components, sequential or serial interactions such as food chains, interactive networks such as food webs, and cybernetic networks in which energy and matter exchange are regulated by negative feedback of information (Patten and Odum 1981).

All of these categories of ecological systems can be formalized as causal systems by the state space (Zadeh and Desoer 1963) or general dynamical system (Mesarovic and Takahara 1975) theory. The capacity to interact is the same as the capacity to have an environment, and this is a characteristic of open systems. Most open systems have both inputs z_t and outputs y_t, where t is time. The input time functions z_t, beginning just after time t, which an object may experience comprise a set Z, and similarly the repertoire y_t of responses to these inputs, beginning also the moment after t, constitutes an output set Y. The times of interest are specified from a time set T. An interval $(t, t']$ begins right after t and extends to and including t'.

Most systems do not give a unique response to a given input; they respond multiply. To obtain an input-output *function*, meaning for one cause there is a unique effect, it is necessary to supply information about the internal condition of the responding system at the time input is received. This is the state $x(t)$ at time t, whose values also come from a set X, the state space. It is the important role of the states from X in establishing uniqueness between the elements of Z and Y that gives the name *state space* system. Such systems are also termed *dynamical* or *determinate*. These systems exist in a stimulus-providing environment, and generate unique responses to unique excitations based on internal state. The only other property required to make them causal is that they be "nonanticipatory": the response shall not precede the stimulus (e.g., Patten et al. 1976).

Mathematically, the determinate system is modeled by a pair of functions: the *response function* ρ taking input and state into output:

$$y=\rho(z,x), \text{ or } \rho:Z\times X\rightarrow Y,$$

where ZxX is the Cartesian product (the set of all ordered pairs (z,x) of the elements) of the sets Z and X, and the *state transition function* ϕ:

$$x=\phi(z,x), \text{ or } \phi:Z\times X\rightarrow X,$$

which provides the means of changing state with time. Time may be either discrete or continuous; for ease of description and depiction, examples of the discrete type will be used.

Figure 2 illustrates the operation of the response-transition function pair on an interval $[t, t']$, from t to t' inclusive. The initial state $x(t)$ at time t and input $z_{tt'}$ are operated upon by ρ to generate $y_{tt'}$ on $(t, t']$ and ϕ produces several (shown) intermediate states prior to leaving the system in state $x(t')$ at the end of the interval. A vegetation map of the Okefenokee (McCaffrey and Hamilton 1980) has been produced based on aerial photography flown in 1977. This spatial mosaic of plant communities represents the state of the system $x(t')$ at the end ($t'=1977$) of a long history of lawful development provided by a response-transition function pair operating at every point in space under the stimulus of a unique history of inputs, $z_{tt'}$. The state at the end of this history, $x(1977)$, represents the initial state for future continuation of dynamical behavior under the influence of subsequent inputs, $z_{t'}$. By now, this development has culminated in the present state of the vegetation, $x(1984)$, which may or may not be distinguishable from that recorded in 1977 depending upon the resolution of observations employed.

Example 1

To illustrate the operation of the state space formulation, consider the roles of water level and fire in determining Okefenokee vegetation.

Let fire be an input variable $z1$, taking values (light, moderate, severe, etc.) from a set Z. Vegetation can be represented by an output variable y that assumes values (undamaged, slightly damaged, severely burned, etc.) from another value set Y. If water level

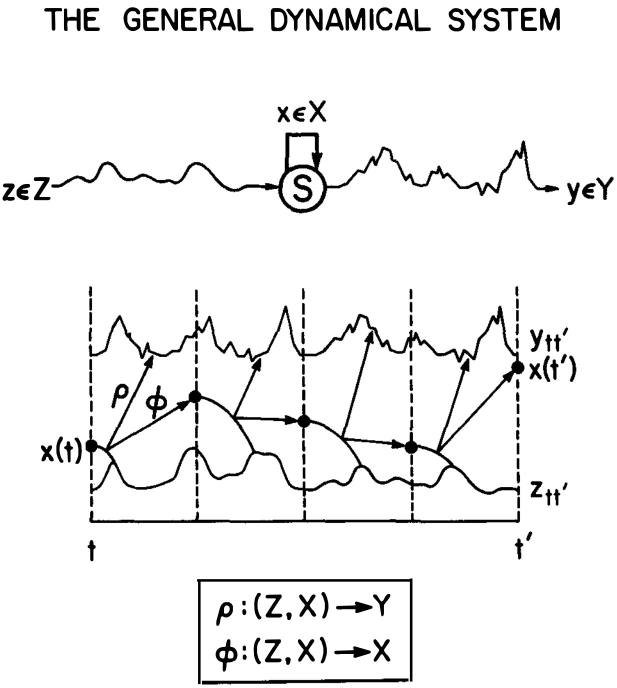

Figure 2.

is high, then fire damage will tend to be lighter than otherwise; water level mediates the vegetations's response to fire, and therefore, becomes a state variable x to which values are assigned from X (say cm above mean sea level). The swamp's response to fire can then be expressed by a response function ρ which maps fire severity $z1$, and water level x, into vegetation response y. Furthermore, water level is a function of precipitation and current water level. Precipitation can be represented by a second input variable $z2$, which takes values (e.g., mm of rainfall, etc.) from the input value set Z. Therefore, water level in the swamp can be generated dynamically by a transition function φ which takes precipitation $z2$ and water level x into subsequent water levels.

Some general rules follow. Given two identical systems (same lawful behavior as defined by identical ρ and φ functions): (1) identical inputs and states will yield identical outputs, (2) identical inputs but different states will yield different outputs, and (3) different inputs with identical states will also yield different outputs.

Ecological Disturbance Theory

In developing a systems evaluation of a large, complex ecosystem like the Okefenokee, it is quickly apparent that the system is not a pristine wilderness evolving dynamically through time without perturbation. To the contrary, Okefenokee Swamp is dominantly a product of the disturbances it has historically experienced. Given a representation as a dynamical system, and the need to incorporate disturbances into this description, there are only four ways to do this: (1) change the state, (2) change the input, (3) change the transition function and (4) change the response function. The consequences of making each of these kinds of perturbations will be described and illustrated in the sections which follow.

Case 1. Change of State

Figure 3 illustrates the consequences of making an intial state change. At the beginning of the interval $[t, t']$ are indicated two different states, $x1(t)$ and $x2(t)$. The system whose alternative states these are is subjected to input $z_{tt'}$. The transition function ϕ, representing the system as a lawful object, generates two different final states at the end of the interval, $x1(t')$ and $x2(t')$. The system response function generates a different output, $y1_{tt'}$ and $y2_{tt'}$, corresponding to each initial state, $x1(t)$ and $x2(t)$. The sources of these two output behaviors is in this case the different initial states. If initial state is changed, dynamical system behavior will also be changed for all time in the future.

Example 2

Figure 4 illustrates this case in terms of the effect of water level (state) on the composition of Okefenokee vegetation (output).

If fire does not occur, $z1_{t't''}$, and water level remains above the peat surface, $x1(t')$ (Figure 4, top), then mixed cypress (*Taxodium*)-bay (*Magnolia, Persea, Gordonia*)-blackgum (*Nyssa*) stands, $y1_{tt'}$, are replaced by mixed hardwoods, $y2_{t't''}$, containing

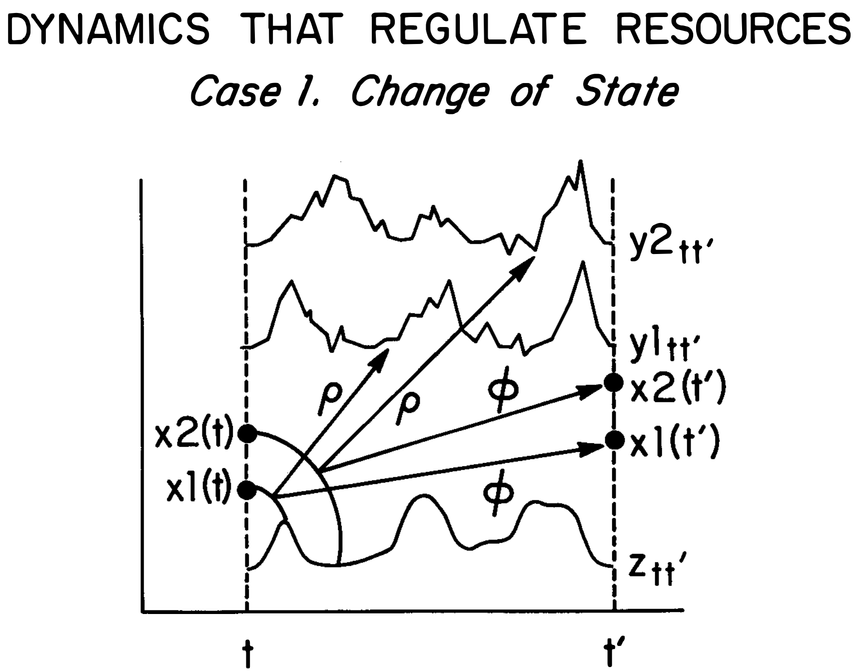

Figure 3.

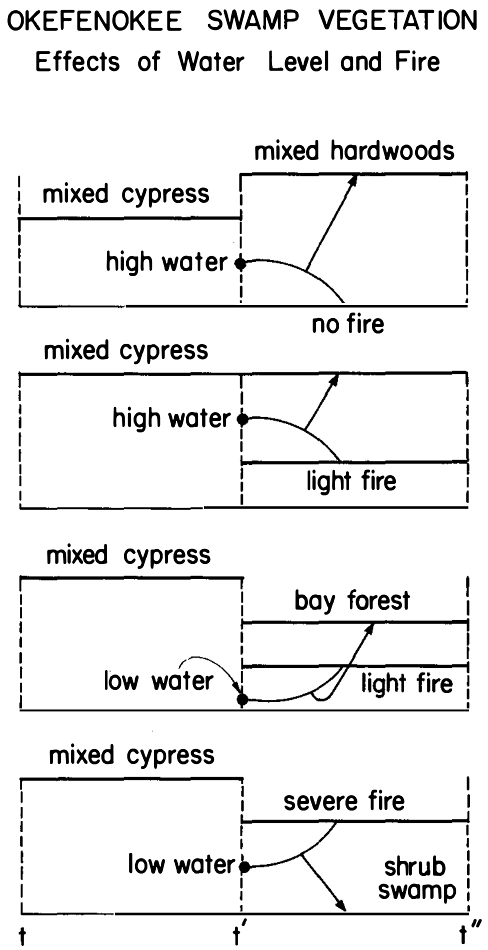

Figure 4.

blackgum, bays, maple (*Acer*), ash (*Fraxinus*), oak (*Quercus*) and sweetgum (*Liquidamber*). Light or moderate fires, $z2_{t't'}$ (Figure 4, second from top), under these water level conditions, are required to maintain the cypress-bay-blackgum stage. If water levels are lowered, $x2(t')$, to at or below the peat surface (Figure 4, third from top), corresponding to a different initial state, light to moderate fires, $z2_{t't''}$, produce bay swamps, $y3_{t't''}$. However, prolonged occurrence of low water, $x2(t')$ (Figure 4, bottom), may lead to severe fires, $z3_{t't'}$ (a change of input), in which case the low water initial state generates cypress-shrub (*Lyonia, Cyrilla, Ilex, Itea, Leucothoe*) swamps, $y4_{t't''}$.

Here, severe fire is a secondary result of the initial low water state, and these two conditions together produce a unique vegetation response not observed under high water and light fire conditions. The operative disturbance is the lowering of the water level accompanying drought, and it is modeled in Figure 4 as a change of state.

Case 2. Change of Input

In the previous example, fire frequency and severity changed as a secondary response to a primary state change. A second kind of disturbance to a dynamical system is one involving a primary alteration of input. Figure 5 shows a system in initial state $x(t)$ subjected to two different inputs, $z1_{tt'}$ and $z2_{tt'}$. The response function ρ generates two different outputs, $y1_{tt'}$ and $y2_{tt'}$, corresponding to the two inputs. The state transition function φ produces two different states, $x1(t')$ and $x2(t')$, at the end of the interval. Subsequently, even with only one input function $z_{t'}$, two behaviors, $y1_{t'}$ and $y2_{t'}$, are possible, according to the case 1 situation, in response to the two different states at t'. In this case, then, a secondary state change arises from a primary change of input. The general result is if input is changed, the behavior of the dynamical system will also be changed for all future time.

Example 3

Case 2 can be illustrated by water level control of lignin and lignocellulose decomposition in the Okefenokee. Here, water level will be considered an input variable. Figure 6 summarizes some lignocellulose and lignin contents of selected swamp plants. In general, the aquatic macrophyte species such as *Nymphaea, Orontium* and *Utricularia* have low concentrations of these complex molecules, whereas the woody species such as *Pinus* and *Taxodium* have relatively high concentrations. When these plants die, the rates at which their lignin and lignocellulose are decomposed are controlled by water level.

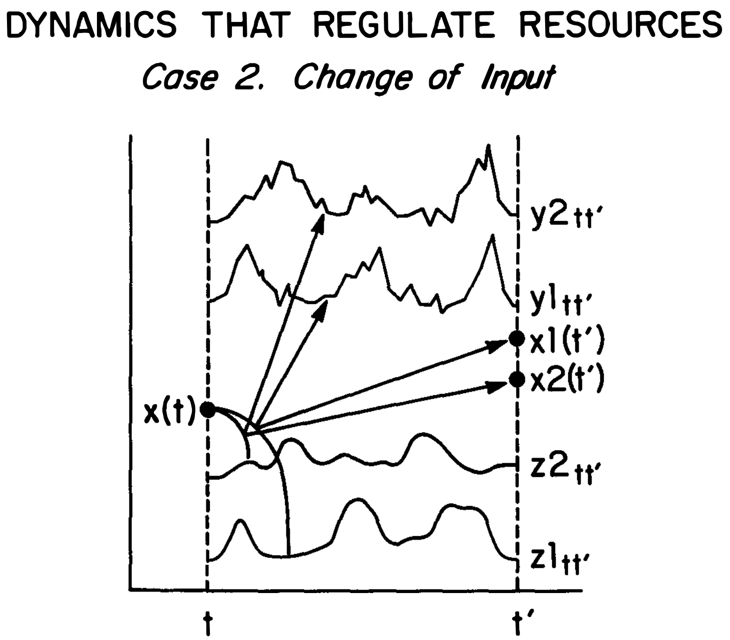

Figure 5.

LIGNOCELLULOSE AND LIGNIN CONTENT OF SELECTED OKEFENOKEE SWAMP PLANTS

Genus	% Extractive Free Lignocellulose	% Klason Lignin
Carex	84.6 ± 1.6	12.5 ± 2.1
Nymphaea	54.8 ± 0.2	7.2 ± 0.2
Orontium	54.9 ± 2.7	4.1 ± 0.8
Panicum	84.7 ± 1.6	15.0 ± 0.3
Pinus (Cambial Wood)	60.7 ± 2.6	20.9 ± 0.9
Taxodium (Wood)	83.8 ± 0.2	37.0 ± 0.4
Utricularia	47.1 ± 0.4	4.8 ± 0.2

Figure 6.

Specifically, the cellulose moiety of lignocellulose is decomposed two to four times faster than lignin, and these rates are reduced to only 25 percent under anaerobic conditions. Anaerobic conditions occur when water levels are high, and the prevailing decomposition processes under these circumstances include fermentation, denitrification, sulfate reduction and methanogenesis, which yield methane and occasionally hydrogen sulfide as gaseous products. Aerobic decomposition yields carbon dioxide, and occurs most rapidly when water levels are low so that surface litter and peat are exposed to the atmosphere.

Figure 7 represents the situation as a general dynamical process. Here, beginning with an aerobic microbial community $x1(t)$ under low water input conditions $z1_{tt'}$, carbon dioxide $y1_{tt'}$ is generated during the first subinterval $(t, t']$, and the system is left in an aerobic state $x1(t')$ at t'. Beginning in this state on the second subinterval $(t', t'']$, input change to a high water condition, $z2_{t't''}$, transforms the state to anaerobic, $x2(t'')$, while carbon dioxide, $y1_{t't''}$, continues to be generated in response to the initially aerobic state, $x1(t')$. The system begins the third subinterval $(t'', t^{(3)}]$ anaerobically, $x2(t'')$, and this with continued high water, $z2_{t''t^{(3)}}$, generates methane as output, $y2_{t''t^{(3)}}$ and also continues the anaerobic state, $x2(t^{(3)})$. Beginning in this state in the last subinterval $(t^{(3)}, t^{(4)}]$, where water levels now become lower, methane continues to be generated over the interval, $y2_{t^{(3)}t^{(4)}}$, where water levels now become lower, methane continues to be generated over the interval, $y2_{t^{(3)}t^{(4)}}$, but the system is left in a final state, $x1(t^{(4)})$, which is aerobic.

The change in water level as input from low to high induces a state change from aerobic to anaerobic decomposition, and this is registered as measurable change in the kinds of gases generated from these processes. Once a change of state has been induced from an input change, the subsequent pattern follows along the same lines as Case 1, change of state. As this example illustrates, it is possible to provide a lawful rendering of the complex processes of water level control of lignin and lignocellulose degradation in Okefenokee Swamp in terms of the general dynamical, state space system.

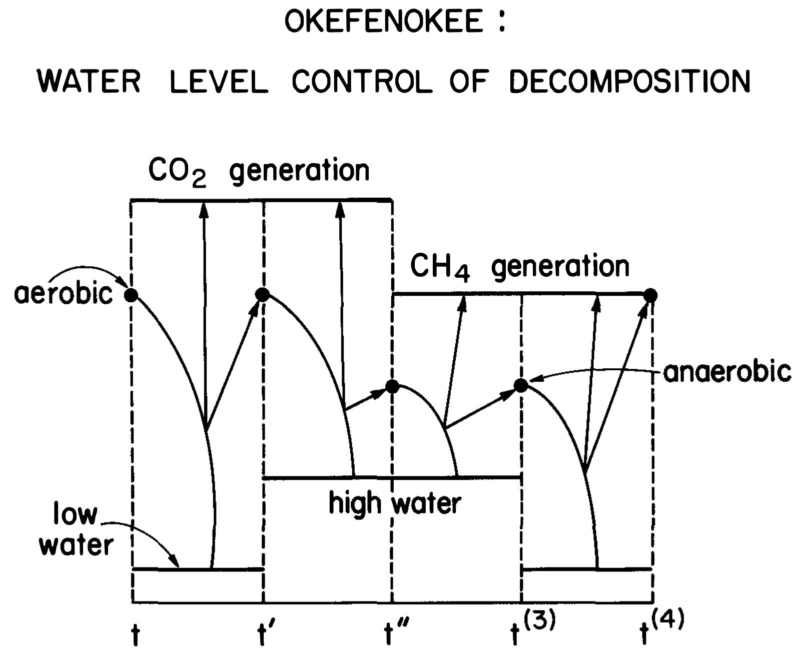

Figure 7.

Case 3. Change of Transition Function

Figure 8 illustrates the consequences of a state transition function change on dynamical behavior. As the transition function represents the law of the system, a change in this law signifies a very fundamental change in the nature of the system. In the figure, beginning in state $x(t)$ at time t, input $z_{tt'}$ on (t, t') is converted by ρ to output $y_{tt'}$. Transition function ϕ_1 leaves the system in $x1(t')$ at t', and ϕ_2 generates $x2(t')$. Thus, two different initial states $x1(t')$ and $x2(t')$ are available to determine behavior on $(t', t'']$. With input $z_{t't''}$, ρ generates $y1_{t't''}$ based on $x1(t')$, and $y2_{t't''}$ based on $x2(t')$. A change of transition function, then, results in different states being generated which, with continuation of the new transition function, produces permanently altered future behavior.

Example 4

Grossly, there are three major community types in Okefenokee Swamp: marshes $x1$, shrubs $x2$ and forests $x3$. Depending upon water level, as already discussed, the decomposition of carbon compounds will proceed aerobically, yielding carbon dioxide, or anaerobically, producing methane. In addition, carbon is also evolved from the conducting tissues of submergent aquatic macrophytes in the marshes, and is lost through deposition to deep peat.

The upper table of Figure 9 shows the proportion of carbon lost by these four processes in the three different ecosystem types (Flebbe 1982). Each carbon loss regime represented

DYNAMICS THAT REGULATE RESOURCES

Case 3. Change of Transition Function

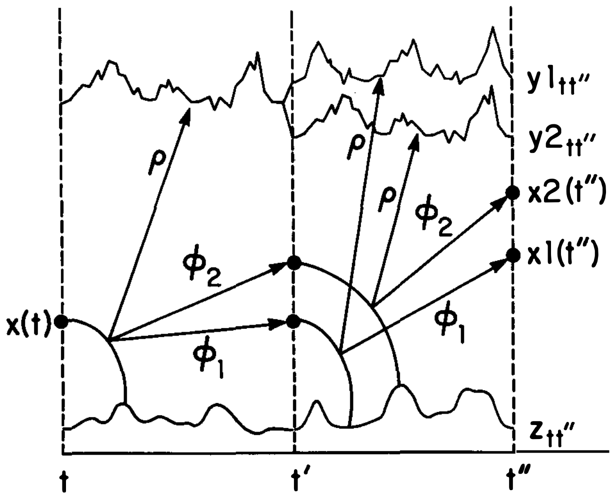

Figure 8.

by a row in the table can be taken as an output characteristic, $y1$, $y2$ and $y3$, of the respective community. Inspection of the three rows shows that each community has a different carbon loss regime in the sense that each unit of carbon which enters them is ultimately lost from them by different proportions of the four processes. The carbon which enters comes from various sources, as shown in the lower Figure 9 table. Carbon that exits as carbon dioxide has its origins in either the atmosphere, litterfall, or root respiration. That which leaves the system as methane originates as either litterfall or in deep peat deposits. Each of the three community types again has a different regime describing these origins, as indicated by the three rows of the table. These data are also representative of the output variable from each community type. These two tables (upper and lower) taken together specify output characteristics, $y1$, $y2$ and $y3$, of, respectively, marsh, shrub and forest communities in terms of the fates and origins of carbon in these communities. The source of the differences shown in these tables is different state transition functions, $\phi 1$, $\phi 2$ and $\phi 3$, for each community type.

Figure 10 depicts the dynamics. With marsh $x1(t)$ prevailing at the beginning of the interval, and with no fire, $z1_{tt'}$, on the first subinterval $(t, t']$, carbon regime $y1_{tt'}$ will occur, and the marsh transition function $\phi 1$ will cause succession to shrub, $x2(t')$, at t'. With shrub the initial state for $(t', t'']$, carbon regime $y2_{t't''}$ will occur, and with continuance of no fire, $z1_{t't''}$, the shrub transition function $\phi 2$ will cause succession to forest. With forest, $x3(t'')$ the initial state for $(t'', t^{(3)}]$, carbon processing regime $y3_{t''t^{(3)}}$ will prevail during this subinterval. However, if the input becomes modified, to $z2_{t''t^{(3)}}$ representing

OKEFENOKEE: TRANSITION FUNCTION REGIMES FOR CO_2 AND CH_4 PRODUCTION IN THREE COMMUNITIES

EACH UNIT OF CARBON INPUT LOST BY:

	CO_2 evolution	CH_4 evolution	CO_2 and CH_4 loss through macrophytes	Deposition to deep peat
Marsh (y1)	37%	2%	38%	23%
Shrub (y2)	38	6	0	56
Forest (y3)	66	3	0	31

EVOLVED GASES HAVE THE FOLLOWING ORIGINS:

	CO_2			CH_4	
	Atmosphere	Litterfall	Root respiration	Litterfall	Deep peat
Marsh (y1)	2%	98%	0%	50%	50%
Shrub (y2)	3	34	64	9	91
Forest (y3)	3	86	12	50	50

Figure 9.

fire, then the forest transition function $\phi 3$ will cause reversion to shrub, $x2(t^{(3)})$. Shrub swamp will generate regime $y2_{t^{(3)}t^{(4)}}$, and contamination of fire, $z2_{t^{(3)}t^{(4)}}$, will cause further regression under $\phi 2$ to marsh, $x1(t^{(4)})$. This leads to regime $y1_{t^{(4)}t^{(5)}}$ on the next subinterval, and if fire continues, $z2_{t^{(4)}t^{(5)}}$, the system will remain in marsh, $x1(t^{(5)})$. This example shows how a complex set of wetland processes yields readily to a lawful dynamical system representation.

Case 4. Change of Response Function

While change of state transition function represents a fundamental alteration of the system, a response function change is merely a modification of what is seen or measured as output by observers. Figure 11 illustrates this straightforward case. The system initially in state $x(t)$ is exposed to input $z_{tt'}$ and transitions under ϕ to $x(t')$. Under $\rho 1$ one output, $y1_{tt'}$, is observed, and under $\rho 2$ another, $y2_{tt'}$.

Example 5

In the Okefenokee watershed (Figure 1), water flows into the swamp in surface water

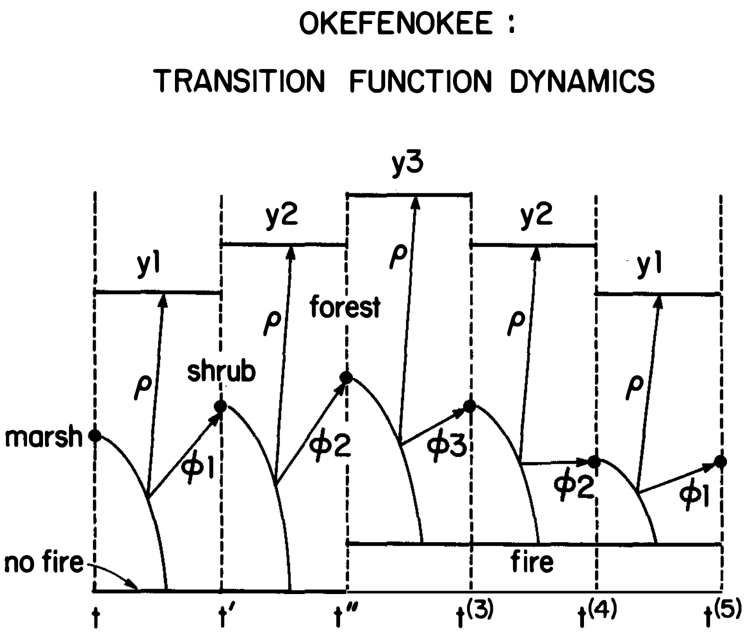

Figure 10.

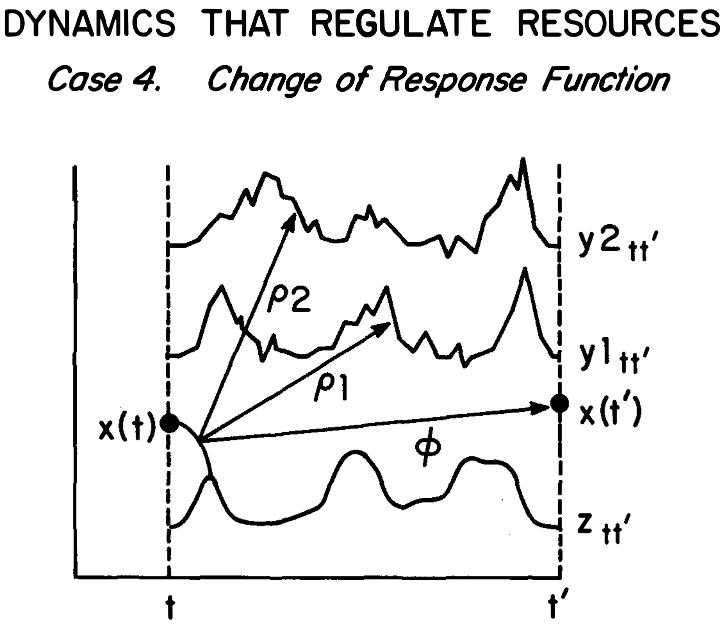

Figure 11.

streams flowing off the uplands. The uplands are managed for pine (*Pinus elliotti*) production, which is improved by xeric conditions. Therefore, some sections of all major streams on the uplands have been channelized to lower water tables. Steam channelization measurably affects water quality variables. Specifically, increased concentrations of dissolved oxygen, total and suspended solids, sulfate, chloride, ammonium, calcium, magnesium, sodium, aluminum and silicon are observed (Blood 1981). In comparison, no changes occur in the variables temperature, conductivity, carbon, potassium, and iron. Channelization does not result in any decreases in measured water quality constituents.

The release of substances into the swamp at higher than nominal rates is potentially of concern, and stream monitoring may someday be needed to generate necessary information about pollutant loads. Monitoring is expensive in time and money required to collect and process samples and analyze and present data. Knowledge about impacts of channelization on stream chemistry and other water quality characteristics makes it possible to select monitoring variables to achieve an optimum cost-benefit relationship.

For example, for unmodified streams a small set of output variables $y1$, consisting of only easily measured temperature, dissolved oxygen, conductivity and pH, might be monitored. With channelization, however, a larger set $y2$ of variables consisting of $y1$ plus total and suspended solids, sulfate, chloride, ammonium, magnesium, sodium, aluminum, and silicon would be measured. This second group of variables would add expense, but money would still be saved because in no circumstances would the variables water color, dissolved solids, phosphorus, non-ammonium nitrogen, carbon, potassium, and iron be determined. Thus with foreknowledge of the effects of channelization, a monitoring program for maximum efficiency and minimum cost can be instituted.

The design of optimum monitoring represents choices about how an external observer will view the system, and corresponds to a choice of response function ρ. In Figure 12, beginning in the unchannelized state $x1(t)$, selection by $\rho1$ of monitoring variables $y1_{tt'}$ occurs, and the streams through their normal processes ϕ remain in the unchannelized state $x1(t')$ at the end of the first subinterval $(t, t']$. Therefore, on $(t', t'']$ reduced monitoring $y1_{t'tt''}$ continues. On this subinterval, however, a stream or streams are disrupted by channelization. This is shown as a new state $x2(t'')$ at t'', but one that does not arise naturally from the operation of ϕ on former states. The transition $x1(t') \rightarrow x2(t'')$ thus appears spontaneous in the diagram. A higher resolution representation might portray the process of channelization by means of a second disturbance transition function ϕ^* operating during $(t', t'']$. Once channelized, $x2(t'')$, streams always remain so on the interval $(t'', t^{(4)}]$ depicted, and therefore a decision $\rho2$ is made to monitor the expanded set of water quality variables, $y2_{t''t^{(4)}}$. This example demonstrates that the general dynamical system model is not just an esoteric theoretical construct. Properly applied, it can have significant practical value in organizing and understanding environmental protection and other management problems.

Conclusion

This paper began with a statement about the desirability of hardening ecology as a science as a basis for stronger and better solutions to applied problems by the applied environmental sciences, such as wildlife management. Wetlands, as this special session of this 49th North American Wildlife and Natural Resources Conference has amply

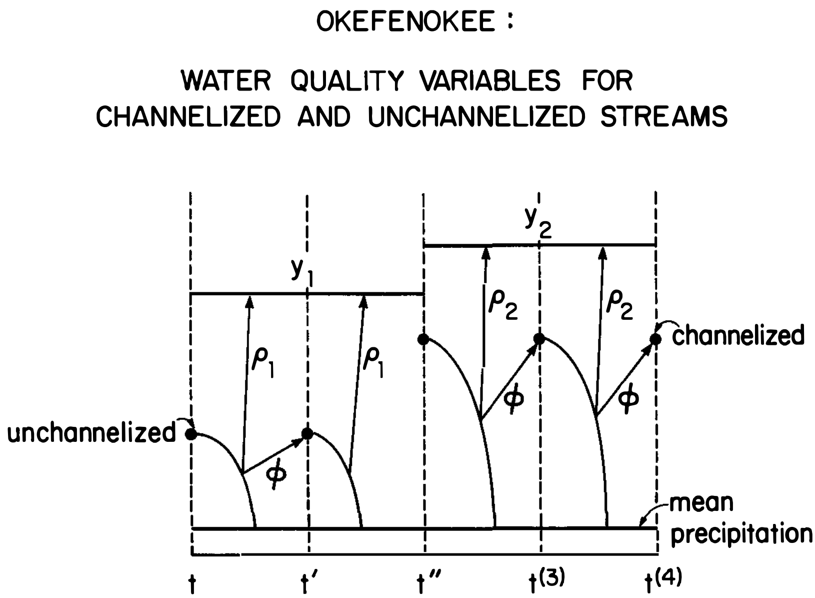

Figure 12.

documented, are among the most widespread, least known, and most important for wildlife of the many different kinds of landscape ecosystems. Their proper study and evaluation requires more rigor than is generally available in ecological science.

The argument has been made that instead of being chaotic and overwhelming in their complexity, ecological systems do in fact operate in lawful, and therefore predictable, ways. Science needs to discover these laws and place them within an operational framework. System theory has, in effect, been nominated to provide this framework. The formal state space, or dynamical system, model which explains and represents causal behavior is at the base of all further systems science developments. By demonstrating, within a generalized disturbance theory of dynamical systems, how several phenomena pertaining to the dynamics and management of Okefenokee Swamp fit readily to the dynamical system scheme, the inherent lawfulness of all complex ecological systems has been illustrated. This lawfulness needs to be elaborated, understood, and applied in the same ways that laws from mathematics, physics, and chemistry have formerly found their uses.

Rigor and formalism are possible in ecology and its applied sister sciences. It is to be hoped that the pressing needs for more and more refined solutions to complex man-environment problems will stimulate such developments. An exact science of wildlife management, coming out of an exact science of ecology, is within the realm of long term possibility.

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Needs for Private Sector Wetland Research: Ducks Unlimited's Perspective

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Ducks Unlimited (DU) is a private, non-profit, international conservation organization which has been in operation for the past 46 years. Our major objective is to preserve, develop, and restore wetland habitat, with the priority being habitat for breeding waterfowl in Canada. To date, there are more than 2,300 active marsh projects developed across Canada encompassing over 3.2 million acres (1.3 million ha) under agreement. Projects range in size from 10-acre (4 ha) beaver ponds to 50,000-acre (20,000 ha) marsh complexes. This year we are embarking on a new small wetland complex program aimed at preserving even smaller basins. Although habitat is developed with waterfowl given foremost consideration, DU commonly provides benefits to agricultural, domestic, and recreational users as well as to other species of flora and fauna.

Drainage and degradation of waterfowl habitat is continuing rapidly in North America (e.g., Lynch-Stewart 1983). For this reason, DU continues to commit the majority of its resources to securing and maintaining wetlands rather than intensively managing habitat already protected. We are committed to investing our limited resources so as to maximize waterfowl production per dollar contributed. To this end we have an active program of wetland reconnaissance and inventory aimed at selecting and then prioritizing potential project areas. Our preliminary investigations are directed at estimating waterfowl values and establishing construction and operation costs for all inventoried wetlands showing promise for development.

Our projects usually involve the installation of engineering works (ditches, dykes, pumps, and dams) that permit careful regulation of water levels. Water control is necessary to provide productive waterfowl habitat and to allow us to abide by the legal agreements signed with governments and landowners. Projects are often costly, with expenses varying depending on local soils, climatic conditions, topography, physical access, hydrology, and landowner/government requirements. Those which seem economical move ahead to the construction phase of habitat development. Following project completion, water levels are operated at the appropriate flood stage, depending on vegetation and waterfowl responses.

Ducks Unlimited retains an in-house biological research group. Their primary function is to provide information that will assist the company in making economical and biological decisions during the habitat development process. For example, one ongoing research program is aimed at providing baseline information for estimating waterfowl production on various types of DU marshes developed across Canada (Wishart et al. 1982). This information, in combination with that derived from more specific studies, is used to prescribe internal works (e.g., artificial islands, level ditches, etc.) and operations (e.g., drawdowns, setting operating water levels, etc.) which would efficiently offset economic and biological limiting factors.

Such information also helps DU estimate what duck production might be expected with development of various types of projects. Of necessity, our broad based surveys do not permit us to conduct intensive studies into the mechanisms behind patterns of waterfowl production we observe. As a company devoted to developing and managing waterfowl habitat, we must rely on the published literature for information that will enable better interpretations of our findings.

We will use an example to illustrate this. Backflood irrigation is a process by which water is held on agricultural land for several weeks in the spring and then drained. The benefits of this type of irrigation to hay and other crop production are obvious to farmers and biologists alike. If backflood irrigation is beneficial to waterfowl, projects incorporating such schemes have great potential in agricultural areas because they offer attractive trade offs for the farmer on whose land the project is built.

On the basis of a 1983 in-house study and available literature, we feel that properly designed backfloods have benefits for waterfowl. Where agricultural interests must be considered, we promote this technique in lieu of seeing wetlands drained. In our study, pairs used shallowly flooded backflood basins for territorial and feeding areas and nested in the lush cover once water was removed. However, because individuals were not marked, few inferences could be made about how pairs used the backfloods relative to reproductive and pairing status or how broods used backflood basins relative to water level changes. Were pairs forced to emigrate or forego breeding if water levels dropped after territory establishment? Was there sufficient permanent water remaining in the system to rear all broods produced? Were brood movements which were forced by declining water levels leading to mortality? Only with intensive multi-year research on individually marked and radioed birds can these sorts of questions be answered. Such information would allow a better understanding of backflood irrigation systems. Improvements to the net worth of projects incorporating backflood schemes would be achieved by fine tuning water operations schedules in relation to waterfowl use.

Although DU is currently in a wetlands securing phase, some management is conducted and inevitably it is likely we will move toward more intensive management. Thus, we have a need for developing and improving management techniques now so that the tools and experience will be available to us when we need them.

This paper is divided into three broad areas of research which, in order of importance, to DU are: (1) Waterfowl-habitat relationships, (2) water manipulation-effects on vegetation, and (3) land use practices. Although many topics could be discussed under each of these headings and others, we will attempt to illustrate our points with a few examples.

Waterfowl-Habitat Relationships

Research into the relationships between waterfowl and their habitat is a priority to DU. Studies, including our own, have addressed various aspects of these relationships across a range of geographic areas and seasons, and Ducks Unlimited relies on information provided by such research to properly develop breeding habitat. To assist in our decision-making process, we need, in the short term, (1) reliable estimates of duck production on projects already developed, and (2) comparisons of production before and after development.

Since 1978, two major in-house evaluation programs have been operated by DU, with a primary objective of providing this kind of information. This work is ongoing. To date, more than 100 projects have been studied across Canada in 11 biomes (Wishart et al.

1982). A large volume of information has been collected, analyzed for in-house use, and stored in an accessible format.

A secondary objective of our evaluations is to identify potential limitations to waterfowl production on each of our case study projects. However, of necessity, our efforts have been limited to correlational analyses rather than an experimental approach. With these limitations, inferences as to cause and effect are tenuous. Implications drawn from these analyses must be tempered with field observation, literature support, and experience. However, an intuitive approach to waterfowl management should be based on results arising from well-designed scientific studies.

Thus, there is a primary need for intensive and long term research into understanding how waterfowl respond to dynamic wetland habitats. The study of marked individuals of known reproductive status would enable better interpretations of waterfowl use patterns we have recorded. Other questions could also be better addressed. For instance, what functional roles do DU projects play in a wetland complex? What are the magnitudes and directions of brood movement to or through our projects? How are movements and survival affected by water conditions inside and outside the project basin? What potential impacts do various water management schemes have on brood movements and survival?

The following example gives insight to the difficulties associated with interpreting single factor correlational analyses. Spring water conditions in our Alberta Parkland study area during 1983 were relatively poor. However, heavy rains during June flooded many temporary wetlands (Types I–III of Stewart and Kantrud [1971]). The 10 project areas we studied that year were divided into two groups, "high" or "low," depending on the density of temporary wetlands within a 1.25-mile (2 km) radius of the project basin. Brood densities recorded on the projects were compared between the two groups using a Wilcoxon 2-sample test. Our null hypothesis was no difference in brood density existed between groups.

Our results showed that the group of projects with "low" densities of temporary ponds supported higher brood densities ($P<.01$) than those with "high" pond density. These results could be interpreted in two ways. We could conclude that by random chance, a significant difference was detected (Type I error) and the result has no biological significance. This can easily happen in single factor analyses of complex problems. For instance, projects with "high" temporary pond densities may also have been surrounded by poorer nesting cover, supported lower pair densities, been of lower productivity, etc.

An alternative explanation recognizes the potential impact of peripheral temporary ponds on brood density observed within the project basin. For example, broods on project areas with "high" densities of temporary wetlands may have been dispersed. Broods may have been concentrated on project basins in areas where alternative brood water was less readily available. Intensive studies of marked individuals would allow us to better interpret the meaning of such results and understand how wetland complexes are used by breeding waterfowl. Such information would be useful in determining project placement and establishing priorities for construction.

Numerous advantages would also be associated with establishing long term study areas because important year effects are usually confounded by changes in location over a series of short term studies. The value of inferences made about waterfowl-habitat relationships from such short term work is limited.

We are strong advocates of the hypothetical-deductive (HD) approach to conducting research and rely most confidently on results derived in this manner. In fact, virtually all outside research funded by DU is experimental in nature and, with practical application, will provide tangible benefits to our programs of habitat development. Although we recognize the importance of intensive and long term studies in providing insight into mechanisms behind waterfowl habitat relationships, DU will continue to rely on outside agencies and institutions to play a leading role in that area.

Water Manipulation—Effects on Vegetation

As mentioned earlier, to control emergent vegetation on projects, DU manages water levels when possible. Where feasible, projects are built with variable control structures and manipulations can be gravity induced. In other projects, pumps or siphons are used.

Other means of managing marsh vegetation have been developed for projects where water control is not possible. They include level ditching, over-ice mowing, herbiciding, burning, blasting, etc. Such techniques can be refined and other similar methods await development. However, we feel the most critical information gap continues to lie in our knowledge of how various water level management regimes affect marsh vegetation.

At present, in areas where intensive water level management is underway, our approach is to have field staff gain practical experience by subjectively monitoring and recording vegetation responses on a case history basis. Such information is exchanged among staff through informal meetings, seminars, and reports. Again, we rely on current literature for an understanding of important processes which interact to determine the outcome of water level management in general. By using this approach, informed and experienced personnel will be available when we have the resources and mandate for more intensively managing wetlands.

Although our list of water management case histories continues to grow, many questions about the mechanisms behind the observed vegetation responses remain unresolved. As with understanding waterfowl-habitat relationships, inferences about effects of water management on changes in marsh productivity and vegetation patterns can only be based on carefully designed studies because any one factor is usually confounded by a multitude of other covarying factors.

Critical information is needed for incorporation into project design so that proper water level management will be possible in the future. For example, what is the critical date by which substrates must be drained to promote germination and vegetative expansion by various wetland plant species? Knowing that date as well as information on drawdown-reflooding rates, flood depth, soil moisture needs, etc., would allow the establishment of more cost-efficient engineering design criteria for water control structures.

Gaining a better understanding of the important life history characteristics of common wetland plant species should be a primary goal of current wetland research. Knowing how these characteristics affect the establishment of different species under various water regimes will allow wetland managers to better prescribe management schemes. We believe such an approach will yield more reliable results sooner for wetland managers than will more general community level studies.

The Delta Waterfowl Research Station, in cooperation with DU, has embarked on a long term Marsh Ecology Research Program (MERP) in an effort to provide critical information necessary for proper water level management and to better understand freshwater marsh ecology. MERP is a carefully designed long term experiment which examines the effect of flooding, drawdown and reflooding depth on important ecological processes in freshwater marshes. Importantly, MERP is also designed to test for any year effect on those processes. Several shorter term companion studies have concentrated on specific topics of marsh ecology. In total, MERP will make important contributions to our understanding of how water level manipulations affect ecological processes in freshwater marshes.

MERP should be used as an example for future experimental research because it will spawn concepts and hypotheses that will need testing in other regions of North America. For example, differences in water chemistry, climatic conditions, benthic soils, and plant species will lead to variable results of water management. Genotypic variation within some plant species allows a much greater tolerance to flooding in areas of high precipitation than is common on the prairies. These are important factors which must be considered both when designing and operating our projects.

DU encourages wetland ecology studies that are modeled after MERP's experimental approach. In particular, studies are needed in the arid prairies and in forested zones of high precipitation in the east and north. The effects of substrate scarification, epipelic algal blooms, and existing bud and seed banks on vegetative response during drawdown also need study. Likewise the effect of water level fluctuation during partial drawdown on seed bank distributions and germination patterns needs attention. Finally, the impacts of wetland vegetation pattern and composition on macroinvertebrate production and waterfowl use needs careful study so that proper vegetative associations can be maintained.

Land Use

DU is operationally concerned with wetland basins. At the same time, we recognize that characteristics of entire wetland complexes are functionally important to waterfowl. The quality of surrounding upland cover directly affects nesting success but land use also influences hydrological characteristics and within-basin productivity.

Values of productive agricultural land are high and DU cannot hope to effect widespread changes in land use in relation to waterfowl by acquiring entire wetland complexes. What we can do is use our broad base of operations as a means of promoting dialogue on a grassroots basis with landowners. Through our field staff and agricultural extension program we promote land use practices beneficial to waterfowl. Research directed toward developing methods (i.e., farm equipment, new cropping techniques, chemicals, etc.) that are environmentally safe and promote soil and water conservation is deemed to be very important. By demonstrating the economic benefits of such methods we feel that they will be more quickly accepted by farmers than if we promote only the positive effects they have on waterfowl.

At the same time, research is needed to measure the impacts these and other farming practices have on waterfowl in various biomes. Only with this information can we establish the costs and benefits of promoting various methods. Such research might also suggest modifications that may prove beneficial to waterfowl or could alert us to potentially dangerous farming practices.

Zero-tillage and rotational grazing are two agricultural systems that could have significant positive impacts on waterfowl populations if their use becomes widespread. They seem to provide real economic advantages to agriculture, but despite this their acceptance has come slowly. Now is an opportune time to devise means of tailoring these methods for maximum benefit to waterfowl through research.

Herbicide application is a key element of zero tillage. How do such chemicals affect egg hatchability and wetland productivity? Will waterfowl readily nest in low stubble or cropland, and will nest predation rates in these areas approach the low rates that probably occurred in expansive areas of native shortgrass prairie.

We believe rotational grazing will be most beneficial to waterfowl when plots of fertilized tame hay are used in rotation with plots of native cover. Cattle are able to graze the small but fast-growing tame hay plots early in the spring, leaving the larger expanses of slow-growing native cover to rejuvenate. By the time cattle are moved to the traditionally overgrazed native areas, waterfowl nesting is well under way or completed.

Again we have questions about the net benefits to waterfowl of such systems compared to conventional grazing practices. For example, information is needed about how stocking rates, timing of cattle movements, and location of plots in relation to wetlands relate to waterfowl nest density and success. Research directed at better establishing the agricultural benefits of this technique is also warranted. For example, do increases in beef production offset increased labor and fencing costs? To what degree is bull breeding efficiency increased by restricting cow movement? What are the long term effects on range quality of such intensive use?

Ducks Unlimited is concerned about the accelerating loss of small temporary wetlands. Such basins are often the easiest to drain, most prone to silting, and the most costly to develop. They are critical to waterfowl as productive feeding areas, pair sites, and brood-rearing areas when flooded, and their value has been thoroughly documented. Means of reducing upland salinization at wetland edges and in groundwater discharge areas would assist wetland protection efforts. Sociological surveys are needed to determine what other measures could be used (education, economic incentives, etc.) to convince farmers to stop degrading these wetlands.

More information is needed to clearly show the public worth of wetlands. The economic value wetlands have in terms of flood control and water table maintenance, as well as recreation, need to be established. This information needs to be combined with innovative approaches to convince governments to change their present policies, which commonly encourage farmers to drain and clear "unimproved" acreage.

Summary

Ducks Unlimited requires information that will assist in making economic and biological decisions during the habitat development process. Long term, carefully designed studies using individually marked birds are needed to better understand the complexity of waterfowl/habitat relationships.

We also advocate hypothetical-deductive research combined with a practical approach directed at developing and improving wetland management practices. Of great importance to us is understanding how water level management influences patterns of emergent vegetation and basin productivity.

Finally we encourage research into developing alternative agricultural techniques that will indirectly improve upland nesting cover and within-basin habitat. New methods of influencing government policy and agricultural land use practices are needed and seen as the primary means by which wide scale positive benefits will be achieved.

We do not intend this paper to be a list of research studies that DU is looking to fund. Our informational needs are broad and basic and probably do not differ substantially from those of other organizations or institutions interested in understanding and managing wetlands. We differ from some in that our primary interest is in the practical application of this information as a means of guiding the habitat development and restoration process.

This paper is intended to let others know how and why we do things. If along the way we can generate interest and point to some gaps in wetland research, we will have achieved our objective.

Acknowledgements

We wish to express our appreciation to DU biological staff across Canada for their direct or indirect input into this paper. In particular we thank W. Cowan, S. Rushforth Guinn, B. Clay, B. Chappell, D. Sexton, and M. Hilland.

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Research Gaps in Assessing Wetland Functions

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In May, 1983, 40 widely recognized wetland scientists and resource managers, representing Federal, State, and private entities, were brought together to analyze a state-of-the-art methodology for the assessment of wetland functions. This methodology was developed by Mr. Paul Adamus for the Federal Highway Administration (FHWA) (Adamus 1983). The goals of the workshop were to: (1) determine the technical validity and practical utility of the FHWA methodology for use as an assessment tool; and (2) identify areas where further research is necessary to develop a new methodology or improve on the FHWA methodology in order to obtain a reasonable estimate of the degree to which a wetland fills different functions (e.g., maintenance or improvement of water quality, food chain support, flood control, and ground water discharge or recharge) and the importance of wetland use by man (e.g., recreation, open space, and commercial harvest of fish and wildlife). Although it is frustrating to have to assess wetlands when there are still gaps in our knowledge of wetland functioning, a recent wetland acreage analysis by the National Wetland Inventory of the U.S. Fish and Wildlife Service shows that less than half of the estimated original 215 million acres (87 million ha) of wetlands in the United States remain. An annual average of 458,000 acres (185,490 ha) of wetlands was lost during the 20-year period between the 1950s and the 1970s (Frayer et al. 1983). Resource and development agencies have an immediate need for a means to perform multiple resource analyses of wetlands, to examine wetland functions, and to identify cause-and-effect relationships between biological and physical variables (such as siltation) and wetland functions (such as fishery habitat support).

The paradox of not having enough information to fully understand a complex environmental system, while the need exists to generalize and make predictions in order to protect rapidly vanishing resources, is apparent. More research is needed in order to better understand how wetlands function. At the same time, the best information currently available must be utilized to develop standardized, objective assessment tools that help us make sound decisions in balancing society's development needs with preservation of environmental quality. The critical examination of the FHWA assessment methodology by the workshop participants revealed research gaps with respect to wetland functions of both an applied and basic nature (Sather and Stuber, in prep.). It is these gaps that we address here.

FHWA System

The FHWA system was the subject of the wetland values workshop because it represents the most comprehensive method to date for the analysis of all known or suspected wetland functions. It also provides the capability to look at how different functions of a wetland are related (e.g., a high level of sediment trapping may eventually limit the wetland's function in flood control).

It is important to recognize that, in the FHWA system, the description and analysis of wetland functions is based on the existing scientific literature. Therefore, the system is only as good as the current literature base. The information base for wetland functions in the FHWA system varies from high for some functions, such as fisheries and wildlife habitat, to low for other functions, such as food chain support and ground water recharge and/or discharge. Because the system has a literature basis, it is possible to identify gaps in our knowledge of wetland functions. This information can, in turn, be used to establish sound research priorities. The FHWA system is designed for easy revision to incorporate increases in our knowledge about wetlands.

Let us briefly examine the structure of the FHWA assessment system, which served as the reference point for the wetland values assessment workshop and the background for the research recommendations discussed in this paper. The FHWA system is based on an analysis of three components of a wetland function, opportunity, effectiveness, and significance (Adamus 1983: Vol. II:1):

> *Opportunity* considers whether a wetland has a chance to fulfill a particular function. *Effectiveness* considers the probability of a wetland being productive in maximizing the opportunity given it to fulfill that function. *Significance* considers the degree to which the performed function is valued by society. . . .

Opportunity and effectiveness for each of the 11 wetland functions identified by Adamus (ground water recharge, ground water discharge, flood control, shore anchoring, sediment trapping, nutrient retention, food chain support, fisheries habitat, wildlife habitat, active recreation, and passive recreation) are separately analyzed through the evaluation of 75 predictive factors. These predictors (roughly synonymous with the terms "descriptors," "indicators," and "determinants", used in other procedures) are used to hypothesize relationships between a biological or physical parameter and a wetland function (Figure 1).

Applying the FHWA methodology results in a high, moderate, or low ranking of the opportunity, effectiveness, and significance of the wetland for each of the 11 functions (Figure 2). The degree of accuracy of the ranking is dependent on the number of predictor questions answered, the replicability of the responses to predictor questions, and other factors, such as questionnaire design and the validity of the hypotheses about the link between a biological or physical parameter and a particular function.

It is the adequacy of the scientific literature on which the FHWA system is based that we wish to address further today. The importance of this factor is obvious; the FHWA system can be no more accurate in describing wetland functions than our current knowledge about wetland functions.

Research Needs Related to Wetland Functions

One of the most important results of the workshop that evaluated the FHWA methodology was the identification of gaps in our knowledge of wetland functions. Hypotheses relating physical parameters to wetland functions are often based on literature specific to a certain geographic area or applicable only to the same wetland type as where the original study was done. Enough regional variation may exist to justify an evaluation system that is sensitive to differences in wetland function; i.e., hierarchical in structure with a standard,

Function	Hypothesis based on Literature review	Physical factor (Predictor)	Predictor question
Wildlife habitat	Sinuous/irregular basins indicate higher waterfowl habitat value.	Shape of basin	Is the basin generally: 1. Sinuous or irregularly shaped,* or mostly surrounds a series of islands?
	a) Sinuous basins are correlated with slower water velocities which are preferred by waterfowl (especially Groups 1 and 7).		2. Rounded or mildly elliptical?
	b) Sinous/irregular basins are likelier to have a greater interspersion of wetland cover types, and generally have greater "edge" which benefits breeding waterfowl, and wintering waterfowl in need of shelter from the elements.		* These criteria are defined in Adamus 1983 Vol. I, p. 53.

Figure 1. An example of the type of relationship of scientific literature to predictor questions used in the Federal Highway Administration Wetland Functional Assessment procedure (Adapted from Adamus 1983).

Function	Effectiveness	Opportunity	Significance	Functional significance
Ground water recharge				
Ground water discharge				
Flood storage				
Shoreline anchoring				
Sediment trapping				
Nutrient retention				
Food chain support				
Fishery habitat				
Wildlife habitat				
Active recreation				
Passive recreation and heritage				

Figure 2. Summary, in matrix form, of the information that results from an application of the Federal Highway Administration Wetland Functional Assessment procedure. High, moderate or low are the possible responses for the matrix. Effectiveness, Opportunity, and Significance are combined for an overall Functional Significance rating (condensed from the Summary Response Sheet, Adamus 1983. Vol. II:55).

National format, but including regional questions. This approach is taken in the FHWA method to the degree that existing information permits. However, more attention to regional variation may be necessary in future research in order to accurately assess wetland functions.

The next four sections of this paper summarize identified research gaps in terms of our ability to accurately assess the hydrology, water quality, food chain support, and habitat functions of wetlands. This summary reflects the information in the workshop reports prepared by four workshop panels.

Hydrology

Little research has been done on the hydrology of wetlands, even though water is the driving force behind their existence. This is probably partially related to the fact that analyses of hydrologic functions cannot be done without a large number of detailed, precise measurements. Water budgets often are used to estimate the various components of the hydrologic cycle, even though a large variation can exist in the measurement and estimation of components of the budget, which can result in large, hidden errors.

Comparative studies that address the effects of climate, species, vegetation cover, density, and phenology on hydrologic processes generally are lacking. Long term research on basic hydrology is needed to increase our understanding of the physical factors that determine wetland characteristics.

Hydrologic components, such as evaporation and ground water recharge and discharge, need to be analyzed at type localities chosen on the basis of climate, geology, and vegetation, with data transfer value to the entire regional area. Long term studies will help prevent invalid conclusions based on short term phenomena, such as unusual climate conditions. The methods and results should be carefully documented. Several questions related to obtaining hydrologic data should be addressed to ensure standardization of wetland assessments:

- How often, where, and when should measurements be made:
- What are the potential errors in measurement and how can they be minimized?
- What measurement tools are needed and what is their availability?
- What is the correct design and proper placement of the instruments used to obtain the measurements?

When integrated hydrologic processes (all components taken as a sum) are analyzed, attention should be given to system dynamics (seasonal and yearly fluxes and changes in water chemistry) and paleohydrology (long term variability). More information is needed on the geochemistry of ground water and organic and inorganic surficial deposits, as well as the hydraulic properties of wetland soils, in order to better define the relationship between ground and surface water. Additional research in the identification of plant or chemical indicators of ground water discharge, similar to those now used in semiarid and arid regions (Lissey 1968, 1971), may prove useful in providing an accurate and more rapid assessment of wetland ground water recharge than is available with current hydrologic measurements.

Assumptions about the flood control and flood peak desynchronization functions of wetlands, based on the location of the wetland in the drainage basin, wetland size, storage area, constriction of the outlet, and other factors, need to be tested for validity before the predictive factors now included in the FHWA system can be confidently used. The fundamental nature of runoff is not well understood, and it is difficult to make definitive statements regarding the role of various types of wetlands in runoff production or storm water detention. This function is of greatest significance in populated areas, and studies of the flood control function of wetlands are especially needed in urban and suburban areas. In addition, the effects of wetland size and vegetation form on shoreline anchoring ability need to be examined.

Finally, it is quite possible that we have not yet fully identified all of the hydrologic functions of wetlands that need to be examined. We must keep in mind that wetlands provide an integral link between ground water and surface water, and as such, they should be regarded as part of an even larger hydrologic system.

Water Quality

The ability to assess the water quality maintenance or improvement capabilities of wetlands (i.e., nutrient retention and sediment trapping) would be improved by more research in several areas.

Water quality is partially dependent on hydrologic factors; therefore, water budgets and flow processes need to be better understood in order to more accurately predict nutrient retention. Ecosystem significance factors, such as threshold loadings, need to be defined because each system has its own saturation point. The role of wetlands in the retention of anthropogenic substances (heavy metals, toxins, and pathogens) needs to be included in any analysis of wetland water quality functions. Predictive capabilities for this attribute need to be outlined, as has been done for nutrient retention and sediment trapping. We currently may be identifying some of the appropriate predictors of anthropogenic substance retention; however, there are still aspects of anthropogenic substance behavior in wetlands that are not fully understood. For example, some substances may undergo transformation in a wetland, and the relationship of the physical and chemical environment to these transformation processes is not well documented.

Finally, although adequate input-output data is available for an assessment of sedimentation, sediment processes largely have been researched in aquatic systems and need to be assessed more directly in wetlands.

Food Chain Support

Currently, there are three hypotheses in the FHWA system that are used either directly or indirectly to estimate food chain support or food web relationships of wetlands. These hypotheses are that food chain support is primarily related to: (1) the quality and quantity of detritus produced during decomposition; (2) the level of primary production; and (3) the degree of coupling between a wetland and adjacent open water. These hypotheses need further long term research and testing that incorporate four components: (1) examination of ecosystem variability; (2) comparative studies of a variety of wetland types; (3) the use of a team of experts in hydrology, nutrient cycling, succession, microbiology, and related factors; and (4) the use of standardization and documented methods.

Long term research in food chain support should focus on two questions: (1) What is the relationship between the amount of primary production in a wetland and secondary production in the wetland or wetland basin? and (2) What are the food chain relationships between wetlands and adjoining open water? The Food Chain Panel believed that detailed field studies cannot be replaced by rapid assessment techniques, such as the FHWA system, until these two questions are answered better. The Habitat Evaluation Procedures

(HEP) or the Habitat Evaluation System (HES), currently in use, may be possible alternatives to the food chain analysis in the FHWA system.

Habitat

The habitat assessment component of the FHWA system is divided into fish and wildlife habitat analyses. The fish habitat analysis is subdivided into two categories: freshwater/anadromous and saltwater. Wildlife habitat analysis is broken into the general categories of habitat diversity, harvestable waterfowl (nesting, summering, wintering, and migrating), and other wetland-dependent birds. Habitat analysis is performed at a species group level, with the option to also consider the habitat requirements of one or more particular species within a species group. The species analysis is intended to be a rapid assessment. A more detailed habitat analysis can follow application of the FHWA system, utilizing other methodologies, such as HEP.

The habitat panel expressed the concern that there was an inadequate literature base to support certain predictors or hypotheses linking environmental factors to species support capability in the FHWA system. For example, some of the habitat-related hypotheses in the FHWA methodology are based on literature that is specific to certain geographical areas or wetland types. Generalization of the results of these studies to broader applications (such as all warmwater fish or all populations of northern pike) may result in an erroneous analysis. Recognizing potential species habitat variability through the regionalization of predictor questions, as was done in the FHWA system to the degree possible based on existing information, may be necessary to an even greater degree for a valid habitat evaluation. Region-specific hypotheses on habitat requirements need to be based on typical wetlands in that region. Analysis of the literature, as presented by Sather and Smith (in prep.), has helped determine areas where studies of typical wetlands have not yet been done.

In addition to the need for regional research on habitat requirements, the habitat workshop panel felt that there has been a relative lack of wetland habitat studies on fish, amphibians and reptiles. Although there have been more bird studies, these studies have often been too short term to adequately reflect the dynamic nature of wetland ecosystems. Long term studies on all of these components is needed.

The habitat panel also believed that we need to further examine community aspects, in addition to, or in place of, species analysis, when performing a wetland habitat evaluation. Guilding (Short and Burnham 1982) was one approach that was discussed for potential application to wetlands. A community approach to habitat evaluation should emphasize the influences of community structure and physical characteristics of the environment on vertebrate populations.

The most important need in habitat research is for long term studies designed to increase our understanding of wetland dynamics. Similarly, an assessment should allow for analysis of the long term dynamics of the wetland, so that a temporary or atypical condition is not evaluated, resulting in a misrepresentative habitat value. We also need to study the habitat functions of areas that are not defined as wetlands, yet are wetland-influenced, because a change in the functioning of the wetland may well affect important adjacent habitat.

The Importance of Wetland Functions to Society

Attributes of wetlands that have socio-economic utilization potential need to be addressed in order to develop a complete understanding of the importance of wetlands. These attributes are best addressed according to four categories (Niering 1984):

> *Experiential uses* refers to the use of a wetland that involves contact between people and the wetland and may be considered contact dependent . . . . *Consumptive uses* are actual or potential uses of wetlands that involve a consumable product that can be taken away from the wetland area . . . . *Nonconsumptive/societal uses* include uses or values that result from the natural intrinsic functions of wetlands that generally benefit society as a whole and are not enjoyed by a specific group of people or within a limited time frame . . . . *Global functions* are functions of wetlands that relate to the maintenance of our life support systems.

A long list of wetland uses can be identified according to these four categories. An objective means of evaluating these wetland uses needs to be developed that can be used in concert with the evaluation of other natural wetland functions. Psychological/social studies, with expertise from physical scientists, life scientists, and landscape designers, are needed to supplement the existing literature base in order to develop accurate predictors of wetland use by man.

Regional evaluation within a standard framework will probably be necessary because of the regional variability that exists in the perception of wetland uses and values. In addition, the relationship between demographics and socio-economic utility need to be researched and better defined. Research that focuses on developing an understanding of how management alternatives affect wetland functions also is needed. Many ecosystems have been influenced by man; it is important to understand how these management options can affect the functioning of wetlands.

Methodology Design

In addition to more basic research to increase our understanding of wetland functions, research on the design of evaluation methodologies, such as the FHWA system, is needed. In particular, studies are necessary to determine if the FHWA system is sensitive enough to separate the level of wetland functions into two, three, or five different levels of ranking in a valid manner. A statistical analysis of the interaction of predictors also is needed. The FHWA system, as well as any further derivations of this system, needs field validation against extensively studied wetlands and across a variety of wetland types in order to document sensitivity, applicability, and validity of the assessment methodology. Research on methodology design, computer compatibility, and objectiveness is part of this need.

Research techniques for evaluating wetland parameters, such as measurements of primary production, are critical to the success of wetland studies. A summary of the best measurement techniques available should be developed for use as a guideline to any wetland evaluation system.

Summary

In summary, the Federal Highway Administration has developed a methodology to assess the level of wetland functions and the importance of wetlands to man using physical and biological parameter predictors, developed after a review of the literature. Use of such a methodology increases the ability of a resource manager to efficiently assess wetland resources during initial project planning, target wetland acquisition needs, and a variety of other management requirements. In May, 1983, 40 wetlands experts evaluated the FHWA methodology and believed it to be the best existing framework for wetland evaluation. Research gaps were identified, however, in relation to the four major functional areas of wetlands: hydrology; water quality; food chain support; and habitat. Further research needs were also identified in determining the importance of wetlands to man. Finally, studies on the design of wetland evaluation methodologies will ensure the development of a standard, objective, realistic wetland assessment methodology that addresses the range of wetland values to man.

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Values of Fish and Wildlife: Public Trust and Economic

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Opening Remarks

James H. McDivitt

This session of the 49th North American Wildlife and Natural Resources Conference was intended to discuss values of fish and wildlife from the perspective of economics and the public trust. After reviewing the proposed papers, it became apparent that the session is one-sided in favor of economics. Consequently, a caveat is offered to all readers. Most of the authors are economists and their perspectives on values are primarily those of economists. Although a more balanced agenda might have been preferable, the papers that are presented provide insight into the world of wildlife resources as seen by economists. Many resource specialists, managers, and administrators have a better sense of resource ethics and public trust law than of the principles of economics used to evaluate their programs. Hopefully, this session will be a step toward broadening all who participate.

Before we start, I would like to remind you that economic criteria are only one set of criteria used in decision making. The Water Resources Council referred to three coequal objectives of (1) economic efficiency, (2) environmental quality, and (3) social responsibility as criteria for resource planning. Resource economists are trained in a framework that relates economic theories to physical or biological opportunities, to resource limits, and to the legal, organizational, and cultural institutions of mankind. We sometimes use jargon to facilitate communication within our professions. I believe we will find that our principal differences are in jargon and emphasis, rather than in basic philosophy. If my hypothesis is not true, I hope we can finish with a better understanding of our basic differences.

The papers have been grouped into two panels, and are intended to provide insight into two areas of interest concerning valuation. The first panel will describe values relative to use, in the sense of consumption, and will discuss what wildlife and fish are worth to consumers in terms of recreation. The first paper will address, specifically, how various economic measures should be used. The second panel will consider nonconsumptive or future users' values. To the extent that the public trust is to provide sustained production of renewable resources for future generations, these are economists' approaches to this issue.

I would like to thank all the session participants and to express my appreciation for all suggestions and assistance provided.

A Field Guide to Wildlife Economic Analyses

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Much unnecessary confusion about the economic value of wildlife is caused by inadequate knowledge of basic economic concepts. This is aggravated by a common failure to identify and separate different policy questions which require different kinds of dollar value-related answers. The information required by questions of national economic efficiency, for example, are different than what is needed to address concerns about local economic impact.

The purpose of this paper is to identify and clarify several major sources of confusion that commonly inhibit effective wildlife valuation. First, economic values in the context of the Public Trust Doctrine are shown to be broader than the financial perspective often taken in practice. This is followed by clarification of concepts of economic efficiency. Common abuse of expenditure information is exposed, and the proper role of expenditures in analysis of economic impact is clarified. Finally, the important relationship between economic value on the one hand and resource quality and price on the other hand are explained.

Public Trust Doctrine

In the United States the Public Trust Doctrine assigns ownership of the nation's wildlife resources to the State or Federal government. The government thus has the incentive and responsibility to manage these resources as trustee for the benefit of the public. The Public Trust Doctrine recognizes that market failures would result in inefficient resource allocation without cooperative intervention. The public agent is expected to pursue broad economic efficiency rather than the more narrow and incomplete financial incentives seen by private firms. In this way wanton resource exploitation and the tragedy of the commons are hopefully avoided.

The Public Trust Doctrine recognizes there are many benefits of wildlife to people in addition to commodity values. Broadly defined, the economic benefits of wildlife go beyond market prices to reflect the benefits to birders, hunters, and citizens who enjoy knowing wildlife exist. Many of the papers which will be presented in this session will be analyzing the nonmarketed values produced by consumptive and nonconsumptive uses of our wildlife resources. In this paper, the notion of the Public Trust Doctrine serves to

[1] Comments by Drs. M. Hay and J. Charbonneau have improved the clarity of this manuscript significantly.

highlight the first pitfall the wildlife biologist often faces in identifying and evaluating wildlife values: the difference between economic values and financial values. Financial values reflect only revenue or sales received by firms or public agencies (i.e., cash changing hands). Economic values are much more general. Financial values may ignore externalities and values which flow in ways that cannot be captured as revenue (Bator 1958). At best, financial values are a subset of economic value and, at worst, may be a serious distortion. In any case for any good or service to have a positive economic value, it must have two properties. It must provide at least some consumers (but not necessarily all) satisfaction or enjoyment. Second, the good or service must be *scarce* in the sense that at a zero price (free) consumers want more than is available. Wildlife certainly meets both of these properties. Some wildlife recreation opportunities are so scarce they are once in a lifetime in nature (e.g., bighorn sheep and mountain goat hunting permits).

Figure 1 illustrates what Randall and Stoll (1983) call a "Total Value Framework." The financial value of wildlife reflects a *portion* of the social benefits (defined in terms of willingness to pay) of recreational and commercial uses of wildlife.

Beside the citizens' economic values of onsite recreation (both consumptive and non-consumptive) and commercial uses of wildlife, there are many off-site user values. These include option, existence, and bequest values. Option value can be thought of as an insurance premium people would pay to insure availability of wildlife recreation opportunities in the future. Existence value is the economic benefit received from simply knowing wildlife exist. Bequest value is the willingness to pay for economic benefits of providing wildlife resources to future generations.

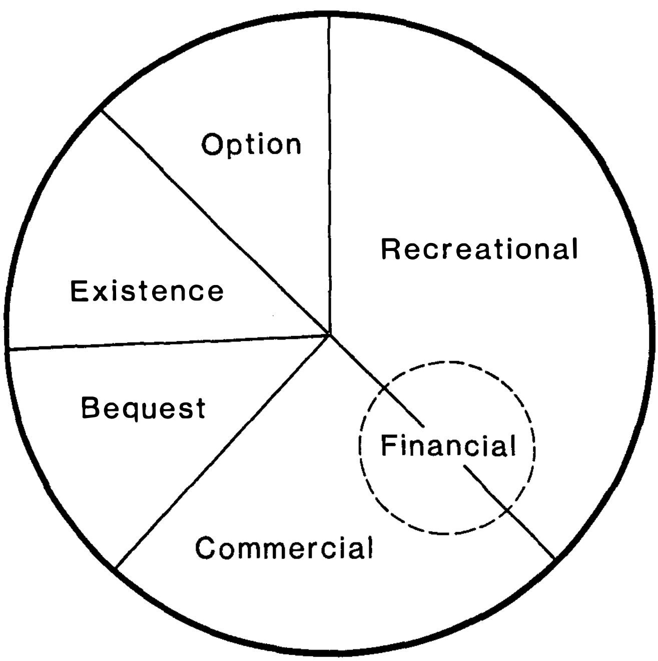

Figure 1. Total value of wildlife.

These off-site user values were first put forward in the economics literature by Weisbrod (1964) and Krutilla (1967). The values have been measured using the Bidding Game Method for bighorn sheep and grizzly bears by Brookshire et al. (1983). They have also been measured by water quality, air quality and wilderness by Walsh et al. 1978, Brookshire et al. 1982 and Walsh et al. 1984. While option and existence values may be present for manufactured consumer goods, Randall and Stoll (1983) claim those values are likely to be, at the margin, empirically insignificant in size compared with certain scarce wildlife species.

The relationship of economic and financial values for wildlife is confusing to managers accustomed to dealing only with marketed resources such as coal or timber. For these resources, where the market approximates perfect competition, the economic and financial values of additional units of outputs are almost synonymous.

Financial values (sales revenue, profit) are useful in answering questions about profitability of guide services or retail outlets for recreational equipment. Financial feasibility of business is often important to county and state officials from a job creation or property tax standpoint. These legitimate concerns have little to do with the economic value of wildlife, however.

Economic Efficiency Values Versus Expenditures

Many of the questions posed by Federal and state wildlife programs involve determining whether the economic gain from some investment such as fish ladders or habitat developments exceeds the costs of such developments. A similar question is asked in evaluating National Forest Plans or the cost effectiveness of mitigation plans. The answer to the question "do the benefits exceed the cost of some resource action" requires comparison of the willingness-to-pay (consumer and producer surplus) of gainers to willingness-to-pay of the losers (U.S. Water Resources Council 1979, 1983, Walsh 1983, and Dwyer et al. 1977). When the willingness-to-pay values of project gainers exceed willingness-to-pay of losers the present net value is positive or the benefit-cost ratio is greater than 1. What this means is efficiency of resource use has been increased by reallocating resources from lower value uses to higher value uses. Such a reallocation of resources is economically efficient since it increases the size of the economic "pie." Harberger (1971), Mishan (1976), and many others (Just et al. 1982, Sassone and Schaffer 1978) state that the demand curve for the service under study should be used as the basis for estimating consumers' (or in this case, recreationists) willingness to pay for increases in wildlife recreation opportunities (more trips, higher harvest, increased sightings of a particular bird). Economists' term for consumers' net willingness to pay is called "consumer-surplus". Consumer surplus represents the consumers' additional (net) willingness to pay for the opportunity to hunt or fish at some site. It is a net or additional willingness to pay since it is in addition to their current expenditures. Figure 2 illustrates this concept. The demand curve shows the quantity of trips a bird watcher might take at alternative travel costs, where travel cost is used as the "price" of a trip. In this hypothetical example, if the travel cost is only $10, he or she will take four trips. This birdwatcher's net willingness to pay to have the opportunity to go bird watching at this site is the area under the demand curve but above the cost of $10. In Figure 2, the consumer surplus and hence net willingness to pay associated with four trips is $105 (45+32.5+20+7.5). This $26.25 average consumer surplus per trip ($105 divided by 4) represents the economic efficiency benefits that answer questions posed by benefit-cost analysis. The *gross* will-

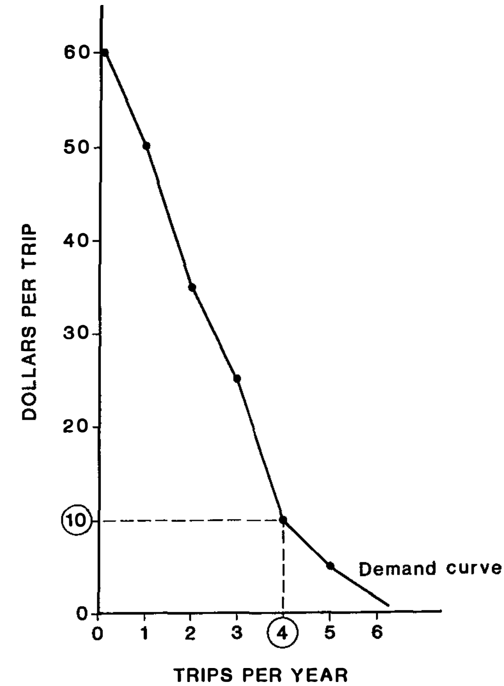

Figure 2. Demand curve for wildlife recreation.

ingness to pay is the entire area under the demand curve. In this example it is one $105 plus the $40 of expenditures.

Consumer surplus sometimes stands as a conceptual stumbling block for people involved in economic valuation. It is difficult for some to see consumer surplus as a real or tangible economic benefit because it represents money that has not actually been collected by a business or governmental agency. The fact that consumer surplus is quite tangible can be demonstrated in the case where it would be feasible to charge each individual his or her maximum willingness to pay for each unit. Such pricing schemes involve a "perfectly discriminating monopolist" using "first degree price discrimination" (Nicholson 1978). The fact the government does not try and capture the full willingness to pay for each unit (the consumer surplus) as revenue does not diminish the existence of such a consumer surplus. In absence of perfect price discrimination, the uncollected monies that could be paid reside as additional income to the consumer.

The Resources Planning Act (RPA), National Forest Management Act (U.S. Forest Service 1982), BLM's Rangeland Investment Policy (1982), and the U.S. Water Resources Council Principles and Guidelines (1983) all require resource valuation to be done in terms of net economic surplus to the consumers and/or producers. This net surplus is the value remaining *after* all costs have been paid and is the net willingness-to-pay. This is not measured by the actual expenditures of the consumer. Expenditure information is useful for certain kinds of policy decisions requiring knowledge of community dependency as opposed to net benefit and economic efficiency. It is also useful for analysis of economic impacts where the purpose is to expose the distribution of costs and benefits. We will next show that use of actual expenditure information to measure wildlife benefits for efficiency-related decisions is incorrect and grossly misleading.

The demonstration that actual expenditures (say our $10 per trip in Figure 2) is not correct for *valuation* of wildlife recreation proceeds at two levels. First, we define costs as benefits foregone. The more it costs society to harvest a certain number of trees, the less the net gain to society. That is, the more we give up to get something, the less net benefit there is to having it. In this respect, not only is it inappropriate to compare expenditures (or jobs created), it works to the detriment of wildlife anyway. A grossly inefficient deficit timber sale that requires several miles of expensive road building will result in thousands of dollars of expenditure and dozens of jobs. If the value of the trees is less than all of these expenditures, there has been a *net loss* to society. Expenditures in excess of economic benefits means the cost of what was given up exceeded the benefits of what we got. An example of the beneficial treatment wildlife gets when the net benefits (gross benefits minus the expenditures) of agricultural development is compared with habitat preservation can be seen in Hyde et al.'s 1982 paper on the Birds of Prey Conservation Area in Southeast Idaho. They evaluated a trade off between agricultural development and preservation of the prey base. The net benefits of agricultural development were very low due to the high costs (expenditures) necessary for farmers to cultivate this land and pump the water from the Snake River. If one judged the economic benefits on expenditures, the inefficient agricultural development would look feasible. Given the low net benefits of agriculture, the opportunity cost of maintaining the prey base for the Birds of Prey Conservation area was also quite low. The opportunity cost of preserving wildlife habitat may often be negligible when the value of development is correctly evaluated.

Figure 3 illustrates the inappropriateness of expenditures for valuing wildlife. Let's say that an agency has the choice of restoring one of two lakes for fishing. Lake A is located at a distance which requires $40 of expenditure to visit the site. At this cost per trip only two trips are taken. The total fishermen expenditure associated with Lake A is thus $80 ($40 × 2). Alternatively, Lake B could be improved and opened for fishing. Lake B is close enough that the expenditure associated with visiting it is only $20 per trip. With our given demand curve, we see that fishermen would take four visits to Lake B. At a cost of $20 per trip, this too results in an expenditure of $80.

The recreationist's expenditures will be the same whether one selects Lake A or Lake B for improvement. Does the equality of recreationists's expenditure mean there is equality of economic benefits? Clearly not! Because anglers would prefer four trips to two trips (for the same total cost of $80), it would be more beneficial to improve Lake B. What sort of measure or criteria would lead a decision maker to choose B over A? Expenditures would say provide either A or B. Not surprisingly, comparing recreationists' net willingness to pay (the area under the demand curve but above the travel cost) will lead us to choose Lake B over A. This result comes about because the consumer surplus associated with Lake B (area 20-60-B in Figure 3) is larger than for Lake A (40-60-A in Figure 3). Here the consumer surplus for Lake B is $80 while for Lake A it is only $20. Therefore, use of expenditures as a measure of benefits will often lead us to improve or build new recreational sites as far away from users as possible. With a higher cost few trips will be taken. This leads to maximum *inefficiency*.

While the loss of benefits from eliminating a fishing site through hydropower develop-

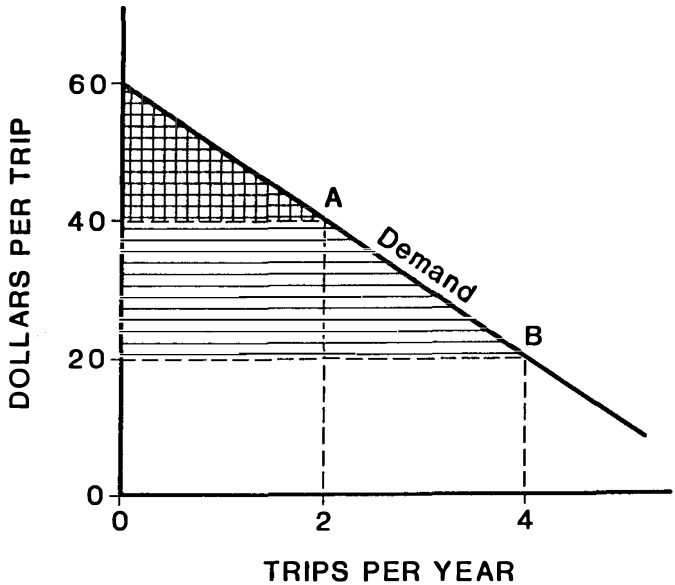

Figure 3. Comparison of expenditures and net benefits.

ment is measured by the loss in consumer surplus, the actual expenditures no longer spent at that site are not an economic cost to society as a whole. Fishermen are not simply going to take the money formerly spent on fishing at site *X* and set fire to the money. They will spend that money visiting site *Y* or in buying some other good or service. Thus, the local gasoline station next to site *X* may lose sales revenue when site *X* is eliminated, but the gasoline station at site *Y* will get more revenue.

From the point of view of economic theory, moving expenditures from one locale to more efficient investments in another location has no negative net effect on national economic efficiency. Of course, this assumes that resources are reasonably mobile and that the transfer creates dislocation costs less than the gains in efficiency. Unlike the textbook models, short run dislocation costs may be high, as evidenced by stresses caused by closing a locally dominant major industry. And, individuals who lose income in the transfer tend not to find satisfaction in the knowledge that others have gained income elsewhere. As in the transition from candles to electric lights, a few groups bore a large part of the costs while most everyone received a small part of a much larger gain. However, local politicians, industry associations, and the National Environment Policy Act of 1969 demand a display of how the costs and benefits of a change from the status quo are distributed. The standard way to address issues of equity in performing benefit-cost analysis is to display not only the net benefits (net present value) but also which groups receive benefits and which groups bear the costs (Desvousges et al. 1983).

An alternative way of displaying the impacts on local communities of resource actions is through the use of "regional economic analysis." Here the portion of actual expenditures made in the surrounding communities are translated into local income and employment.

Input-output models are often used to estimate the "multiplier effects" of the expenditures on employment. However, the multiplier effects of additional income to one town is almost always offset by a multiplier reduction in local income to other towns.

At this point, it should be clear what the U.S. Water Resources Council Unit Day Values and the U.S. Forest Service Resources Planning Act Values are supposed to represent. They are intended to be administratively acceptable measures of net willingness to pay per visitor day or Recreation Visitor Day. This is the correct measure for benefit-cost analysis. While one may not agree with the dollar values per se, they are at least attempting to measure net willingness to pay, not expenditures. Therefore, one should not use these Unit Day Values with a multiplier to determine local impacts.

Price vs. Consumer Surplus

Another obstacle to correct wildlife valuation is the common allegation that market prices and consumers' surplus cannot be compared. This problem stems from confusion about underlying concepts and failure to separate different questions requiring different answers. The correct measure of gross value to the consumer is the amount of monies the consumer is willing to pay for the thing in question. Net value to the consumer is this sum less the expenditures required to obtain it, i.e., consumers' surplus.

The technical relationship between price and consumers' surplus is shown in Figure 4. We again rely on the demand curve as the measurement of consumer's valuation (Harberger 1971). The actual shape of the demand function will depend on the nature of the market and the context of the question. In Figure 4 we use a downward sloping function representing the entire market or industry. For the good in question, let the

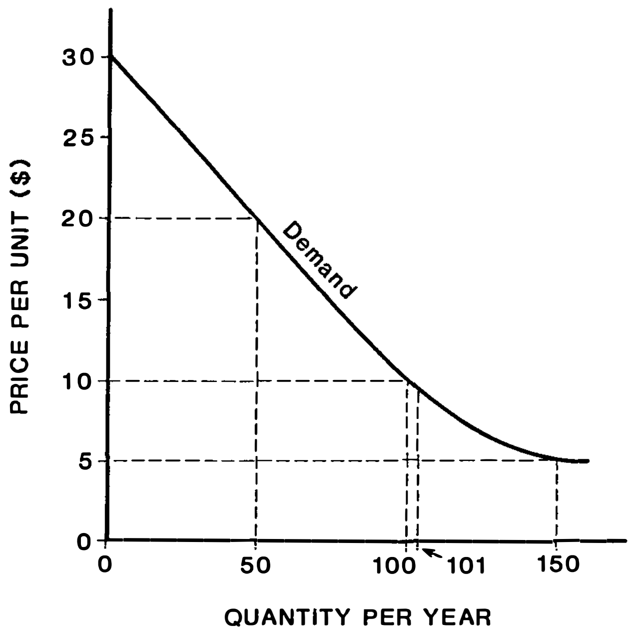

Figure 4. Price versus consumer surplus.

current quantity being exchanged be 100 units at a price of $10. The gross value of one additional unit in this market area is $10. This is the consumers gross willingness to pay for that unit. The price is also $10, so the net willingness to pay is zero. The marginal unit has no net benefit.

If the price is reduced to $5 and the quantity exchanged becomes 150 units, the old price of $10 cannot be used as the consumers' gross willingness to pay for the 50 additional units. The gross willingness to pay for these 50 units is the area under the demand curve between 100 and 150 units, in this case a bit less than $375. At the new level of consumption the 150 units can all be purchased for $5 each. The gross willingness to pay for the last unit consumed is thus the market price of $5 and the net willingness to pay for this last unit is zero. The willingness to pay for the other 49 added units is greater than $5, however, as shown by the downward slope of the demand curve, and thus generates consumers' surplus. For example, the 100th unit consumed could have been sold for $10. It has been sold for $5. The net willingness to pay enjoyed by the consumer for the unit is thus $5 in the form of consumers' surplus. The total consumers' surplus associated with the increase of 50 units is the triangular area below the demand curve between 100 and 150 units and above the price of $5, or a bit less than $125[2]. This is the net economic benefit of the change no matter what the units are, be they bicycles, trees, or RVD's of wildlife viewing. The differences arise because some questions ask for net willingness to pay at the margin (e.g., a very small change), and some questions ask for net willingness to pay for non-marginal changes (e.g., a very large change). In *any case*, if there is surplus, it should be measured and counted. Where there is none, the situation is no different, there simply is not any to be measured and counted.

Timber and meat are traded in national or international markets. A change in timber provided by one ranger district of a Western National Forest will make no detectable changes in quantity or price in the national market. If price and quantity do not change, market price measures the gross value of the change on the ranger district. Because the change is marginal, however, there is no consumer surplus involved. In a sense, while the demand curve for the indusry is downward sloping, each ranger district produces such a small proportion of the nation's timber or AUM's that its demand curve is horizontal at the current market price. That is, by varying its output from zero to 100 percent of capacity, the change, when viewed for the market or industry as a whole, is still marginal. Hence, no change in price. With no change in price there is no change in consumer surplus. Hunting and fishing, however, often take place in small or localized markets. A majority of hunters and anglers visit areas within 200 miles (360 km) of their homes. Elimination of one major cold water stream or lake for trout fishing will make a substantial change in the quantity and price (i.e., travel cost) of fishing opportunities available to people for whom the eliminated opportunity was the most efficient choice. In such a case there will be significant consumers' surplus associated with elimination or addition of an opportunity. On the other hand, imagine a place in Minnesota where there are hundreds of identical uncongested lakes, each no more than 1 mile (1.6 km) from one another. The loss of one lake would have no measurable effects on the price faced by an angler and hence no loss in consumer surplus for recreation.

[2] The *total* net willingness to pay for the price fall from $10 to $5 equals the consumer surplus on the additional 50 units sold ($125) and the increased consumer surplus from the lower price on the original 100 units purchased ($500).

Net Benefits vs. Resource Quality

Another source of confusion relates to differences in the value of resources of different quality. The gross willingness to pay for steelhead fishing, for example, is generally higher than for trout fishing. However, because the opportunities are often available only at a few remote rivers, travel costs for steelhead fishing tend to be higher than trout fishing. The combined effect is that net willingness to pay for steelhead fishing may be lower than trout fishing in some cases. In these cases, lower net benefit flows from the higher quality resource because the higher price offsets the quality differential. On the other hand, introduction of a new steelhead site with substantially lower travel cost will produce more net benefit than a new or existing trout site. The same holds true for timber bids. Walnut trees are much more valuable than maple trees, but a remote stand of walnut trees in an inaccessible location will have a lower bid price than a stand of maple trees near the mill. In this case, the higher quality trees are worth less because of higher harvest costs.

Conclusion

While efforts should continue to refine our methods of estimating demand curves for consumptive and nonconsumptive wildlife recreation, as well as offsite existence values of wildlife, one must conclude that the conceptual basis of wildlife valuation is consistent with valuation of market commodities. While all of the theoretical rough edges have not been resolved, use of net willingness to pay will certainly improve the allocation of wildlife and other natural resources. When issues of resource allocation to increase benefits to society as a whole are considered, net willingness to pay is the appropriate dollar measure. Expenditures are not correct in benefit-cost analysis but are useful only for determining the local or regional impacts on jobs or income. The employment gains in one area are eventually offset by employment losses elsewhere. Use of market prices or profits to firms may be useful for evaluation of producers' willingness to pay but can also be used to determine changes in financial feasibility of local businesses when public agencies take some action.

With regard to improving our benefit-cost analyses of wildlife resources, biologists and economists should work together to move away from less reliable unit day value approaches toward greater use of site specific empirical techniques. Biologists can help economists adapt and apply empirical techniques, such as the Travel Cost, Contingent Value, and Household Production Methods, to valuation of wildlife dependent recreation. Both disciplines and wildlife resources will surely benefit from such cooperation.

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Agricultural Management Practices and Wildlife-Related Recreation: Pheasant Hunting Recreation in Iowa

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Introduction

Agricultural activities modify the natural environment to enhance the flow of agricultural products from the land. The consequences associated with agricultural activities that modify the environment include increased soil erosion, increased use of chemical inputs, and altered (usually reduced) flows of other goods and services from the land and water.

Public concern has arisen over agricultural management practices that may threaten the future productivity of our land and water resources. First, soil erosion may reduce our ability to meet long run demands for food and fiber at reasonable prices. Second, sediments and chemicals entering our streams, lakes, and reservoirs reduce the output of fish, wildlife, and recreational opportunities. Third, some agricultural management practices tend to impair the productivity of upland and wetland wildlife habitat by reducing food, cover, water, and diversity.

Unfortunately, little is known about the costs incurred by society as a consequence of particular agricultural management practices (National Research Council 1982). Studies are underway to measure the potential on-farm productivity losses associated with soil erosion (Crosson 1983). However, further research is needed to establish the off-farm productivity losses associated with particular agricultural management practices. More specifically, the impacts of current practices on aquatic, wetland, and upland habitats need to be established and the benefits of potential habitat improvements need to be estimated.

The objective of this analysis is to develop a framework that can be used to assess the economic impacts of particular agricultural management practices on wildlife habitats and to determine the implications for pheasant hunting recreation benefits in Iowa. It is difficult to quantify the direct impacts of agricultural management practices on wildlife populations and to relate wildlife populations to recreation benefits realized. Additionally, a well-defined market for wildlife does not exist, complicating the estimation of economic benefits from improved recreational opportunities.

The household production function model proposed in this analysis of pheasant hunting recreation will concentrate on the relationship between agricultural management practices and individuals' recreation decisions. Farmers' management decisions (Miranowski and Bender 1982), combined with public recreation-provision decisions, affect the quality and quantity of habitat that is important to the wildlife recreation experience. Changes in the supply (habitat) characteristics affect the individual's cost of producing recreation activities and influence the decision to participate in recreation.

Pheasant Habitat

Pheasants are farm game birds and, consequently, the abundance of cultivated land in Iowa has provided a rich environment for them. Many factors interact in a complex way to affect pheasant population. Most of these factors, however, could be assigned to the influences of weather conditions and habitat. For the purposes of this study, weather is considered a stochastic phenomena, while habitat is assumed to be controllable to a large extent by land management practices.

Based on a study by Farris (1977), the long term status of pheasants depends upon the quantity and quality of available habitat. For pheasants in Iowa, the two major limiting habitat requirements are winter cover and nesting cover. Winter cover includes vegetation that provides adequate shelter from winter storms and predators. In Iowa, pheasants commonly seek winter cover in areas of undisturbed grassland, farm groves, smaller stands of trees, brushy areas, drainage ditches, and sloughs. The area in winter cover types must be of adequate size to sustain the population and of adequate distribution to offer safe proximity to food sources.

Nesting cover must consist of quality cover type of sufficient abundance and distribution. A wide range of cover types have been used by pheasants for nesting, but of these the most productive include oats, hay, undisturbed grassland, brushy areas and road and railroad ditches (Farris 1977, Mohlis 1974). The availability and consequent productivity of an area for nesting is a function of the existing vegetation at the start of the nesting season and the length of time that the vegetation is left undisturbed. Thus, the amount of vegetation left standing from the previous growing season is crucial to the availability of nesting sites in Iowa, and the success of established nests can be undermined by early mowing of grass crops or cultivation of rowcrops (Farris 1977).

Agricultural Land Use and Pheasant Populations

Pheasant habitat requirements clearly indicate the central role that agricultural land management practices play in influencing pheasant populations. The history of pheasants in Iowa parallels Iowa's agricultural development. Prior to 1940s, diversified farm practices provided appropriate habitat for pheasants. The continuing agricultural trend toward larger acreages, less diversified cropping practices, and more intensive management, resulted in less winter cover, diminished food supplies, and declining quantity and quality of early nesting cover.

Studies of Iowa and similar agricultural regions have examined the relationship between agricultural land use trends and declines in pheasant habitat (Farris 1977, Mohlis 1974). Mohlis' study concentrated on land use changes in 27 counties in northcentral Iowa and their relationship to declines in pheasant habitat from 1938 to 1973. During this period, land use in Iowa remained predominantly agricultural (89 percent of Iowa's total land area), but the mix of agricultural uses changed dramatically from small grains, hay, and pasture to corn and soybeans. Some nonagricultural land use changes were also significant. Wetlands, undisturbed grassland, fencerow vegetation and farm groves declined dramatically while drainage ditches and roadsides increased during the 1939–1973 period. This trend away from acres in oats, clover, wetlands, and undisturbed grassland was cited by Mohlis (1974) to be the main reason for these reductions in nesting cover. The percentage of land providing winter cover also fell, largely attributable to the decline in farm groves and wetlands.

General Theoretical Framework

The household production framework has been suggested and used as a way of modeling relationships between supply characteristics and recreation behavior. Household production function theory was first developed in connection with the allocation of nonwork time by Becker (1965) and has since been extended to recreation activities in studies by Bockstael and McConnell(1981), Deyak and Smith (1978), Miller (1979), and Miller and Hay (1981). The household production function is a reformulation of the traditional economic theory of consumer behavior. According to traditional theory, a household maximizes its utility,

$$u=u(x_1, x_2, \ldots, x_n)$$

subject to a budget constraint

$$I=\Sigma p_i x_i,$$

where x_i=quantity of good i purchased in the market,
p_i=price of good i purchased in the market, and
I =money income.

The household production function literature augmented consumer theory by assuming that households, by combining their time and market goods, produce commodities that enter directly into the household's utility function. Thus households are both producers and utility maximizers.

In terms of recreation demand, the general idea behind the household production function is that households maximize utility derived from a set of final goods or services, which include recreation-related quantity and quality variables, such as number of days spent participating in a recreation activity and bag rates. The household maximizes its utility subject to budget constraints and household production functions for final services. These production functions for final services of outdoor recreation may depend on factors such as time, travel costs, fees, recreation-related expenditures, and supply variables. The supply variables of interest may include the number of acres in recreation areas or wetland habitat, the population of game species, and environmental quality measures. For the purposes of this study, we are interested in supply characteristics that are important determinants of the quantity and quality of pheasant hunting recreation.

Specific Model

A more formal model was designed to highlight the effect of agricultural land use on household pheasant hunting decisions. The model follows a form similar, although with some important departures, to those presented by Wilman (1983), Bockstael and McConnell (1981), and Miller (1979). The model identifies the relationship between agricultural management practices and pheasant populations that is important to pheasant hunting recreation. Agricultural management practices may affect the household's ability to produce the recreation commodity, days spent in pheasant hunting recreation.

The pheasant supply relationship important to the hunter can be expressed in the general form:

$$S=S(H) \tag{1}$$

where S is the population or stock of pheasants, and H is a vector of pheasant habitat characteristics important to producing pheasant stocks. These habitat characteristics may include the percentage of total land in important winter or nesting cover types and important management practices for those cover types.

The household's utility function is assumed to be well-behaved and of the form

$$U=U(Z_{ph}, Z_o) \tag{2}$$

where Z_{ph} is the number of days spent at pheasant hunting recreation and Z_o is a composite of other final goods and services. It is further assumed that the household behaves as if it were subject to the following budget constraint and production functions.

$$I=W(\bar{t}-t_{ph}-t_o)=p_{ph}x_{ph}+p_ox_o \tag{3}$$

$$Z_{ph}=Z_{ph}(x_{ph}, t_{ph}, S) \tag{4}$$

$$Z_o=Z_o(x_o, t_o) \tag{5}$$

where x_{ph}=purchased goods used in production of pheasant hunting days,
x_o=purchased goods used in production of other goods and services;
t_{ph}=time required to produce Z_{ph},
t_o=time required to produce Z_o,
$\bar{t}$=total available time,
P_{ph}, p_o=prices of purchased goods,
W=wage rate,
I=money income,

It is assumed that the household selects the least cost combination of purchased goods and time, yielding a cost function for the production of final goods and services:

$$C=C^{Z_{ph}}(Z_{ph}, p_{ph}, p_o, W, H) + C^{Z_o}(Z_o, p_{ph}, p_o, W). \tag{6}$$

when no joint production occurs (Miller 1979). Maximizing the household's utility function subject to the cost function, the demand equations for pheasant hunting recreation, Z_{ph}, and other final goods and services, Z_o, can be derived from the first order conditions.

Yet, what is generally estimated is a reduced form participation equation with Z_{ph} a function of the exogenous demand factors and supply characteristics. Unfortunately, the usual lack of price data frequently limits the exogenous variable set to habitat characteristics (supply) and socioeconomic variables (Miller 1979).

Empirical Analysis

The pheasant hunting recreation model for Iowa attempts to explain days of pheasant hunting recreation by individual participants in terms of socioeconomic variables, travel costs, and supply or habitat characteristics. The primary source of information for this analysis is the *1980 National Survey of Hunting, Fishing and Wildlife Related Recreation* (NSHFWR). This survey, designed and administered by the U.S. Fish and Wildlife Service and the Bureau of Census, was conducted in two stages. The first stage involved a telephone interview of households to gather socioeconomic data and information on hunting, fishing, and wildlife associated recreation participation for each household member. In the second stage a mail questionnaire was distributed to the sample of hunters, fishermen, and nonconsumptive recreationists identified in the telephone interview. For the state of Iowa, the survey resulted in usable data for 2,340 individuals from the first stage inquiry and 620 hunters and fishermen from the mail survey.

For the purposes of this study, a subset of all Iowans who hunted pheasants in Iowa was isolated from the national survey. The subset consists of 232 observations after omitting those with missing values in key variables. Also, for Iowa, the survey identified five regions of participation. This regional delineation coincides with that used by the Iowa Conservation Commission,which divides Iowa into five predominant agricultural production regions. The survey information on miles traveled and days spent pheasant hunting was defined by region of participation.

Table 1 lists the definitions and summary statistics for socioeconomic characteristics, costs, and pheasant habitat variables from the survey data that were considered important in this study. The socioeconomic variables expected to be significant were AGE, SEX, and INCOME. SEX and INCOME are expected to be positively related to DAYS while a negative relationship would be likely between AGE and DAYS. Round-trip miles (travel cost) to area of participation, DIST, is postulated to have an inverse relationship to DAYS.

Supply variables are not included in the NSHFWR and, therefore, were acquired from other sources. County level supply information was necessary to estimate average supply characteristics for each of the five regions of participation identified in the NSHFWR. Information by county on land and water acres are from the 1977 National Resource Inventory. County land use data for cropland acres, pasture and hay acres, and woodland are from the *1978–79 Iowa Land Use Data* figures compiled by the Iowa Soil Conservation Service. Acres in corn, soybeans, oats, and hay for each county were obtained from the *1981 Iowa Agricultural Statistics*. Cropland is defined as the sum of acres in cropland, pasture,hay, and woodland. The variables for percentages of cropland in the various management practices used in this study are defined in Table 1.

Tillage data on cropland acres in no-till and minimum (conservation) till were acquired from the Iowa Soil Conservation Service's 1983 Conservation Tillage Survey which consists of estimates for each county made by Soil Conservation Service field office personnel. Reduced till refers to both no-till and minimum till activities. PREDTIL is thus the percentage of rowcrop acres under reduced till practices, where rowcrop acres include those in corn and soybeans.

We do not propose to develop an integrated explanation of pheasant hunting recreation decisions for Iowa. Rather, the purpose of this empirical analysis is to illustrate how a household production model might be used to consider the impacts of agricultural management practices on recreation decisions. Typically, such empirical analyses rely on a two step procedure. First, a probability of participation equation is estimated for the recreation activity. Second, an intensity of participation equation, which is a reduced form equation loosely related to the household production model, is estimated.

Given the purpose of this analysis, we will ignore the probability of participation decision. Instead, the analysis will concentrate on the intensity of the participation of individuals from Iowa who hunted pheasants in Iowa during 1980. Because of data limitations, no attempt is made to estimate demand equations for particular habitat characteristics even though such information would be useful for policy decisions.

The preliminary results from estimating the reduced form intensity of participation equation for pheasant hunting recreation in Iowa are reported in Table 2. Models A and B differ in the set of habitat characteristics considered. Although the statistical results are promising, only the coefficients of the socioeconomic variables, AGE and INCOME, are significantly different from zero at a 0.05 level of confidence.

The results with respect to specific socioeconomic variables are quite interesting and consistent between models. Contrary to the results of some previous studies, the intensity of participation in pheasant hunting appears to decline with age and to be linearly related.

Table 1. Definition of variables and summary statistics.

Variable name	Definition	Unit of measurement	Mean	Standard deviation
DAYS	Number of days spent pheasant hunting	days	9.76	13.82
AGE	Age of participant	years	33.48	13.83
SEX	Sex of participant	1=if male 2=if female	1.04	0.19
INCOME	Participants's household income	thousands of dollars	23.64	13.53
DIST	Rountrip miles traveled by participant to most frequently visited hunting site in region of participation	miles	61.43	90.07
PREDTIL	Percentage of cropland in reduced till	% of acres	68.06	5.97
PROWCROP	Percentage of cropland in corn and soybeans	% of acres	72.73	14.62
PCORN	Percentage of cropland in corn	% of acres	44.84	8.88
PSOY	Percentage of cropland in soybeans	% of acres	27.88	8.14
POATS	Percentage of cropland in oats	% of acres	4.66	1.74
PHAY	Percentage of cropland in hay	% of acres	7.17	3.85

Table 2. Intensity of participation in pheasant hunting recreation in Iowa, 1980.

Variable	Model A	Model B
Intercept	−7.318	−83.355
	(−0.62)[a]	(−1.41)
AGE	−.172	−.178
	(−2.64)	(−2.71)
DIST	−.015	−.017
	(−1.53)	(−1.65)
INCOME	.152	.153
	(2.30)	(2.31)
PREDTIL	.321	1.321
	(1.69)	(1.68)
PCORN	.070	
	(0.62)	
PSOY	−.172	
	(−1.16)	
PROWCROP		−.074
		(−.92)
PHAY		1.584
		(1.33)
POAT		.142
		(.22)
R^2	.082	.086
F-ratio	3.49	2.99
Obs.	=231	

[a] t-statistics in parentheses.

Studies for waterfowl hunting indicated that age was instrumental in explaining the probability of hunting and the probability of hunting waterfowl but not in the intensity of participation (Miller and Hay 1981). As in most previous studies, the household income variable is a significant factor in explaining the intensity of participation in hunting. Given differences in functional form, the income coefficient is not readily comparable to previous studies. SEX variable was included in the initial runs, but the coefficient was not significantly different from zero.

The distance, DIST, or travel cost variable has the expected negative sign and the coefficient is significantly different from zero at the 0.10 level. As the cost of producing a day of pheasant hunting recreation increases, the level of household production or participation declines. Unfortunately, travel costs are only a partial accounting of the costs of producing the recreation activity, and excluding other costs introduces specification bias.

The habitat characteristics (supply variables) that are a consequence of agricultural management practices are critical in this analysis, because the household's production of pheasant hunting recreation is dependent on the levels of these inputs. We hypothesize that PREDTIL, PHAY, and POATS will have a positive impact on the intensity of participation because higher percentages of reduce till, hay, and oats imply more food and better nesting habitat for pheasants, assuming all other things equal. Likewise, PCORN, PSOY, and PROWCROP provide less suitable habitat and increase the cost to the household of producing pheasant hunting recreation. Thus the signs of these coefficients are expected to be negative.

In both Models A and B, PREDTIL has a positive impact on the days of pheasant hunting recreation in the region. Thus as farmers respond to rising energy prices and incentives to conserve soil, the quality of pheasant habitat and likewise the pheasant hunting recreation benefits should increase. Typically, the social decision calculus ignores the potential wildlife recreation benefits associated with soil conservation programs and oil price decontrols. None of the coefficients of the rowcrop variables (PROCROP, PCORN, and PSOY) were significantly different from zero. Both PROWCROP and PSOY had the hypothesized negative sign.

PHAY and POAT are two additional measures reflecting the availability of nesting cover as well as habitat for brooding and winter cover. Both variables have received significant attention in the wildlife literature as important pheasant habitat factors. Although both coefficients have the expected signs, PHAY is significantly different from zero at only the 0.20 level and POAT is not significantly different from zero. The latter result leads to the conclusion that POAT is not a significant factor in an individual's decision to participate in pheasant hunting recreation in a particular region but PHAY may be an important consideration. Once again, government farm programs and soil conservation policies may influence the levels of these variables.

Finally, a caveat is in order. The supply characteristics all enter the models in a linear fashion. Previous work summarized in Miranowski and Bender (1982) indicates that the diversity of habitat types is an important factor in determining wildlife populations. Too much of any characteristic may be undesirable. Thus over the limited range of diversity in Iowa our coefficient estimates may hold, but the results may not be meaningful in another regional context representing a signficiantly different habitat.

Conclusion

This analysis studied the relationship between agricultural management practices and decisions concerning the intensity of pheasant hunting participation, using a household production model. Central to this analysis was the recognition that the habitat necessities of pheasants are largely determined by farm management decisions and the governmental policies that influence them. Previous studies have dealt with the role of habitat characteristics in wildlife recreation particiption but in very general terms. This analysis, on the other hand, specified land use types and management practices, such as acres in corn, soybeans, oats, hay, and conservation till, that directly affect the availability and quality of winter and nesting cover important to pheasant. Based on the results of this study, certain management practices, such as the percentage of cropland devoted to reduced till and to hay, do affect the level of pheasant hunting participation. The percentage of cropland in corn, soybeans, or oats, however, does not appear to affect significantly the rate of pheasant hunting participation in Iowa.

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Benefits to Deer Hunters from Forest Management Practices Which Provide Deer Habitat

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Introduction

Biologists and ecologists have for some time been aware that forest management practices can affect wildlife populations through their influence on the availability of desirable wildlife habitat.[1] Scientists who study human motivations in a recreational setting have known that the satisfactions hunters derive from hunting experiences are influenced both by the environment in which the hunting takes place and by whether or not they are successful.[2] However, unlike such forest products as timber, wildlife habitat and pleasing recreational environments do not have readily observable market prices. For public agencies charged with the management of forest resources, this has made provision of outputs such as timber, for which the benefits are easily determinable, easier to justify than wildlife habitat or pleasing recreational environments, for which benefits are not easily measured.

This paper will set out a theoretical model for the measurement of the economic efficiency benefits from management practices that provide deer habitat and a desirable hunting environment and will measure these benefits for part of the Black Hills National Forest in South Dakota.

Background to the Theoretical Model

In general two types of approaches are possibilities for measuring the economic efficiency benefits from the provision of wildlife habitat and a pleasing hunting environment for hunters. One, the contingent valuation approach, uses direct questioning techniques to obtain values for hunting days, visits or seasons, or simply for the existence of certain types of wildlife. This approach is exemplified by the Stoll and Johnson (1984) paper in this session. The other approach, and the one which is used here, uses information on the actual behavior of hunters to infer the benefits they derive.

More specifically, the behavior that is observed in the second approach is the hunter's

The research on which this paper is based was undertaken as part of the Forest Economics and Policy Program of Resources for the Future and is supported by funds from Resources for the Future, the U.S. Department of Agriculture Forest Service, and the National Science Foundation.

[1] Based on extensive literature searches. Both Boyce (1977) and Thomas (1979) have developed relationships which express the suitability of an area for wildlife habitat in terms of its land and vegetative characteristics. For example, Boyce, in studying deer habitat in hardwood forests in the southern Appalachians, found that forage availability and the size of openings permitting utilization of forage were key factors. Thomas's work focusing on the Blue Mountains of Oregon and Washington provides similar findings.

[2] In the "Human Dimensions in Wildlife" session at the Thirty-eighth North American Wildlife and Natural Resources Conference, all three papers on the topic (Potter et al. 1973, More 1973, Stankey and Lucas 1973) stressed this point. The paper by More uses a quotation from the Spanish philosopher Ortega y Gasset (1972) to illustrate the role of success in hunting. "One does not hunt in order to kill; on the contrary, one kills in order to have hunted."

choice of a hunting site. A forest environment can be viewed as providing a set of hunting sites.Hunting benefits have often been assessed directly in terms of hunters' demands for visits to these sites using a consumer's surplus measure of benefit. However, the demands for visits to these sites can be viewed as being derived from the attributes or characteristics of the sites and demands may be assessed for these characteristics. The consumer's surplus approach can then be used to assess benefits associated with obtaining a certain level of the characteristic or of a change in the availability of the characteristic.

In the case of recreational deer hunters, at least one of the relevant characteristics would be expected to be the probability of bagging game. The literature on the motivations of hunters (Potter et al. 1973, More 1973, Stankey and Lucas 1973) shows that bagging game is a necessary, although not necessarily the most important, element of a recreational hunting experience. Hence vegetative characteristics that provide desirable habitat for game are likely to have some appeal for hunters. However, it is also true that vegetative and landform characteristics that provide a pleasing landscape for hunters will be important.

Given that forest vegetative characteristics can affect the hunter's recreational experience both directly and indirectly, through the provision of wildlife habitat, management practices which affect these vegetative characteristics are likely to affect the quality of the hunting experience and therefore the benefits provided to hunters. What is done in this paper is to use observations on hunter choices of sites in the Black Hills National Forest, along with information on the costs associated with these choices, to assess the benefits associated with management practices that increase the availability of desirable hunting sites.

The Theoretical Model

The model used in this study is a variant of the well-known travel cost approach. The basic idea of the travel cost approach is that travel costs to a recreation site can be viewed as necessary expenditures to consume the services of a recreation site. Assuming a group of consumers with the same demand curve for visits to the site, variation in necessary expenditure to visit the site constitutes exogenous variation in the price of the site and identifies the recreationist's demand curve for the site.

Placed in an individual utility maximizing framework the approach says that a recreationist chooses the number of visits to consume based on budget limitations and the price of a visit. Implicit in the travel cost approach is the assumption that the level of characteristics (site quality) or their prices are constant along the demand curve.

The basic travel cost model can be expanded to allow for variation in characteristic levels and/or prices. There are at least a couple of ways the model can be expanded. Alternative one is to allow the level of a characteristic, or its price, to act as a demand shifter in the basic travel cost model, enabling the assessment of benefits from increasing the level of the characteristic or decreasing its price.[3] This requires that it be possible to identify the full travel cost demand curve at each characteristic level or price. It also requires that the value of increasing the level of a characteristic at a site is zero when no visits are taken to the site. That is, having a higher level of deer habitat quality at a site is not worth anything to someone who does not visit the site.

Alternative two, which was the one used in this study, is to estimate the demand curve for a characteristic directly. The basic travel cost model is expanded to allow the hunter to choose the levels of certain characteristics he wishes to consume by choosing the sites

[3] For an application of this technique in a fisheries setting see Vaughan and Russell (1982).

he wishes to visit. As in the basic travel cost model he makes these choices subject to his own budgetary limitations and the prices of visits to alternative sites. Viewed in terms of identifying demand curves for characteristics, the relative prices of visits to various sites provide information on the necessary expenditures required to obtain different levels of the characteristics. Exogenous variation in these necessary expenditures and/or other identifying restrictions are necessary to identify the demand curve for a characteristic.

If the demand curve for a characteristic is to be used to estimate the benefits of increasing the level of that characteristic available at a site, it is required that the demand curve for the characteristic be identified. It is also required that the level of a characteristic chosen is constant across visits taken by that individual. This is equivalent to the above assumption that the level of the characteristic be constant along the demand curve for visits. In this case we cannot assume that the price of a visit is constant, because any change in necessary expenditure to obtain the characteristic will automatically change the price of a visit. Finally, it is required that an additional visit is worth nothing if the level of the characteristic of concern is reduced to zero. Here the characteristic of concern will reflect both desirability of wildlife habitat and desirability of hunting environment. The former of these is a proxy for the probability of bagging game during a visit and, given the role of success in providing hunter satisfaction, it is reasonable to assume that if a hunter could not afford to go to a site which would yield him a positive probability of bagging game, he would not make any hunting visits.

In the case of hunting, where the probability of bagging game is at least part of what is represented by the relevant characteristic, there are two submodels that can be derived from alternative two. They differ in the way that the quantity variable (days or visits) affects hunter satisfaction from consumption of the characteristic reflecting bag probability. In one case, satisfaction from the level of the characteristic consumed during a day (or visit) is simply multiplied by the number of days (or visits) to obtain total seasonal satisfaction from consumption of the characteristic. In the second case the level of the characteristic itself is multiplied by the quantity variable giving a proxy for seasonal bag probability. Seasonal satisfaction is derived from the season bag probability. These differ when the function relating bag probability and satisfaction is nonlinear. The first case results in the level of the quantity variable being indeterminate. That is, only whether there will be zero or a positive amount is determined by the variables in the model. The level is either random or influenced only by the variables outside the model.[4] The second case results in the level of the quantity variable for a given bag probability being chosen through minimization of the cost of achieving that bag probability. Both cases were used in this study. However, here, results are presented only for the first case.[5]

[4] There are a couple of potential problems that could arise, but did not prove to be serious in this study. The first is selectivity bias. This would occur if nonhunters would have tended to choose different levels of a characteristic than hunters, given the same prices. For a discussion of this problem see Heckman (1976). The second potential problem involves the influence of the probability of bagging game on the number of days hunted when there is a bag limit. This could result in smaller numbers of days when a high probability of bag was chosen. However, there was no observable tendency for days hunted to decline with higher levels of the quality characteristic representing probability of bagging game chosen.

[5] Bockstael and McConnell (1981) have reviewed the theory and estimation of this household production function approach to valuing the economic value of wildlife. One of their conclusions is that the conditions for identification of the parameters of the demand equations are quite restrictive when several choice variables (days, and a number of characteristics) are made endogenous to the model. This is what necessitates some of the identifying restrictions mentioned above; first, that there is exogenous variation in the necessary expenditure to obtain a certain level of characteristic; second, that the quantity variable is exogenous to the model and exhibits only random variation, or alternatively that the correct measure of the quality characteristic is seasonal quality and that quantity is by definition constant at unity.

The Case Study

The case under consideration involved forest management practices on the Black Hills National Forest of South Dakota. After preliminary investigation as to the nature of sites that seemed to be desirable due to the greater number of hunters and/or greater probability of success, taking into account accessibility, two quality attributes or characteristics were derived. One, HEIGHT, is an elevation variable. Hunters seemed to like to get away from the main highways and back into the more rugged parts of the Black Hills. A second was MGDEAD. This variable is a proxy for forage provided in small openings. It was constructed using a forage variable, calculated from basal areas of ponderosa pine, and a proxy variable for openings.[6] Since elevation is not a variable which can be subject to management action, demand curves were estimated only for MGDEAD. This variable represents wildlife habitat desirability and may also represent some aspects of a hunting environment that hunters find desirable for reasons other than the desire to bag game.

It was not possible to estimate full travel cost demand curves at different levels of MGDEAD, or at different prices for MGDEAD. This was because there is not sufficient variation in the price of a visit independent of the price of MGDEAD. This meant that alternative one was not possible, and alternative two was used. Both of the cases for alternative two were estimated. However, results are presented only for the first case.[7]

In estimating the two submodels of alternative two it was necessary to treat the quantity variable as days rather than visits. This was because when the probability of bag is used as a quality characteristic, that probability must be calculated for a given time period. In addition it was apparent in observing the pattern of trade-off between visit length and number of visits, that Black Hills deer hunters regarded the two as perfect substitutes. A hunter would take only one long visit or many one-day visits depending upon the relative cost of a day used to increase visit length versus a day used as an additional visit. Hunters close to the Black Hills took a number of one-day visits. Hunters further away took only one long visit. This suggests that hunters themselves viewed the day rather than the visit as the appropriate unit of consumption.

To estimate the demand curve for the first case of alternative two, it was assumed that the number of days visited, whether in one-day visits or longer visits, exhibits only random variation. Only whether or not any positive quantity of days occurs, and not the actual quantity, is affected by variables within the model. There is some support for this assumption in the data. When distance is regressed on the number of one-day visits, it is not a significant predictor. This is contrary to what one would normally expect in traditional travel cost model applications where visits is used as quantity variable without regard to length of visit.

The demand curve for MGDEAD was estimated assuming it to be the same across all hunters, except for the presence of demand shifters. These demand shifters included such variables as the age of the hunter and the number of years hunted, and essentially measure differences in hunter preferences. Holding hunter demand for MGDEAD constant, it is

[6] The proxy variable for openings was the average number of dead trees per acre in the compartment. It was chosen because areas high in this variable appeared to be attractive to hunters and to have high success rates. After some discussions with Black Hills Forest personnel and people from the South Dakota Department of Game, Fish and Parks, it was hypothesized that the reason for this was that the high numbers of dead trees were due to mountain pine beetle infestation. The combined result of the infestation and the management of it created small openings, as trees were removed from around the infested tree or trees.

[7] The approach used here is very similar to that used by Mendelsohn (1983). However, Mendelsohn calculates the marginal cost prices on a per visit basis.

still true that the price (or marginal cost) that a hunter must pay to obtain a given level of MGDEAD varies across the origin town of the hunter. Hunters living in different towns have different relative accessibilities to different parts of the forest. It is this variation in the marginal cost (or price) of obtaining MGDEAD that identifies the demand curve for MGDEAD.

Once the demand curve for MGDEAD is determined, the benefit or cost to the hunter of a management change which shifts the hunter's marginal cost curve can also be determined by calculating the change in the consumer's surplus obtained by the hunter. Aggregating over all hunters, the aggregate consumer's surplus change can be obtained for individuals who were consumers before the marginal cost decrease. There is, however, an omitted item. It is possible that the decrease in marginal cost would be sufficient to induce some new hunters to hunt. A better, though not exact, estimate of the consumer's surplus benefits to a new hunter would be the full consumer's surplus to an existing hunter after the marginal cost decrease, minus any fixed costs incurred.

Prices or marginal costs for MGDEAD are not directly observable. However, the marginal cost for a given town can be obtained by regressing the total costs of hunting for an individual from that town on the levels of MGDEAD and other characteristics (HEIGHT) consumed and then differentiating with respect to MGDEAD. Total cost curves for MGDEAD were estimated for five towns at different locations relative to the forest: Rapid City, Sturgis, Custer, Hot Springs, and Lead-Deadwood. These were obtained by using total costs for individuals from these towns and regressing these on various combinations of the MGDEAD and HEIGHT variables. Table 1 gives one of the better fitting equations for each town. The marginal cost of MGDEAD for each town was calculated by taking the partial derivative of total cost with respect to MGDEAD. Marginal cost estimates derived from the equations in Table 1 are presented in Table 2 below. Since the marginal cost estimates derived for MGDEAD do not vary with the level of MGDEAD for a given town, they can be used as prices in the demand equation for MGDEAD.[8] Both linear and semilog versions of the demand functions are estimated. Weighted versions (to correct for heteroscedasticity) were also used. These are shown in Table 3.[9]

Now enough information has been generated to obtain measures of consumer's surplus changes that would occur due to some management action. It will have been noted from Table 2 that the Lead-Deadwood area has a relatively low marginal cost of obtaining MGDEAD. This is because of easy accessibility to an area exhibiting high levels of a desirable characteristic. One question that might be asked involves determination of the additional consumer's surplus that would be obtained by a hunter from another town were the characteristic made equally easily available to him at the same level. For illustrative purposes, the consumer's surplus benefit that a hunter from Custer would obtain were he to have the same marginal cost for MGDEAD as a hunter from Lead-Deadwood, with the marginal cost of HEIGHT remaining constant, is analyzed here.

This is not merely an abstract example. Timber sales are scheduled to take place on

[8] If the marginal cost estimates for MGDEAD for a given town varied with the level of MGDEAD, it would not be possible to simply use them as exogenous prices in the demand equation, because MGDEAD and its marginal cost would be simultaneously determined.

[9] It might be expected that MGDEAD and HEIGHT are simultaneously determined, and consequently that HEIGHT should not be used as an exogenous demand shifter in the demand curves in Table 3. However, in this case MGDEAD and HEIGHT are for most towns not highly correlated, implying that any simultaneous relationship is not that strong. Hence a block recursive rather than a simultaneous model was assumed, with HEIGHT being determined independently of MGDEAD. HEIGHT can then be entered in an exogenous demand shifter in the demand curve for MGDEAD.

Table 1. Estimates of the total cost relationship.

Dependent variable	Rapid City Total cost	Sturgis Total cost	Custer Total cost	Hot Springs Total cost	Lead-Deadwood Total cost
INTERCEPT	25.26	59.24	−47.60	135.57	34.13
	(8.01)**	(29.94)	(79.66)	(86.74)	(25.98)
HEIGHT	0.12		−0.13		0.11
	(0.02)**		(0.25)		(0.05)**
MGDEAD	0.041	−0.033	0.25	−0.44	−0.0053
	(0.018)**	(0.065)	(0.08)**	(0.31)	(0.030)
DISTANCE	0.16	0.031			
	(0.03)**	(0.18)			
DHEIGHT	0.84×10^{-4}				
	(0.55×10^{-5})				
DMGDEAD		0.00060			
		(0.00050)			
OPEN		0.74×10^{-3}		0.0019	
		(0.24×10^{-3})**		(0.00021)**	
DOPEN		-2.15×10^{-6}			
		(9.03×10^{-7})**			
STAY				−93.18	83.70
				(132.04)	81.1
PMGDEAD				0.12	0.019
				(0.40)	(0.14)
SQUARE	0.54×10^{-4}		0.00045		
	(0.18×10^{-4})**		(0.00015)**		

Table 1. Estimates of the total cost relationship. *(continued)*

Dependent variable	Rapid City Total cost	Sturgis Total cost	Custer Total cost	Hot Springs Total cost	Lead-Deadwood Total cost
R^2	0.53	0.44	0.75	0.76	0.23
Adjusted R^2	0.52	0.37	0.73	0.72	0.09
F	60.11	5.98	32.11	20.13	1.63
L	−1,320.1	−202.4	−174.1	−130.3	−127.6
N	276	44	36	31	27

Where:

HEIGHT = the average elevation of hunting sites chosen minus 4,500 ft (1,371.6 m).
MGDEAD = the forage generated by the average basal area per acre of ponderosa pine at the hunting sites visited, multiplied by the average number of dead trees per acre. The latter is a proxy for the probability of forage being in small openings (less than 10 acres [4.0 ha]).
OPEN = HEIGHT × MGDEAD
DISTANCE = distance from the origin town to the closest point in the Black Hills National Forest.
DHEIGHT = DISTANCE × HEIGHT
DMGDEAD = DISTANCE × MGDEAD
DOPEN = DISTANCE × OPEN
STAY = whether any trips were overnight trips.
PHEIGHT = STAY × HEIGHT
PMGDEAD = STAY × MGDEAD
SQUARE = HEIGHT × HEIGHT

Bracketed numbers are standard errors.
**Indicates significance at 0.05 level (two-tailed test).

Table 2. Marginal cost estimates for MGDEAD.

Rapid City	0.041
Sturgis	$(0.74 \times 10^{-3} - [0.22 \times 10^{-5} \times \text{DISTANCE}])$ HEIGHT
Custer	0.25
Hot Springs	$0.0019 \times$ HEIGHT
Lead-Deadwood	0

forest subcompartments 30304 and 30305 within the next few years. These compartments are roughly the same distance from Custer, as other subcompartments, currently exhibiting higher MGDEAD values, are from Lead-Deadwood. If harvesting in these compartments is done so as to reduce average basal area per acre to the 70 to 80 range and so as to distribute cutting in a pattern of small openings, then a situation similar to that in the Lead-Deadwood area could exist.

First consider the current situation in subcompartments in the vicinity of Custer, and in the vicinity of Lead-Deadwood. Table 4 shows the values of the key variables for the compartments.

According to silvicultural prescriptions for compartments 30304 and 30305, thinning cuts and shelterwood cuts would result in a reduction in average basal area per acre from 117 to 94 in 30304 and from 118 to 65 in 30305.[10] Over the two subcompartments this gives an average basal area per acre in the 70 to 80 range. If the manner of harvest is such that the basal area reduction is distributed in a pattern similar to a series of small openings, then the MGDEAD variable for visitors to the 30304 and 30305 variables should be in the neighborhood of that for visitors to the area around Lead-Deadwood. This would yield benefits to hunters from Custer because the marginal cost of MGDEAD would drop to that of hunters from Lead-Deadwood. Table 5 gives consumer's surplus changes for a hunter who was hunting prior to the marginal cost change. Consumer's surplus changes are calcuated for the three alternative demand equations of Table 3. The consumer's surplus gain for a Custer hunter is in the \$99 to \$124 range. In 1980 there were 844 hunters from Custer.[11] This would have meant aggregate benefits for Custer hunters in the neighborhood of \$94,000, or \$15 per member of the population of Custer County.

In fact the number of hunters may change, although it is not possible with current data to estimate the extent of the change. If the decrease in the margnal cost of MGDEAD results in new hunters, these new hunters may well obtain greater consumer's surplus changes than existing hunters. For these new hunters the best consumer's surplus estimate we can obtain is the full consumer's surplus after the marginal cost change net of fixed costs. In the case of Custer this amount is the sum of the \$99 to \$124 change and the original total consumer's surplus amount, minus fixed costs. This gives a total of \$243 to \$393 per new hunter. The present participation rate for Custer County is 0.14, higher than any other county. If this were to increase to 0.15 there would be about 56 new

[10] Shelterwood system is an even-aged silvicultural system in which, in order to provide a source of seed and/or protection for regeneration, the old crop (the shelterwood) is removed in two or more successive cuttings. The shelterwood cuttings prior to the last cutting remove trees in a mature stand so as to effect opening of the canopy and provide conditions favorable to regeneration. This can also create openings of the size that provide desirable deer habitat.

[11] There was no actual estimate of the number of hunters from Custer. However, 270 hunters returned report cards from Custer County. The average return rate of 32 percent, which seems to be fairly constant across the counties for which both the number of hunters and report cards are available, would have meant 844 hunters from the county.

Table 3. Demand curves for MGDEAD using PRICEH.

Dependent variable	Linear unweighted MGDEAD	Linear weighted MGDEAD	Semilog LOG (MGDEAD)	Semilog LOG (MGDEAD)
INTERCEPT	308.38	295.38	5.69	5.67
	(27.88)**	(24.90)**	(0.05)**	(0.05)**
HEIGHT	0.34	0.33	0.64×10^{-3}	0.62×10^{-3}
	(0.04)**	(0.03)**	(0.73×10^{-4})**	(0.71×10^{-4})**
PRICEH	−324.72	−215.84	−0.565	− 0.420
	(122.25) **	(109.70) **	(0.236)**	(0.22)**
ANTLESS	10.24	16.49	0.08	0.015
	(17.59)	(15.76)	(0.03)	(0.03)
INCOME	−0.09	−0.045	-0.33×10^{-4}	0.89×10^{-5}
	(0.10)	(0.09)	(0.20×10^{-3})	(0.18×10^{-3})
YRSHUNT	2.21	1.49	0.005	0.003
	(0.76)**	(0.69)**	(0.001)**	(0.001)**
R^2	0.17		0.16	
F	20.46		19.19	
N	520	520	520	520

Where:

MGDEAD	=the forage generated by the average basal area per acre of ponderosa pine at the hunting sites visited, multiplied by the average number of dead trees per acre. The latter is a proxy for the probability of forage being in small openings (less than 10 acres [4.0 ha]).
HEIGHT	=the average elevation of hunting sites chosen minus 4,500 feet (1,371.6 m).
PRICEH	=0.041 for Rapid City, [0.00074 − (0.0000022 × DISTANCE] × HEIGHT for Sturgis, 0.25 for Custer, 0.0019 × HEIGHT for Hot Springs, and zero for Lead-Deadwood.
ANTLESS	= 1 if the hunter applied for anterless license, 0 ifhe did not.
INCOME	=the hunter's income level in hundreds of dollars.
YRSHUNT	=the number of years the hunter has hunted.

Bracketed numbers are standard errors.

**Indicates significance at the 0.05 level (two-tailed test).

Table 4. Vegetation characteristics by subcompartment.

Town	Subcompartment	Average basal area per acre (per ha)	Pounds per acre of forage (kg per ha)	Average no. of standing dead trees (per acre)
Custer	30304	117 (26.9)	140 (156.7)	0.0 (0.0)
	30305	118 (27.1)	137 (153.6)	3.2 (7.9)
	31002	99 (22.7)	205 (229.8)	6.5 (16.1)
	31003	106 (24.3)	177 (198.4)	0.6 (1.5)
Lead-Deadwood	70301	46 (10.6)	623 698.3	7.5 (18.5)
	70302	85 (19.5)	275 308.2	11.8 (29.2)
	70303	82 (18.8)	292 327.3	5.5 (13.6)
	70304	76 (17.4)	332 372.1	32.2 (79.6)
	70305	98 (22.5)	209 234.3	11.1 (27.4)
	70307	66 (15.2)	409 458.4	26.3 (65.0)

Table 5. Consumer's surplus changes.

Town	Linear unweighted	Linear weighted	Semilog unweighted	Semilog weighted
		Price M		
Rapid City	16	16	15	14
Sturgis	14	15	16	16
Custer	113	124	102	99
Hot Springs	84	120	76	51
Lead-Deadwood	0	0	0	0

hunters who would in the aggregate obtain an annual increase in consumer's surplus of $13,600 to $22,000. Added to the $94,000 for existing hunters, this gives a total of between $107,600 to $116,000.

Table 4 also provides estimates for a similar management change that would produce a vegetative pattern, similar to that in the vicinity of Lead-Deadwood, in the vicinity of each of the other towns. One can note that smaller benefits accrue to hunters from other towns. Part of the reason for this is the relatively large cost reductions experienced by Custer hunters. Hunters from Hot Springs and Custer currently have the greatest marginal costs for MGDEAD. Substantial reductions in cost can be expected to yield substantial benefits. Another part of the reason is that hunters from Custer tend to choose higher elevations than hunters from other towns except Lead-Deadwood. As the elevation variable (HEIGHT) is a demand shift variable, this results in higher consumer's surplus estimates.

The $99 to $124 benefit range for a Custer hunter is for one hunting season. If a management policy were instituted to maintain the situation that produced these benefits, rather than to maintain the existing situation, then it would be possible to evaluate it by allowing benefits to occur annually and calculating the present value of benefits from the policy. For example, if the new vegetative pattern resulting from harvesting in 30304 and 30305 were to be maintained for 20 years and annual benefits of $112 per hunter were to accrue at a 6 percent discount rate, then the present value of discounted benefits would be $1,300 per hunter. If the number of hunters did not change, this would be $1,097,000 in the aggregate. Allowing the participation rate to increase by one percentage point would bring this amount to around $1,300,000.

If the second case for alternative two is estimated, the results are somewhat different, but the present value of benefits is in the same range. Some sensitivity testing was also done excluding observations with very large numbers of days. The sensitivity testing produced a range of estimates from around $800,000 to around $1,400,000. The results presented here are at the upper end of that range. After considering the results of the alternative models and the sensitivity testing, the most reasonable benefit estimate was judged to be about $1,000,000.

Management practices affecting other subcompartments can be evaluated in a similar manner. What is necessary is to determine for whom and how the marginal cost of MGDEAD is changed. When the marginal cost curves are estimated statistically, this means that the marginal cost for hunters from some origin must change in such a manner as to be the same as the existing marginal cost for hunters from another origin. In the case that was presented above, Custer's marginal cost for MGDEAD became Lead-Deadwood's marginal cost. However, a similar vegetation pattern could have been produced elsewhere and the marginal cost curve would have changed differently.

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Estimating Substate Values of Fishing and Hunting

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I. Introduction

Resource managers often face tradeoffs among alternative uses of fish and wildlife resources. Management budgets are limited, requiring difficult choices among valuable competing ends. Justification of a fish or wildlife enhancement project often requires the value of additional fishing or hunting to exceed the project cost. Preservation of habitat must compete with development alternatives, the benefits of which are often presented in dollar terms. At present, fish and wildlife resource decisions are hampered by inadequate information on the economic value of recreational fishing and hunting. This lack of information stems primarily from the nonmarket nature of those activities. With few exceptions, fishing and hunting are not sold in a market like bushels of wheat or tons of coal so there are no market prices to use as measures of their value. The institutional setting in which decisions affecting publicly owned natural resources are made gives greater credence to dollar-denominated measures of benefits and costs than to nonmonetary measures. Those wishing to preserve fish and wildlife resources need arguments couched in the language of that institutional framework. It is sometimes said that streams and wetlands should be protected because they support a rich and diverse biota, but conceptual arguments based on species diversity and environmental slack are often not decisive in practice. Better estimates of the dollar value of fish and wildlife will improve resource decision making.

This paper provides a summary of ongoing efforts to derive economic values of fishing and hunting from the 1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (1980-NSFH). The next section provides a brief description of the kinds of economic values of interest and their proper uses. The third section describes the travel cost method, the empirical approach used in our analysis. The fourth section is a discussion of the 1980-NSFH and our economic value estimates, their uses, and limitations. Finally, the last section summarizes results to date and describes additional economic value studies that are planned.

II. Measures of Economic Value

There are two common measures of the economic value of fishing and hunting, each with its own conceptual underpinnings and uses: (1) net economic value or consumer surplus, and (2) expenditures. Expenditures have been widely used as a measure of economic value due, in part, to their ready availability from surveys and other sources. Expenditures by fishermen and hunters are useful indicators of the importance of those activities to the local or national economy, but they do not measure the economic value of fishing and hunting to the participants or to society. Fishermen and hunters get direct utility from their sport. The utility of those experiences does not show up in cash register receipts, but it has an economic value. We measure that value, termed consumer surplus, in dollar terms.

The relationship between expenditures and consumer surplus is shown in Figure 1. The curve, *dd*, is an individual hunter's demand curve for hunting trips to a site. It shows the number of trips the hunter would take per year for each cost per trip. It is downward sloping, which means that the higher the cost per trip, the "price" on the vertical axis, the fewer trips he would take. If the cost rose to $60 per trip, he would no longer visit the site because that is more than he is willing to pay for even one trip. If his cost per trip is C_o, he will take Y_o trips per year. At that point, his willingness to pay for an additional trip is equal to the cost of a trip. A rational hunter would not take more than Y_o trips. His annual cost for Y_o trips is measured by the shaded rectangle. However, for each trip he took before reaching Y_o, the hunter would have been willing to pay more than he actually had to. This "consumer surplus" for each trip is the difference between his cost, C_o, and the demand curve, *dd*, at that point. The summation of that consumer

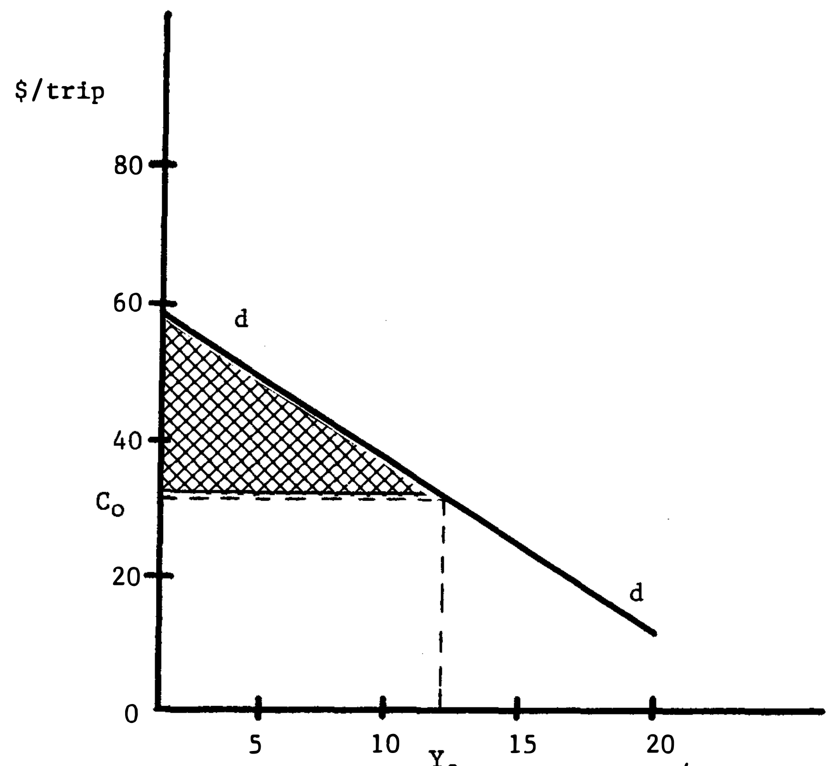

Figure 1. Individual hunter's demand curve for hunting trips per year.

surplus for a year's hunting is represented by the cross-hatched triangle. Economists are agreed that consumer surplus is an appropriate measure of the value of the activity to the individual and the net economic value to society. The travel cost method described in the next section is used to estimate demand curves like that in Figure 1, from which consumer surplus values are calculated.

The Travel Cost Method

The travel cost method (TCM) was originally formulated by Hotelling in 1947 (see Cicchetti et al. 1976) and substantially refined by Clawson and Knetsch (1966). Since then, numerous articles and books have dealt with theoretical refinements and practical issues associated with the technique (see, for example, Brown and Nawas 1973, Gum and Martin 1975).

While specific approaches differ, the basic premise of the TCM is that the number of trips an individual takes to a site to fish or hunt depends on how much it costs him to get there. Sportsmen living close to a site will visit it more frequently than those living farther away, other things being equal, because their travel cost per visit is relatively low. The TCM is a method using survey data on the number of trips individuals take and their travel costs to estimate demand curves for trips to that site. Consumer surplus estimates are then derived from the demand curves.

There are two basic forms of TCM which we will refer to as the zone and microdata approaches. In the zone approach, sampling at the site is generally used to determine the rate of visitation per capita from various zones of origin. Travel costs from those zones to the site are then calculated independently. This is the method of Clawson and Knetsch, and has been the more widely used. The microdata approach, the one selected for this study, is based on the number of visits and travel costs for individual participants, and is usually based on surveys conducted away from the site.

By their very nature, TCM estimates of economic value are site specific. Substate regions are the "sites" in our study. Prior to the 1980-NSFH, state fish and game agencies were asked to divide their states into not more than ten "fish and wildlife management regions." During detailed interviews, respondents were asked to look at a map and say in which regions they had fished or hunted in 1980, for what, and how often. Subsequent questions dealt with their travel costs, distance, and related information for each region visited.

Equation (1) shows the basic form of the equations we estimated.

$$\ln Y_{ij}=b_o+b_1C_{ij}+b_2X_1 \ldots +b_kX_k+e_{ij} \quad (1)$$

where:

$\ln Y_{ij}$=natural log of trips in 1980 by ith individual to jth region.
C_{ij}=ith individual's cost per trip to region j.
$X_1 \ldots X_k$=other factors that act as demand shifters.
$b_o \ldots b_k$=coefficients to be estimated.
e_{ij}=a random error term.

It can be shown that an estimate of $-(1/b_1)$ based on a sample of sportsmen visiting region j is the average consumer surplus value for a trip to that region (see Miller 1984).

Equation (1) is deceptively simple. There are a number of particularly thorny problems to deal with, several potential solutions, and, in most cases, persuasive arguments for each. We will briefly discuss three important issues.

Opportunity Cost of Time. Opportunity cost of time refers to the notion in economics that the time "spent" traveling to a site to fish or hunt is a cost just like the cost for gas and other items. If he were not going to fish, the sportsman could, presumably, be earning money or at least using his time for another purpose which he values. It is generally agreed that failure to include the opportunity cost of time in the cost per trip variable will bias its coefficient upward and understate the value of an average trip. A number of different approaches to incorporate the cost of time have been proposed in the literature. We adopt a rule of thumb suggested by Cesario and Knetch (1970) that the opportunity cost of time be valued at a fraction between one-fourth and one-half of the individual's wage. We used one-third the individual's predicted wage as the opportunity cost of travel time. Individual wages were derived from the hedonic wage model of Desvousges et al. (1983) who used results of the Current Population Survey to develop an equation which predicts a wage for each individual based on sociodemographic characteristics (age, sex, education, etc.). Predicted wages generally range from near zero to about $11 per hour. Travel time to the region is calculated from reported distance and an assumed speed of 45 miles per hour. This opportunity cost of travel time is added to other costs per trip. The cost of on-site time was not included.

Multiday Trips. The main problem with multiday trips is the increased likelihood that such trips have other purposes in addition to the fishing or hunting being valued. Including such joint-purpose trips would bias the coefficient of travel cost downward, leading to over-estimates of consumer surplus. In effect, the value attributable to any other purposes (e.g., visiting relatives) would be incorrectly linked to the fishing or hunting trip. Given the problems associated with multiday trips, we present value estimates for daytrips only.

Availability of Substitutes. The importance of substitute sites derives from the observation that one's willingness to pay for fishing or hunting at a given site depends in part on availability of other possible sites as substitutes. The value of a given lake for fishing in Wisconsin would presumably be less than that of a similar lake in Nebraska, other things equal. Accounting for substitute sites requires substantial data beyond those available from the 1980-NSFH. Burt and Brewer (1971) provide the most promising method for accounting for substitutes, and one we intend to explore in future studies. However, at present, our estimates do not incorporate substitutes. The most likely effect of that omission is a downward bias to the travel cost coefficient and, therefore, an upward bias to the value estimates.

IV. Empirical Results.

The 1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation was the sixth in a series of surveys conducted at five-year intervals since 1955. The 1980 Survey was designed primarily to continue the series of reports on participation and expenditures by American sportsmen, but the questionnaires were formatted in such a way as to permit use of the data for economic analysis. The survey method and results are described in U.S. Fish and Wildlife Service (1983).

The survey was conducted in two stages. The first stage involved screening some 122,000 households nationwide to identify participants in fishing, hunting, and nonconsumptive uses. The second stage entailed follow-up interviews with more than 30,000 sportsmen and 6,500 nonconsumptive users. The samples for the 1980-NSFH were derived using stratified sampling methods. Since the individual observations in the data file upon which our estimates are based were not randomly selected, weighted regression procedures were used to estimate our equations in order to avoid biased coefficients (Vaughan and Russell 1983, Porter 1973).

Our initial analysis has concentrated on estimating consumer surplus values for freshwater fishing, but we have estimated demand curves for big game hunting in Pennsylvania and small game hunting in South Dakota. Space constraints preclude presentation of all the demand equations. Table 1 shows an illustrative selection. Figure 2 is a map showing the fish and wildlife management regions corresponding to the equations and values presented here. In all equations, the dependent variable is the natural logarithm of daytrips per year. The opportunity cost of time is valued at one-third the predicted wage rate. To simplify the estimation process, we used the same explanatory variables in all regions.

The travel cost variable, C_o in our original equation (1), performed well. In all regions, the estimated coefficients had the expected negative sign indicating fewer trips as the cost per trip increases, and in all but six they were statistically significant at standard levels. The travel cost measure was based on the respondent's reported share of private vehicle cost for fishing and hunting trips and the computed opportunity cost of time. This differs from the more common approach in which travel cost is calculated as the product of miles to the site and an independent estimate of cost per mile.

We believe that a sportsman's behavior in terms of the number of trips he decides to take is influenced more by what he thinks it costs him than by someone else's (e.g., AAA) estimate of what it costs to operate an automobile. Expenditures for food, lodging, and equipment are not included in the travel cost.

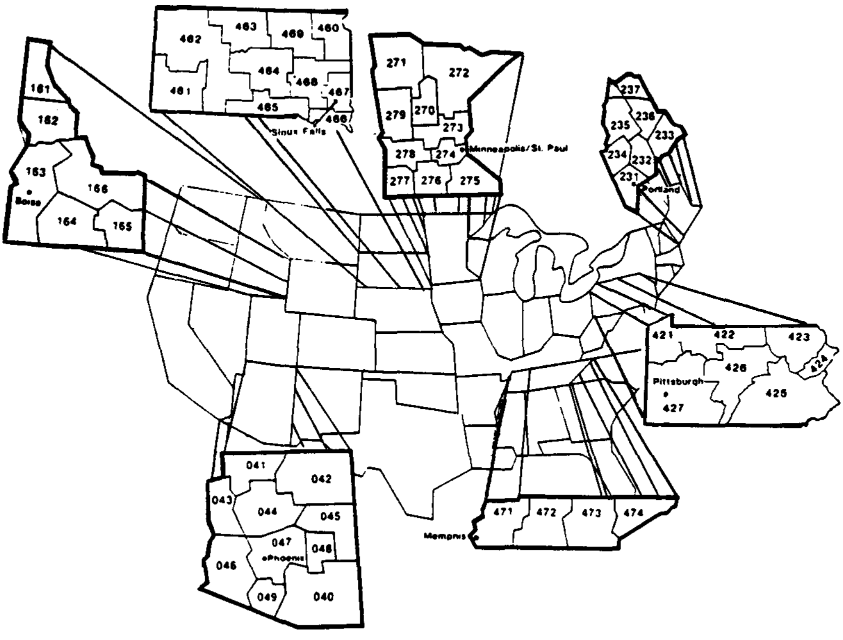

Figure 2. Fish and Wildlife Management Regions in selected states.

Table 1. Representative demand equations for fishing and hunting in substate regions of seven states (dependent variable is $\ln$ [daytrips])[a].

Variable		Intercept	Boat ownership	Youth residence	Years fished	Years hunted	Travel cost	R^2	n
State and Region	Activity								
Idaho 163	Freshwater fishing	2.521	−0.353	−0.159	0.002		−0.040	.09	146
		(0.281)	(0.213)	(0.208)	(0.007)		(0.014)		
Minnesota 272	Freshwater fishing	1.893	0.481	−0.079	−0.014		−0.028	.16	74
		(0.382)	(0.287)	(0.277)	(0.008)		(0.010)		
Arizona 044	Freshwater fishing	1.522	0.479	0.305	0.002		−0.042	.18	38
		(0.439)	(0.350)	(0.378)	(0.015)		(0.019)		
Maine 234	Freshwater fishing	2.578	−0.258	−0.016	−0.005		−0.063	.18	67
		(0.348)	(0.283)	(0.394)	(0.011)		(0.019)		
Tennessee 473	Freshwater fishing	2.430	0.343	0.323	−0.015		−0.075	.15	152
		(0.231)	(0.210)	(0.236)	(0.008)		(0.018)		
Pennsylvania 422	Big game hunting	1.419		0.178		0.006	−0.028	.09	64
		(0.240)		(0.263)		(0.008)	(0.012)		
South Dakota 464	Small game hunting	1.639		0.003		0.018	−0.026	.16	45
		(0.325)		(0.444)		(0.015)	(0.013)		

[a] Standard error in parentheses.

Three variables in addition to travel cost appear in the fishing demand equations, and two in the hunting equations. Boat ownership is a 0–1 variable (1 for owning, 0 otherwise) as is youth residence (1 for population greater than 10,000, 0 otherwise). Years fished is an experience variable. The expected sign of the coefficients of boat ownership and years fished is positive. We expect the coefficient of youth residence to be negative, reflecting the belief that sportsmen who grew up in rural areas and small towns are more avid than are sportsmen with more urban backgrounds and will take more trips, other things being equal. In general, these three avidity variables perform poorly in the regional demand equations. None of them is consistently of the expected sign or statistically significant at standard levels. The fact that none of the demand shifters worked as well as expected has little consequence for the estimates of most interest here, the coefficient of the travel cost variable and the resultant consumer surplus values. The travel cost coefficients are remarkably stable with respect to specification of demand shifters. The only case where the travel cost coefficients would be biased would be if we had inadvertently left out of the equation some factor that was not only important in determining the number of trips but also was correlated with our measure of travel cost. Other than the price of substitutes, we know of no such omitted variable.

Estimated consumer surplus values for daytrips are presented in Table 2. Freshwater fishing daytrip values across states and regions are reasonably similar. While "outliers" exist, in the 30 regions for which daytrip values could be calculated, 17 have values between \$18 and \$38 per daytrip. Intrastate mean regional fishing daytrip values are similar, with the regional mean ranging from a low of \$23 per daytrip in Maine to a high of \$35 per daytrip in Arizona. Hunting trip values are a little higher, on average, than

Table 2. Consumer surplus values for freshwater fishing, and big and small game hunting daytrips in substate regions of seven states[a].

State and Activity	Idaho fishing	Minn. fishing	Arizona fishing	Maine fishing	Tenn. fishing	Penn. big game	So. Dakota small game
Region[b]							
1	\$11	\$42	\$ 7	\$26	\$45	\$45	\$17
2	30	c	d	18	29	36	c
3	25	36	d	20	13	31	48
4	36	33	38	16	34	c	10
5	c	38	24	42		30	38
6	32	24	67	5		24	36
7		19	13	c		43	21
8		20	63				30
9		40	c				16
10		13					50
Intrastate mean	27	29	35	23	30	35	30

[a] All values derived from travel cost regression coefficients statistically significant at the 5 percent level, one tail test.
[b] Region 1 is the lowest numbered region in any state. Region 2 has the second lowest number, and so on. As seen in Figure 2, regions are numbered consecutively starting with a number ending in 0 in Minnesota and South Dakota and ending in 1 in Idaho, Maine, Tennessee, and Pennsylvania.
[c] Corresponding travel cost regression coefficient not statistically significant at acceptable levels. No value is estimated.
[d] Insufficient observations to estimate demand function.

fishing values. They range from a low of $10 per trip for small game hunting in Region 464 of South Dakota to a high of $50 in Region 460 of that State. All the big game values in Pennsylvania are within the range of $24–45 per daytrip.

The day values we estimate appear reasonable in comparison with results of other studies. Table 3 shows value estimates from other travel cost studies of freshwater fishing. The table notes the year of the study, the location, the type of travel cost approach, and whether or not the opportunity cost of time was incorporated, in each case. Some upward adjustment in the value is needed when the opportunity cost of travel time was omitted from the travel cost equation. Based on this comparison, our values appear to be consistent with other estimates in the literature.

Since the travel cost method estimates demand for sites, something is lost when it is applied to a region which may provide a range of fishing and hunting opportunities. The method implicitly assumes that all activities being valued at the site are the same. Thus, within the category of freshwater fishing, for example, no distinction is made between one sportsman who fishes for trout and another who fishes for perch in the same region. In those cases where a particular region offers a variety of opportunities, it is not clear exactly what kind of experience is being valued.

As noted above, these value estimates represent the average consumer surplus per daytrip to the region. As such, they are more appropriate for some uses than for others. Combined with projections of days of use, the average values per day can be used to

Table 3. Comparison of freshwater fishing values from other travel cost demand studies.

Research	Fishing season	Location & activity	Type of TC approach	Opportunity cost of time	Adjusted day value (1980 $)[a]
Gum & Martin (1975)	1970	Arizona coldwater	microdata	none[b]	$22
Brown et al. (1983)	1977	Oregon steelhead	zone	none	$40[c]
Ziemer et al. (1980)	1971	Georgia warmwater	microdata	none[b]	$54[d]
Vaughan & Russell (1982)	1979	Nationwide fee fishing trout sites	zone	BEA average wage	$27
King & Walka (1980)	1980	Idaho coldwater	zone	none	$ 9
Gordon (1970)	1968	Idaho coldwater	zone	none	$ 9
Bianchi (1969)	1969	Kentucky coldwater	zone	$2.93	$ 8
Weithman & Haas (1982)	1979	Missouri coldwater	zone	35% of average wage	$18
Kalter & Gosse (1969)	1965	New York coldwater	zone	none	$24

[a] Per angler unless otherwise noted.
[b] Distance included as a separate explanatory variable in regression.
[c] Value is for trips, not days, unless all trips are daytrips.
[d] Day value per household.

value the gain or loss involved in creating or destroying a particular site. In such a case, the entire consumer surplus triangle of Figure 1 is affected. Small, marginal changes at existing sites, improving access so current participants are each induced to take one more trip, for example, are another matter. Marginal and average values are the same in the semi-log functional form that we use, but, in general, average consumer surplus per day probably overestimates the relatively small change in consumer surplus created. Average consumer surplus is also not appropriate for a relatively large change in fishing or hunting in a region. If, for example, fishing is successively eliminated in many or all lakes in a region or a state due to acid deposition, the value of the total loss would probably exceed the product of average value and number of trips lost. The reason lies in the role of the availability of substitute fishing sites in determining the value of the site in question. As fishing is successively eliminated at first one site and then the next, the value of those remaining increases. With fewer substitutes available, the demand curves for fishing at those sites that remain shift outward to the right, creating an addition to consumer surplus of unknown magnitude. As noted previously, our estimates do not permit evaluation of the effect of substitutes.

V. Conclusions

In the Introduction we note the importance of calculating the value of recreational fishing and hunting in dollar terms. Our work to date demonstrates the potential for using data from the 1980 National Survey of Fishing, Hunting and Wildlife-Associated Recreation to calculate fishing and hunting day values for substate regions of the United States. The empirical results presented above are encouraging. While variables other than travel cost perform inconsistently in demand equations, travel cost, here an aggregate of out-of-pocket and estimated time costs, has strong explanatory power statistically, across both activities and regions.

The methodology we used here is not without weaknesses. More work needs to be done on the possibility of bias induced by the lack of consideration of substitutes. Specification of demand equations needs further refinement on a region by region basis. Using the same set of variables in all regions makes estimation easier, but the low t values and changing signs of some of the demand shifters indicate that the general specification is not correct for quite a few of the regions. Possible measurement error in the travel cost variable should also be examined. The fact that the recall period, the time between the fishing or hunting trip and the survey interview, could have been a year or more, and the difficulty respondents may have had seperating out their share of the cost of a trip with family or friends, both suggest that the reported trip costs may not be totally accurate. These limitations, however, do not overshadow the potential of the 1980-NSFH to provide reasonable estimates of some nonmarket service functions of fish and wildlife resources in a timely and efficient manner across activities and a broad geographical area of the country.

What we have done with the 1980-NSFH thus far merely scratches the surface of what the data base can be used for. Some of the additional studies have been touched upon above; trying to incorporate substitute sites and more region-by-region modification of the demand equations are two areas we intend to explore. The Survey also included three bidding game (contingent valuation) sequences designed to obtain directly the respondent's willingness to pay for deer and waterfowl hunting, and trout fishing. Preliminary review of those responses indicates that the questions were successful and produced results that were quite close to the value estimates we got with TCM. We intend to do more careful analysis of those contingent valuation data. If the value estimates produced by the travel cost and contingent valuation methods continue to be similar, that will be further evidence of the methods' validity for measuring the economic value of fishing, hunting, and other nonmarket resources. We will also try to incorporate the effect of quality differences in our travel cost models. Most management efforts are aimed at improving the quality of fishing and hunting at existing sites rather than creating new sites or opportunities. Being able to place a dollar value on those improvements in quality would be very helpful to managers and planners alike.

Acknowledgements

We would like to thank Warren Fisher and Kenneth McConnell for comments on an earlier version. We are responsible for remaining errors. The results and conclusions presented here are not necessarily those of the U.S. Fish and Wildlife Service.

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Analyzing Values of Fish and Wildlife Populations

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Introduction

For the past three decades, the main thrust of economic research on valuing recreation, including that associated with fish and wildlife, has been focused upon methods of valuing the recreation activity usually in terms of visitor-days or site values. As Batie and Shabman (1979) and Bockstael and McConnell (1981) (among others) have pointed out, the valuation of sites or visits is often a sterile exercise from a policy point of view. Wildlife and wildland managers are faced with decisions about allocating resources to the improvement of habitat and/or populations. The various values generated in most economic analyses are not useful. For example, Gum and Martin (1975) compared values of hunting and grazing on Arizona wildlands, but their analysis was inframarginal and yielded little in the way of direction for incremental management decisions. It appears that wildland managers require approaches that will allow them to manage populations based upon the existing biological conditions and sound economic analysis. It is the purpose of this paper to suggest modeling approaches that can delineate the required information and research needs and generate optimal management strategies. A case study will be used for illustrative purposes.

A Review of Previous Work and Literature

While some practitioners of natural resources management remain convinced that maximum sustained yield is the optimal policy prescription, limited budgets and increasing demands have made resource allocation decisions difficult. The application of decision models to management practices should provide both managers and users with the "best" policies. These models must include all the factors in the wildland management problem—the natural population and its environment, the users, and the managers—in an integrated dynamic framework. "Optimal control" approaches appear to be one way in which to examine resource policy in a dynamic framework that includes both ecology and economics.

Each aspect of the "bioeconomic" model, the popular term, must be quantitatively defined. The ecological portions of the model consist of the dynamics of population changes, including the effects of users of the resource. The economics consist of the effect of population dynamics upon the value which users place on the "experience," and any direct actions or interactions among users which affects these values. The management includes the opportunity for manipulation of the population or species through either habitat or use control and the associated costs of that manipulation. Given these data, an optimal control model will yield the optimal path to a steady state. That steady state may or may not coincide with maximum sustained yield (it may be extinction). Note that these models, in order to be relevant to the managerial decisions, are likely to be quite site and species specific. Although it is certainly theoretically feasible, broader, regional modeling would require significantly expanded modeling. There exists bodies of research and associated literature regarding each of the separate aspects of the modeling, and some work which has been completed on "bioeconomic" analyses.

The valuation of the recreation experience has a relatively long history. Beginning with Hotelling (1938), Trice and Wood (1958), Clawson (1969), and many others, the valuation of recreation visits and sites based upon travel (or other variable) costs has developed and improved. While much of the literature is probably familiar to resource managers, several key developments should be recognized. There has been a shift by many researchers from the aggregate demand analysis toward individual observations in empirical work. The culmination of this movement is found in the utilization of the "household production function" approach to developing demand for recreation activity and the associated values. While quite technical, this approach involves modeling household decisions which are made by utility-maximizing households given their time and budget limitations or constraints (Becker 1965 and Lancaster 1966, for example). Bockstael and McConnell (1981) review the method as applied to wildlife recreation. They conclude that there are serious empirical difficulties due to confounding quantity and quality parameters when both are endogenous. However, it can also be shown that under certain conditions the household production approach is equivalent to the more traditional travel-cost methodology.

One of the benefits of the household approach is that it includes consideration of the cost of time in recreation activities, whereas other approaches may not (Cesario and Knetsch 1970, McConnell and Strand 1981, Smith et al. 1983). Another benefit is the inclusion of site quality as an argument in the utility function, which allows direct consideration of the value of quality. Managerial efforts are generally aimed at improving site quality; thus, it is of crucial importance to managers to determine gains from their efforts. Other researchers have examined site quality using alternative approaches based on travel-cost or least-cost methods (such as Cicchetti and Smith 1973 and Wennergren et al. 1973). Anderson (1983) used a static approach to examine optimal stock enhancement programs for recreational fishing.

There are several other areas of valuation research that are important to the household decision and, therefore, to managers. These include, but are not limited to, choices among sites, the effect on values and multiple destination trips (Haspel and Johnson 1982), and empirical estimation problems (Vaughan and Russell 1982, and Hof and King 1982).

Recently, the use of bidding games or contingent valuation has been examined by economic researchers as a method for obtaining values of recreation experiences following the approach of Bohm (1972), Brookshire et al. (1976) and Randall et al. (1974). They have examined various technical aspects of bidding games, as have several others. This technique may be a fruitful area of obtaining valuations necessary for management decisions. Greenley et al. (1981) used bidding games to determine the demand for, and value of, increasing the number of wilderness areas in Colorado. Bishop and Heberlein (1979) have compared bidding games and travel cost methods of valuation and have found some relatively consistent relationships. In these static models, however, the value estimated is not a function of changes in herd size or characteristics. Rather, the values assigned (consumers' surplus measures of various kinds) are applied to the site on the basis of the existing conditions. Thus, the marginal value of changes in the populations are not addressed.

The second requirement for the bioeconomic model is a quantification of population dynamics for the species under consideration. There are a considerable number of publications dealing with mathematical models of population dynamics (for example, Lotka

1956 and Clark 1976). For most bioeconomic work, a standard growth curve is assumed. Some researchers have utilized specific models of species dynamics or multiple species interactions (Hannesson 1983). Applications of management models to specific sites, however, involve the development of site-and-species-specific models of population dynamics. While such studies do exist, they obviously must be limited in number. The final requirement for the management model is the development of relationships between management practices and population dynamics. Studies of this nature are not abundant, to say the least. The effects of habitat manipulation or harvest controls are not well documented, nor are the costs of these practices readily available. In fact, few studies could be documented. Site-and species-specific studies are even more scarce. Some simulation models are being developed under contract to the federal government, but actual empirical studies are difficult to find. At least part of the reason for this lack lies in the stochastic nature of population dynamics and in the difficulties of accurately studying naturally-occurring populations of game species under alternative management conditions.

There have been a number of bioeconomic analyses which use optimal control or dynamic programming approaches reported in the literature. Many of these studies involve commercial fisheries because there are relatively few problems with benefit estimations and there exist a number of biological treatises on commercial fish populations. Most of these studies focus upon the problem of open access fishery management in a very theoretical way (Anderson 1982, Wilson 1982, and Crutchfield 1983 are recent examples). Some have focused upon the empirics of a specific fishery (Crutchfield and Zellner 1962, Bell 1972, and Lewis 1975, for example). Models of recreational activities are few. Bockstael and McConnell (1981) and McConnell and Sutinen (1979) are two recent studies. Again, these studies are theoretical rather than empirical in nature. The following is a report of our theoretical and empirical examination of the bioeconomics of a specific site and population, specifically deer hunting on the Oak Creek Hunting Unit in Utah.

Valuation Model

Overview

The model used has many of the characteristics of a continuous time optimal control model. Optimal control models identify costate variables that, when applied to wildlife populations, yield shadow values for the units of the population. If some item(s) within our model were optimally controlled, then an optimal control model could be applied directly, and the costate variable for the population would be the appropriate value of a unit of the population. This value would be a by-product of the application of the model in identifying the level of the control instrument (e.g., length of hunt).

Our model differs from an optimal control model in that while the controllable items are controlled to achieve certain objectives, it is not necessary that these controls yield a maximum of the benefit function that we state; however, if the objectives are the same and they are achieved, then the results are theoretically identical. Our model also yields a shadow value of a unit of the population.

The benefit function we are using is the discounted value of the consumers' surplus stream for a deer herd area (hunting unit). This can be viewed as a double summation, a sum over all hunters to get aggregate consumers' surplus, and a sum of discounted aggregate values to get the discounted value of the stream.

We postulate that the hunters individually maximize utility subject to a set of household production functions, a budget constraint, and a time constraint. Within this structure, the hunting experience has two dimensions, quality and quantity, which can both be affected by the hunter's activities. We measure the quality by the probability of bagging a deer (hunter success). This probability also depends upon the herd size within the hunting unit.

The hunting activities (legal and illegal) of the hunters, the number of hunters, the biologies of the habitat and deer population, and the weather are the major determinants of changes in the herd size through time, that is, the herd dynamics.

Below we identify a benefit function that incorporates these features. This function is differentiated with respect to the initial herd size to derive the marginal benefit of herd size, the shadow value of an additional deer. This differentiation yields an equation which identifies the variables to be estimated and the way to combine the variables to estimate the shadow value.

The major strength of this shadow value is that it is conceptually equivalent to a market price in a price-taker market economy. Market prices in such an economy can be shown to be explicit values from a similar surplus maximization problem. Our shadow value is, therefore, comparable to the price of, say, farm animals.

Formal model

The benefit function is

$$B=\int_0^\infty \exp(-rt)\ s(x(t))\ dt \tag{1}$$

where $\exp(\cdot)$ is the natural exponential function (discount function), r is the appropriate interest rate, $s(\cdot)$ is the aggregate compensating variation consumers' surplus function, $x(t)$ is the herd size at time t, and the starting time is zero. The aggregate surplus function is

$$s(x)=\sum_{j=1}^{\hat{n}} s^j(x) \tag{2}$$

where $s^j(x)$ is the compensating variation consumer's surplus for the j'th hunter, and $\hat{n}$ is the maximum number of hunters who hunt in this unit. We let $s^j(x)$ equal zero if a hunter does not hunt in this unit under the prevailing conditions. Below, the utility maximization problem used to identify the relevant characteristics of $s^j(x)$ is stated and briefly discussed.

The population dynamics of the deer herd depend upon the physical characteristics of the area, weather, natural predators, biology of the habitat, and the hunter harvest. Let

$$\frac{dx}{dt}=f(x)-h \tag{3}$$

summarize these relationships where h is the hunter harvest and $f(x)$ captures the effect of the other elements. The hunter harvest is the result of the interaction of utility-maximizing, price-taker hunters, and the deer in the area. For given tastes, prices, roads, and technology, the actual harvest depends upon the deer population

$$h=h(x) \tag{4}$$

The population dynamics are captured in equations (3) and (4) and the initial herd size, x_o. Let this initial value differential equation problem have the solution

$$x(t)=g(x_o,t) \tag{5}$$

This equation identifies the time profile of the herd size that results for the interreaction of the hunters and the deer in their herd area.

Inserting equation (5) into (1) yields

$$B^{*}=\int_{0}^{\infty}\exp(-rt)\; s(g(x_o,\, t))\; dt \quad (6)$$

The present value of the surplus stream now depends upon the starting population (x_o), the interreactions of hunters, deer and biology ($g(\cdot)$), the aggregate consumers' surplus function ($s(\cdot)$), and the interest rate. Differentiating B^* with respect to x_o yields the shadow value of a deer in the initial population. This derivative is

$$\frac{\partial B^{*}}{\partial x_0}=\int_{0}^{\infty}\exp(-rt)\;\frac{ds}{dx}\frac{\partial g}{\partial x_0}\;dt \quad (7)$$

where ds/dx is the marginal consumers' surplus of herd size at each point in time, and $\partial g/\partial x_0$ is the additional deer at each point in time caused by an additional deer at time zero. Information about ds/dx is identified from

$$\frac{ds}{dx}=\sum_{j=1}^{n}\frac{ds^{j}(x)}{dx} \quad (8)$$

and the hunter's utility maximization problem discussed below. The derivative $\partial g/\partial x_o$ can be analyzed numerically and for some $f(x)$ and $h(x)$ functions can be analyzed analytically. In our application we use forms that can be analyzed analytically.

We now introduce the hunter's utility maximization problem and discuss the way it is manipulated. This can be stated as

Maximize $U(Z)$ (9)

subject to:

$$\begin{aligned} &Z_1=F^1(y^1,\, t^1)\\ &Z_2=F^2(y^2,\, t^2)\\ &Z_3=F^3(y^3,\, t^3,\, x)\\ &Z_4=F^4(y^4,\, t^4)\\ &p\cdot(y^1+y^2+y^3+y^4)-(b+Z_4w)=0\\ &t^1+t^2+t^3+t^4-T=0 \end{aligned}$$

where Z_1 is a composite commodity, Z_2 is the quantity aspect of hunting, Z_3 is the quality aspect (hunter success), Z_4 is hours of work, $F^i(\cdot)$ are the household production functions, y^i are vectors of purchased goods, p is a vector of goods prices, t^i is time spent producing Z_i, T is the total quantity of time in the time period, b is nonlabor income and w is the wage rate.

The objective of manipulations of this problem is to generate an expression for $ds^j(x)/dx$ to be used in the combination of equations (7) and (8). The dual problem

$$\text{Minimize: } b=p\cdot(y^1+y^2+y^3+y^4)-Z_4w \quad (10)$$

subject to the other equations in (9) yields the solution compensate nonlabor income function.

Differentiation of this solution (b^*) function using the envelope theorem yields

$$\frac{\partial b^{*}}{\partial x}=\zeta_3\frac{\partial F^3}{\partial x} \quad (11)$$

where ζ_3 is the Lagrangean multiplier for $F^3(\cdot)-Z_3=0$ in this dual problem. Further it can be shown that this derivative is the negative of the derivative of compensating variation consumers' surplus; therefore,

$$\frac{ds^j(x)}{dx} = -\frac{\partial b^*}{\partial x} = -\zeta_3\frac{\partial F^3}{\partial x} \tag{12}$$

In this $-\zeta_3$ is the shadow value of hunter success (Z_3) and $\partial F^3/\partial x$ is the marginal responsiveness of hunter success to herd size. Therefore, we can write

$$\frac{ds^j(x)}{dx} = \left(\begin{array}{c}\text{shadow value of}\\ \text{hunter success}\end{array}\right)\left(\begin{array}{c}\text{marginal responsiveness of}\\ \text{hunter success to herd size}\end{array}\right) \tag{12'}$$

Summary

In summary, the combination of equations (7), (8) and (12 or 12 ') identifies an equation for the shadow value of deer. Equation (12′) indicates that for the *j*'th hunter the marginal value of deer in the herd is the product of the shadow value of the quality of the hunt (hunter success) and the marginal responsiveness of this quality to herd size. Equation (8) indicates that these individual shadow values are summed to get the aggregate shadow value of deer at a point in time. Finally, the shadow value of an additional deer in time zero is identified by the integral in equation (7) to be the discounted, aggregate shadow value of the stream of current and future effects of this additional deer. The integral exists because an additional deer today affects herd size in the future.

Application

Our application used existing data to estimate the shadow value of deer; hence, it is easy to identify in our application modifications that can be expected to increase the reliability of the estimates. We intend to pursue some of these; however, our application illustrates what can and how it can be achieved. The data used to estimate the shadow value of the probability of success were collected by Wennergren et al. (1973). They studied quality and location values for deer hunting in Utah. The hunter success and deer population data were reported in *The Oak Creek Mule Deer Herd in Utah* by Robinette, Hancock, and Jones (1977).

We first discuss the way we estimate the shadow value of the hunter success, ($-\zeta_3$). This shadow value is called in the household production function literature an implicit commodity price (Pollak and Wachter 1975). It is the implicit price of quality (hunter success). At the optimum for the individual hunter this implicit price is equal to the implicit marginal cost of hunter success. A hunter can influence his probability of success in several ways. For example, preseason scouting, equipment purchases or rentals, and traveling to more productive areas. At the optimum, assuming continuous functions, the marginal cost of probability of success will be equal for all of these activities. We estimated this marginal cost using travel cost data because the model indicates they are relevant and they are available. Wennergren et al. (1973) reported that of the site characteristics they examined in attempting to estimate site quality factors, only hunter success was statistically significant. Therefore, using their data, we regressed travel costs on hunter success. The resulting estimate of the marginal cost of hunter success was \$1.169 per percentage point increase in success. The standard error of this estimate is 0.146 and the R^2 is 0.08. Thus, we have a small confidence internal about the estimate, but we do not explain a large portion of the variability in travel costs.

We estimated the marginal responsiveness of hunter success to herd size ($\partial F^3/\partial x$) using Oak Creek deer herd data. The data force us, as they often do, to use a typical hunter instead of many individual hunters. Thus, we write the combination of equations (8) and (12) as

$$\frac{ds}{dx}=n(-\zeta_3)\frac{\partial F^3}{\partial x}$$

where n is the number of hunters. We estimate $n(\partial F^3/\partial x)$ as a unit. To do this we posit that the hunter harvest is proportional the herd size; thus, equation (4) has the form

$$h=h(x)=\gamma x \tag{13}$$

where γ is a positive parameter. Multiplying both sides of equation (13) by $1/n$ yields an equation for hunter success. Differentiating this result with respect to herd size (x) yields our proxy for the marginal responsiveness of hunter success to herd size ($\partial F^3/\partial x$). Multiplying this derivative by n yields $n(\partial F^3/\partial x)=\gamma$; therefore,

$$\frac{ds}{dx}=(-\zeta_3)\gamma$$

Oak Creek hunter harvest and deer herd data for the years 1947 to 1957 were used to estimate γ. The estimate in percent rather than decimal fraction scale is 15.81. Its standard deviation is 0.59, and the R^2 was 0.27. Each year about 16 percent of the herd is legally harvested. Combining the estimates for $-\zeta_3$(\$0.585) and γ(15.81), we estimate ds/dx to be \$18.49.

To complete the task of estimating the shadow value of deer we again examine equation (7). We are treating ds/dx as a constant; therefore, equation (7) can be written

$$\frac{\partial B^*}{\partial x}=\frac{ds}{dx}\int_0^{\infty}\exp(-rt)\frac{\partial g}{\partial x_o}dt \tag{14}$$

We posit a very common form for $f(x)$ in equation (3), namely

$$f(x)=\alpha x-\beta x^2 \qquad \alpha,\ \beta>0 \tag{15}$$

Combining equations (3), (13), and (15) yields

$$\frac{dx}{dt}=(\alpha-\gamma)x-\beta x^2 \tag{16}$$

This differential equation with its initial condition $x(o)=x_o$ has the solution

$$x(t)=g(x_o,t)=[(\frac{1}{x_o}-\frac{\beta}{\alpha-\gamma})\exp(-(\alpha-\gamma)t)+\frac{\beta}{\alpha-\gamma}]^{-1} \tag{17}$$

and

$$\frac{dx(t)}{dx_o}=\frac{dg}{dx_o}=[\frac{x(t)}{x_o}]^2\exp(-(\alpha-\gamma)t) \tag{18}$$

Note that equation (17) is a logistic curve and for $\alpha-\gamma$ positive the limit of $x(t)$ as t increases without bound is $(\alpha-\gamma)/\beta=\hat{x}$. The random component of the weather could be expected to yield fluctuations around $\hat{x}$.

If we let x_0 equal $\hat{x}$ so that we estimate the shadow value of deer in the average or normal herd size, equation (18) becomes

$$\frac{dg}{dx_o}=\exp(-(\alpha-\gamma)t) \tag{19}$$

and equation (14) now becomes

$$\frac{\partial B^*}{\partial x}=\frac{ds}{dx}\int_0^\infty \exp(-(r+\alpha-\gamma)t)dt \quad (20)$$

$$=\frac{ds}{dx}\frac{1}{r+\alpha-\gamma} \quad (21)$$

Using Oak Creek deer herd data for 1947 through 1956 we estimated $\alpha-\gamma$ to be 0.56959 and β to be 0.00026 with standard deviations of 0.29731 and 0.00013, respectively. The dependent variable in this regression was change in herd size and the R^2 was 0.32.

Our estimate of the shadow value of a deer in the Oak Creek herd is \$29.40. This is calculated using equation (21), the estimates reported above, and a discount rate of 6 percent. A discount rate of 0.06 and $\alpha-\gamma$ equal to 0.56959 yields $1/(r+\alpha-\gamma,)$ equal to 1.59. This capitalization factor of 1.59 times \$18.49, the estimate for ds/dx, yields $\partial B^*/\partial x$=\$29.40. The data reported by Wennergren et al. (1973) were for 1970; therefore, this estimate is in 1970 dollars.

Summary

The primary purpose of this paper is to suggest a methodology for determining wildlife population values, and the secondary purpose is to present an illustrative application. The wildlife population, deer herd in our presentation, is viewed as yielding a stream of benefits (consumers' surplus) through time. The discounted value of this stream is the benefit function which is viewed as a double summation, a sum over all hunters to get aggregate consumers' surplus, and a sum of discounted aggregate values to get the discounted value of the stream of future benefits.

This benefit function is differentiated with respect to the herd size to identify the shadow value of a deer, our suggested measure of the value of deer. The major strength of this shadow value is that it is conceptually equivalent to a market price in a price-taker market economy. Market prices in such an economy can be shown to be explicit values from a similar surplus maximization problem.

The consumers' surplus information is derived from a utility maximization, household production function model of the individual hunter. The hunting activity is modeled as having a quality (hunter success) and a quantity component. The herd dynamics that are affected by hunter activities, the biologies of the habitat and the deer herd, and the weather also impact upon the stream of benefits.

The derivative of the benefit function is the marginal benefit of herd size, the shadow value of an additional deer. Using the equations and assumptions in our application, we derived the following equation for the shadow value of deer

$$\frac{\partial B^*}{\partial x}=\frac{-\zeta_3\gamma}{r+\alpha-\gamma}$$

where $-\zeta_3$ is the shadow value of hunter success, γ is the aggregate marginal responsiveness of quality of the hunt (hunter success) to herd size, portion of the herd harvested,r is the discount rate and $\alpha-\gamma$ is a parameter in a logistic (growth) function. The numerator identifies the shadow value of an additional deer at each point in time. The capitalization factor $1/(r+\alpha-\gamma)$ captures the future effects of this deer. It exists because an additional deer today affects herd size in the future, with future effects gradually diminishing to zero. The speed with which this occurs is determined by herd dynamics (α) and hunter activity (γ).

Data for Utah deer hunters and the Oak Creek mule deer herd in Utah were used to estimate the parameters in this equation. We estimated the shadow value of hunter success to be $1.169 per percentage point, the aggregate marginal responsiveness of hunter success to herd size to be 15.81 percent, and the capitalization factor to be 1.59 using r equal to 0.06. This yields an estimate of the shadow value of deer of $29.40 in 1970 dollars.

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Quasi-Option Values of Natural Resources

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1. Introduction: A Stylized Problem

On September 16, 1984, Canada will temporarily regain the option lost through the Columbia River Treaty of partially diverting the waters of the Kootenay river in British-Columbia (The Columbia River Treaty 1964).

A scenic site such as the valley of the Kootenay in Canada can be developed either for recreational purpose or for hydroelectric purpose. The two alternatives are, to a large extent, *mutually exclusive*. The development of the valley for hydroelectric purpose would involve, at least, a partial diversion of the Kootenay river into the Columbia, which, for all practical purposes, should be considered as *irreversible*. The development for recreational purpose requiring less investment and being less damaging to the environment may be considered as reversible (The Columbia River Treaty, 1964, pages 44–48). *Delaying* the decision to divert the Kootenay into the Columbia until the recently completed Revelstoke dam becomes fully operational and until the terms of sale of the Canadian power entitlement to the United States are renegotiated—sometime at the beginning of the next decade—*opens an opportunity to learn* more about long-run Canadian electricity needs. The government of British Columbia and the government of Canada, which has to be involved as well in view of possible international repercussions and financial backing requirements, will be assumed to maximize the present value of the net benefits of the projects. To the extent that a partial diversion of the Kootenay and, a fortiori, its recreational development would not require a major financial commitment on the part of the governments involved relative to their gross domestic product, one can assume that they are *risk-neutral*. This assumption is strengthened by the fact that the risks of either project would be widely shared by the Canadian population while the non-user or existence benefits of the recreational option could be considered as widely disseminated. This means that either investment would be valued at its expected net benefits irrespective of the probability distribution of the net benefits. From 1984 on, Canada has the right, exercisable until 2044, to divert up to 20 percent of the waters of the Kootenay (Canal Flats diversion scheme). In 1994 or thereabout, negotiations will take place concerning the disposal of the Canadian share of electricity benefits. In 2024, Canada acquires the right, excercisable for a period of 40 years, to divert up to 75 percent of the waters of the Kootenay (Bull River-Luxor diversion scheme). From 2044 to 2064, up to 90 percent of the Kootenay waters may be diverted by Canada (Dorr-Bull River-Luxor diversion scheme) (The Columbia River Treaty, 1964). The diversion opportunities are represented in Figure 1.

To simplify the problem, we will assume that the horizon of the problem comprises three periods: before 1994; from 1994 to 2024; from 2024 to 2044. Now that the Libby Dam has been built in the United States, the profitability of a nearly complete diversion scheme has become extremely unlikely, so the period from 2044 to 2064 can be neglected (Krutilla 1967b). Period zero (before 1994) ends at a date when relevant information becomes available (disposal of Canadian share of electricity). Period one corresponds to the same diversion opportunity as in period zero except for additional information. Period

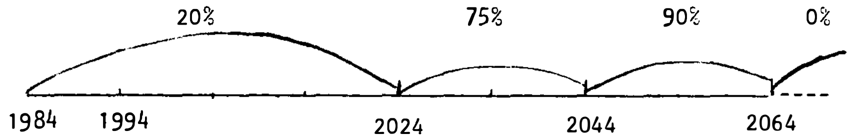

Figure 1. Diversion opportunities of the Kootenay waters for Canada (percentages).

two corresponds to incremental diversion opportunity with respect to the previous periods (percentage of volume diverted increased to 75 percent) and still additional information. In order to simplify the analysis, we will assume that the investment decision of diverting 75 percent of the water in period two is not incremental and is exclusive of the decision of diverting 20 percent of the water in any of the three periods.

Let us assume that the returns on the two alternative investments *depend upon* the realization of either of two *events*: the first one corresponds to a high level of electricity demand in Canada and a relatively low recreation demand; the second corresponds to a low level of electricity demand in Canada and a relatively high recreation demand.

2. Analysis of the Stylized Problem

We will denote by:

I_R, the (reversible) investment in recreation

I_H, the (irreversible) investment in hydroelectric power (20% diversion)

I_H^2, the (irreversible) investment in hydroelectric power (75% diversion)

R, the event of relatively high demand for recreation and relatively low demand for electricity.

H, the event of relatively high demand for electricity and relatively low demand for recreation.

The assumed net benefits of each investment in each contingency are given in Table 1.

While the above net benefits figures are not implausible and bear some relationship to empirical data, they must be considered as arbitrary. I_H^2 must be considered as excluding either I_R or I_H. In other words, I_H^2 will be contemplated in period two if and only if I_H has not been carried out in any of the previous periods. I_R, the reversible investment, will be assumed to last one period only and to be capable of being scrapped at no cost.

The information acquisition is formalized by conditional probabilities according to Bayesian methods (Raiffa 1968).

Table 1. Assumed net benefits (10^6 Can \$).

	Period 0		Period 1		Period 2		
	I_R	I_H	I_R	I_H	I_R	I_H	I_H^2
R	10	−20	10	−20	10	−20	−30
H	−5	30	−5	30	−5	30	50

Table 2. Probabilities.

$P(H_1\|H_0)=0.3$	$P(H_2\|H_1)=0.8$
$P(R_1\|H_0)=0.7$	$P(R_2\|H_1)=0.2$
$P(H_1\|R_0)=0.4$	$P(H_2\|R_1)=0.1$
$P(R_1\|R_0)=0.6$	$P(R_2\|R_1)=0.9$

Let:

$P(H_l|R_o)$ be the conditional probability that H will occur in period 1 given that R already occurred in period 0.

$P(H_l|H_o)$ be the conditional probability that H will occur in period 1 given that it already occurred in period 0, etc.

The optimal strategy for investment takes the following form: "If H^0, invest in I_H in period zero. If R^0, select I_R. If H^1, invest I_H in period one. If R^1, select I_R. If H^2 and R^l, invest I_H^2 in period 2. If R^2, select I_R." Therefore, the *current event* is known before a decision is taken in the current period. *Only the future* is uncertain.

In order to arrive at this optimal strategy, we must compute the total returns of each investment according to the following recursive formula (Bernanke 1983):

$$\begin{bmatrix} Y_H^{H_t} \\ Y_H^{R_t} \end{bmatrix} = \begin{bmatrix} y_H^{H_t} \\ y_H^{R_t} \end{bmatrix} + \frac{1}{1+i} \begin{bmatrix} P(H_{t+1}\ |H_t) & P(R_{t+1}\ |H_t) \\ P(H_{t+1}\ |R_t) & P(R_{t+1}\ |R_t) \end{bmatrix} \begin{bmatrix} Y_H^{H_{t+1}} \\ Y_H^{R_{t+1}} \end{bmatrix}$$

Where Y denotes total returns

Y denotes current period returns

H_t corresponds to event H occuring at period t

R_t corresponds to event R occuring at period t

H corresponds to investment I_H

i is a rate of discount

We will use i approximately equal to 11 percent so that $\frac{1}{1+i}=0.9$

The recursive formula expresses the fact that the total return of an investment in the current period, given that an event has occured, is equal to the current return given that event plus the discounted expected total return one period hence given that event. At the final period, total returns equal current returns, i.e.

$$\begin{bmatrix} Y_H^{H_2} \\ Y_H^{R_2} \end{bmatrix} = \begin{bmatrix} y_H^{H_2} \\ y_H^{R_2} \end{bmatrix}$$

Therefore, the recursive formula should be computed backward in time. In our stylized problem, the results are as follows:

$$\begin{bmatrix} Y_H^{H_2} \\ Y_H^{R_2} \end{bmatrix} = \begin{bmatrix} y_H^{H_2} \\ y_H^{R_2} \end{bmatrix} = \begin{bmatrix} 30 \\ -20 \end{bmatrix}$$

$$\begin{bmatrix} Y_{2H}^{H_2} \\ Y_{2H}^{R_2} \end{bmatrix} = \begin{bmatrix} y_{2H}^{H_2} \\ y_{2H}^{R_2} \end{bmatrix} = \begin{bmatrix} -50 \\ 30 \end{bmatrix}$$

$$\begin{bmatrix} Y_H^{H_1} \\ Y_H^{R_1} \end{bmatrix} = \begin{bmatrix} y_H^{H_1} \\ y_H^{R_1} \end{bmatrix} + \frac{1}{1+0.11} \begin{bmatrix} P(H_2|H_1) & P(R_2|H_1) \\ P(H_2|R_1) & P(R_2|R_1) \end{bmatrix} \begin{bmatrix} Y_H^{H_2} \\ Y_H^{R_2} \end{bmatrix} =$$

$$\begin{bmatrix} 30 \\ -20 \end{bmatrix} + 0.9 \begin{bmatrix} 0.8 & 0.2 \\ 0.1 & 0.9 \end{bmatrix} \begin{bmatrix} 30 \\ -20 \end{bmatrix} = \begin{bmatrix} 48 \\ -33.5 \end{bmatrix}$$

$$\begin{bmatrix} Y_R^{H_1} \\ Y_R^{R_1} \end{bmatrix} = \begin{bmatrix} y_{2H}^{H_1} \\ y_{2H}^{R_1} \end{bmatrix} + \frac{1}{1+0.11} \begin{bmatrix} P(H_2|H_1) & P(R_1|H_1) \\ P(H_2|R_1) & P(R_2|R_1) \end{bmatrix} \begin{bmatrix} Y_{2H}^{H_2} \\ Y_{2H}^{R_2} \end{bmatrix} =$$

$$+0.9 \begin{bmatrix} 0.8 & 0.2 \\ 0.1 & 0.9 \end{bmatrix} \begin{bmatrix} 50 \\ -30 \end{bmatrix} = \begin{bmatrix} 30.6 \\ 19.8 \end{bmatrix}$$

$$\begin{bmatrix} Y_H^{H_0} \\ Y_H^{R_0} \end{bmatrix} = \begin{bmatrix} y_H^{H_0} \\ y_H^{R_0} \end{bmatrix} + \frac{1}{1+0.11} \begin{bmatrix} P(H_1|H_o) & P(R_1|H_o) \\ P(H_1|R_o) & P(R_1|R_o) \end{bmatrix} \begin{bmatrix} Y_H^{H_1} \\ Y_H^{R_1} \end{bmatrix} =$$

$$\begin{bmatrix} 30 \\ -20 \end{bmatrix} + 0.9 \begin{bmatrix} 0.3 & 0.7 \\ 0.4 & 0.6 \end{bmatrix} \begin{bmatrix} 48 \\ -33.5 \end{bmatrix} = \begin{bmatrix} 21.85 \\ -20.81 \end{bmatrix}$$

$$\begin{bmatrix} Y_R^{H_0} \\ Y_R^{R_0} \end{bmatrix} = \begin{bmatrix} y_{2H}^{H_0} \\ y_{2H}^{R_0} \end{bmatrix} + \frac{1}{1+0.11} \begin{bmatrix} P(H_1|H_o) & P(R_1|H_o) \\ P(H_1|R_o) & P(R_1|R_o) \end{bmatrix} \begin{bmatrix} Y_{2H}^{H_1} \\ Y_{2H}^{R_1} \end{bmatrix} =$$

$$+0.9 \begin{bmatrix} 0.3 & 0.7 \\ 0.4 & 0.6 \end{bmatrix} \begin{bmatrix} -30.6 \\ -19.8 \end{bmatrix} = \begin{bmatrix} -4.21 \\ 0.32 \end{bmatrix}$$

The next step is to compute the "expected value of deferring commitment," i.e., the discounted expected maximum total returns according to the following formula:

$$\begin{bmatrix} V^{H_t} \\ V^{R_t} \end{bmatrix} = \frac{1}{1+i} \begin{bmatrix} P(H_{t+1}|H_t) & P(R_{t+1}|H_t) \\ P(H_{t+1}|R_t) & P(R_{t+1}|R_t) \end{bmatrix} \begin{bmatrix} \max\left(Y_H^{H_{t+1}}, Y_{2H}^{H_{t+1}}, Y_R^{H_{t+1}}, V^{H_{t+1}}\right) \\ \max\left(Y_H^{R_{t+1}}, Y_{2H}^{R_{t+1}}, Y_R^{R_{t+1}}, V^{R_{t+1}}\right) \end{bmatrix}$$

At the final period, V is simply the nul vector, i.e.,

$$\begin{bmatrix} V^{H_2} \\ V^{R_2} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Then,

$$\begin{bmatrix} V^{H_1} \\ V^{R_1} \end{bmatrix} = 0.9 \begin{bmatrix} 0.8 & 0.2 \\ 0.1 & 0.9 \end{bmatrix} \begin{bmatrix} \max(30, 50, -5, 0) \\ \max(-20, -30, 10, 0) \end{bmatrix} = \begin{bmatrix} 37.8 \\ 12.6 \end{bmatrix}$$

$$\begin{bmatrix} V^{H_0} \\ V^{R_0} \end{bmatrix} = 0.9 \begin{bmatrix} 0.3 & 0.7 \\ 0.4 & 0.6 \end{bmatrix} \begin{bmatrix} \max(48, 30.6, -5, 37.8) \\ \max(-33.5, -19.8, 10, 4.5) \end{bmatrix} = \begin{bmatrix} 20.9 \\ 20.4 \end{bmatrix}$$

The rule for solving the optimal investment strategy in period zero is as follows:

$\max\ (Y_H^{H_0},\ Y_{2H}^{H_0},\ V^{H_0}) = \max\ (21.85,\ -4.21,\ 20.9)$

$\max\ (Y_H^{R_0},\ Y_{2H}^{R_0},\ V^{R_0}) = \max\ (-20.81,\ 0.32,\ 20.4)$

Since the "expected value of deferring commitment" is not the maximum, the irreversible investment I_H should not be carried out in period zero if H_o has occurred. It should not be carried out, a fortiori, if R_o has occurred since its current return is negative. However, I_R would be worth carrying out if R_o has occurred, since its current return is positive and this is all that is required since I_R is reversible. Its total return is negative if H_o occurs.

The rule in period one is as follows:

$\max\ (Y_H^{H_1},\ Y_R^{H_1},\ V^{H_1}) = \max\ (48,\ 30.5,\ 7.8) = 48$

$\max\ (Y_R^{H_1},\ Y_R^{R_1},\ V^{R_1}) = \max\ (-33.5,\ -19.8,\ 12.6) = 12.6$

Since 48 exceeds 37.8 and since the total return on I_H in period one if H_1 occurs exceeds the "expected value of deferring commitment," we should select I_H if H_1. If R_1 occurs, we should select I_R again since its total return is positive.

Since I_H was carried out in period one when H_1 occurred and since it is irreversible, it is exclusive of all other investments in period two. If R_1 occurred, however, the rule in period two would be

$\max\ (Y_H^{H_2},\ {Y_R}^{H_2},\ Y_{2H}^{H_2},\ V^{H_2}) = \max\ (30, -5,\ 50,\ 0) = 50$

$\max\ (Y_H^{R_2},\ {Y_R}^{R_2},\ Y_{2H}^{R_2},\ V^{R_2}) = \max\ (-20,\ 10,\ -30,\ 0) = 10$

Since there is in period two a second investment opportunity (the 75 percent diversion) which has a higher total return (50), it should be selected if H_2 occurs. If R_2 occurs, I_R should again be selected.

3. The Quasi-Option Value

The *quasi-option value* corresponds to the price an investor is willing to pay in order to be able to change his investment decision, i.e., to recover the options lost through an irreversible investment. This price is always non-negative whatever the source of uncertainty and would be nil for a reversible investment. It stands for the value of future options forfeited. It would be incurred even by a risk neutral individual.

An irreversible investment cannot be made according to a myopic rule which takes the present only into account. It has to trade off the incremental benefits in terms of returns of an earlier commitment against the incremental benefits in terms of information of a later commitment.

Irreversible investments will be undergone less frequently than equally profitable reversible ones. The more equally likely the events upon which the returns depend, the higher the value of information and, therefore, the higher the quasi-option value, the lower the level of investment, and the longer the waiting period before investing, i.e., the longer the option is retained (Krutilla et al. 1972, Arrow and Fisher 1974, Henry 1974a, 1974b, Conrad 1980, Cukierman 1980, Fisher 1981, Dasgupta 1982, Malinvaud 1982, Bernanke 1983).

4. Analogy with a Financial Instrument

A situation analogous to the one giving rise to the quasi-option value occurs when one detains a financial instrument called an *American option*. An American option gives to its holder the right to buy at a specified price, called the exercise price, a stock any time before a given term. If the market price of the stock is higher than the exercise price (the return on the irreversible investment is higher than the returns on alternative reversible investments), the holder of an American option will exercise the option, i.e., buy the stock at the exercise price (carry out the irreversible investment). The value of holding an American option (not investing) is the insurance value which protects the holder against a decrease in the price of the stock (against the regret of an investment alternative). The American option is an insurance against one source of uncertainty only: the decrease in the price of the stock (a more profitable investment alternative). It can be shown that the holder of an American option will never exercise it prior to expiration if the exercise price is a constant and if the option does not entitle its holder to the dividends of the stock. The value of the option is, then, determined by a well-known formula called the BLACK-SCHOLES formula (Smith 1976, Baldwin and Meyer 1979, Tourinho 1979).

Other analogues of the quasi-option value occur in the statistical theory of sequential sampling, the theory of search, the theory of research and development, etc. (Roberts and Weitzman 1981, Bernanke 1983).

5. Resource Depletion as an Irreversible Decision

Extraction from reserves of essential nonrenewable resources is an irreversible decision. A nonrenewable resource is essential if it has no substitute (Fisher 1981). Extraction of an essential nonrenewable resource is irreversible to the extent that any amount extracted at any time depletes a finite stock irreversibly by the amount extracted. One can show that if the price of the resource is uncertain, the royalty on the resource increases at least as fast as under certainty and the incentive to hold reserves for speculative purpose may be larger than under certainty. In other words, under price uncertainty, one may choose not to extract the resource at all at a given time (keep the option open) because of the presence of a quasi-option value (Pindyck 1980, 1981). The benefit of delaying extraction is learning about the price behavior or reducing price riskiness.

A similar type of argument should be applicable to renewable resources when "mining" the resource is contemplated. Extraction of a renewable resource without worrying about the regenerative capacity of the stock is an irreversible decision which is profitable only if the rate of return on "mining" is higher that the quasi-option value of the resource, i.e., the expected regret of having depleted the stock (Anderson 1982, Pindyck 1982).

6. The Option Value of Resources

The option value of an irreversible investment is the risk-premium that a risk-averse individual is willing to pay in order to prevent an irreversible investment from being made, risk against which he cannot fully insure. An individual is risk-averse if he prefers to insure against an investment which yields uncertain returns, whose expected value is nil. The risk premium is what a risk-averse individual is willing to pay over the expected consumer surplus of reserving an option for future use. The option value may occur on the demand site if the demand is stochastic or on the supply side if an input is stochastic. When it occurs on the demand side, it may have any sign, depending upon the relative riskiness of the mutually exclusive alternatives, unless both the utility function and income or wealth do not vary across states of the world. In the latter case, it is non-negative. When the option value occurs on the supply side, it is always non-negative. It is positive in case of aversion towards risk and is nil in case of risk neutrality. Supply uncertainty is always relevant when one considers increments (Weisbrod 1964, Krutilla 1967a, Schmalensee 1972, Greenley 1981, Bishop 1982, Hyde et al. 1982, Brookshire et al. 1983, Smith 1983).

7. Conclusion

The paper has dealt with what is usually called the *quasi-option* value of natural resources. The quasi-option value problem occurs with irreversible investments that exclude investment alternatives and whose returns are uncertain but subject to learning. Additional information, which normally accrues as time evolves or which may be acquired at a cost at a later date, may yield an incentive to disinvest. The quasi-option value is the expected value of perfect information, i.e., the minimum opportunity loss or "regret" of alternative investments, returns that the investor may expect to incur from selecting the irreversible alternative.

Quasi-option values occur in types of situations similar to the ones which give rise to *option* values. There are, however, three fundamental differences between the two concepts.

Quasi-option values are positive even when decision makers are risk-neutral, while option values would be nil in such a case. When the quasi-option value is nil, i.e., when the investment is reversible, the option value is necessarily nil as well.

Quasi-option value being the expected value of perfect information requires that the decision problem be dynamic. In other words, the opportunity for delaying a decision is a crucial ingredient of the problem. The option value does not take the value of information into account. Quasi-option value would be the same for two different decision makers who agree about the probability assessment over returns. In this sense, it is objective. The option value is subjective because it depends upon the consumer's utility assessment. It is simply a risk-premium that a risk-averse consumer would be willing to pay over and above his expected consumer surplus in order to keep open an opportunity for consumption sometime in the future.

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Economics of Endangered Species Management: The Red-Cockaded Woodpecker

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Introduction

In electing to preserve a species, society chooses to exchange goods and services it could otherwise enjoy for the continued presence of a unique biological entity. This tradeoff establishes "endangered species" as a legitimate category for economic analysis. Economics is concerned with describing fair trades, a fair trade being an exchange where the cost of the good demanded is equal to the value of the benefit derived from it. With respect to endangered species, the relevant question becomes whether the value society gains from the continued presence of a particular species equals the costs that must be incurred to guarantee this presence.

As a society, we have implemented a regulatory process by which species listed as endangered are given legal protection from activities which may prove deleterious to their continued survival. Targeted population goals and habitat requirements are established for each species so listed. Population goals are formulated exclusively outside the economic system; it is against the law to use the economic consideration of expected benefits and costs to influence the setting of a targeted population goal. This limits the role of positive economic analysis in endangered species problems to one of describing the most economically efficient means of meeting this goal.

This restricted role is neither confining nor trivial. As the following sections demonstrate, economic analysis can be used (1) to determine the least-cost way of meeting the exogenously imposed population goals under various resource utilization and preservation scenarios and (2) to highlight areas where further research may prove most productive. Furthermore, the type of information provided by this analysis can be used by policymakers to choose among alternative preservation strategies.

This case study describes the marginal costs associated with meeting the targeted population goal for red-cockaded woodpecker (RCW) colonies on the Croatan National Forest in North Carolina. This goal is set at one colony per 200 acres (81 ha) pine forest or 191 colonies on the Croatan[1].

While management strategies at the national forest level vary, and are changing as more is learned about the bird's habitat needs, current preservation efforts for the RCW call for the creation of old growth pine habitat. The increasing scarcity of this habitat type is generally believed to be the cause of the bird's endangerment as mature, live pines (known as *cavity trees*) are required by the RCW for nesting and roosting purposes. Therefore, on Croatan lands devoted to RCW preservation, the timber harvest age is extended beyond the normal 70-year timber rotation. On currently occupied colony sites, the rotation length is extended indefinitely; on lands groomed to replace these colony

[1]A colony is the basic habitat unit of the red-cockaded woodpecker. Within the colony lives the RCW clan, consisting of a mated pair, their unfledged progeny, and non-reproductive helpers.

sites, the harvest age is extended to one which will allow for RCW occupation during the latter part of the rotation.

Timber revenues are postponed or foregone in exchange for RCW habitat. We can determine the net revenues foregone in four steps, described below[2]:

Step 1. Describe and Value Land in Absence of the RCW Preservation Constraint

Croatan forestlands primarily support stands of second-growth southern yellow pine. The Forest Service is in the process of harvesting the mature stands and regulating the forest on a 70-year rotation[3].

Absent the woodpecker preservation constraint, the value of an individual site is equal to the discounted value of the standing timber at harvest time (net of harvest and management costs) plus the discounted value of the net revenues from all future 70-year rotations or:

$$V_{70}=(\sum_{t=0}^{70-a} p(t)Q(t)e^{-rt}-c(t)e^{-rt})+(\sum_{t=0}^{70} p(t)Q(t)e^{-rt}-c(t)e^{-rt})(e^{-r(70-a)}/(1-e^{-r70}))$$

where V_{70} is the value of the site managed on a 70-year timber rotation, $p(t)$ is the expected stumpage price in year t, $Q(t)$ is the expected quantity of marketable timber in year t, $c(t)$ represents the timber management costs incurred in year t, $a(\leq 70)$ is the age of the present stand and r is the relevant interest rate.

Step 2. Describe and Value Land in Presence of RCW Preservation Constraint

The RCW habitat preservation process, as currently employed by the Forest Service, consists of two distinct phases. Present efforts require the cessation of all timber production activities on currently occupied colony sites, thus extending the rotation length indefinitely. Future efforts will require the provision of mature stands into which the bird may move upon abandoning the present colony site[4]. The Forest Service refers to these as recruitment stands.

The treatment prescription for these recruitment stands is still in formulation, with input coming from biologists employed by the U.S. Fish and Wildlife Service and the U.S. Forest Service. As great uncertainty exists regarding our ability "to herd" the RCW from one stand to another, biologists are considering a range of recruitment stand management models. These vary with respect to the number of acres of forestland regulated under the extended rotation length, ranging from requiring that only one, 10 acre (4 ha) parcel of land (per RCW clan preserved) undergo the extended rotation to requiring that all forestlands be regulated on the extended rotation.

We examine a middle ground management scenario, where acreage per recruitment stand is a function of the size of currently occupied colony sites on the Croatan, and total number of acres managed under the extended rotation regime is a function of both the recommended colony site age and the assumed RCW tenure in a given colony site. Our assumptions are as follows: (1) Each recruitment stand is 11.73 acres (4.75 ha) in size. This is the average size of all existing colony sites on the Croatan. (2) The average age of each recruitment stand during bird inhabitation is 75 years for loblolly sites and 95

[2]Variables used in the empirical determination of marginal costs were furnished by local National Forest offices, Forest Survey, local market surveys and standard southern pine yield tables. See Judge et. al. 1983 for detailed description of these data.

[3]A regulated forest is one with an even distribution of age classes.

[4]Colony sites are abandoned with the death of the cavity trees. Cavity tree mortality is estimated at 4 percent to 9 percent per year (Hooper et. al. 1979).

years for longleaf sites. These are the ages recommended by the RCW National Recovery Team. (3) A clan occupies a given colony site for only one generation, that is, six years. This assumption, while unrealistic as clan tenure in a given colony site is usually much longer, serves to give us an upper bound on costs. (4) To simplify calculations, we assume contiguous distribution of lands identical with respect to species and timber production site index. It is important to note that our assumptions, and therefore our results, are subject to modification as wildlife researchers learn more about RCW habitat requirements.

Under these assumptions, our model requires a rotation extended to 78 years on loblolly recruitment sites, and 98 years on longleaf recruitment sites. Each RCW clan requires several recruitment sites, staggered six years apart in age, to assure nesting habitat in perpetuity. Clans occupying loblolly stands require 13 (78/6) such recruitment sites, and in longleaf stands require 17 (98/6) recruitment sites.

Expected revenues from the present phase preservation efforts are zero, as no timber is to be cut from currently occupied colony sites. Expected revenues from the future phase are equal to the discounted value of the costs and revenues generated by the standing timber from now until it is finally cut at the extended age, plus the discounted value of all future, extended rotations or:

$$V_{RCW}=\left(\sum_{t=0}^{X-a}p(t)Q(t)e^{-rt}-c(t)e^{-rt}\right)+\sum_{t=0}^{X}p(t)Q(t)e^{-rt}-c(t)e^{-rt})(e^{-r(X-a)}/(1-e^{-rX}))$$

where V_{RCW} is the present value of all timber revenues generated by each recruitment site managed for RCW habitat, X is the age of the harvest cut under the extended rotation, and all other variables are as previously described.

Step 3. Determine the Net Loss Incurred in Switching from Timber Production to RCW Production

As previously noted, the net costs associated with the imposition of the RCW constraint are equal to the difference between revenues received under the constraint and those which could be received if the constraint were lifted. Preservation in perpetuity of existing colony sites requires foregoing all possible timber revenues. Hence, the net loss associated with this preservation effort is V_{70} for each colony site preserved. Harvesting timber on an extended rotation results in some positive revenues, V_{RCW}, which may offset the loss of the timber revenues from the 70-year rotation, V_{70}. Thus, net losses associated with this scenario are equal to $V_{RCW}-V_{70}$ for each site so managed.

Step 4. Rank Net Losses per Colony Site from Lowest to Highest.

Actual marginal costs of preservation were determined in step 3, above. This final step produces the observations for a marginal cost schedule, a useful tool for determining which sites might be turned over to RCW production at the least cost to society. This marginal cost schedule describes, for each successive RCW clan preserved, and for a given management approach, the cost increment of preserving that clan's habitat. This is also the marginal benefit society must receive from the added clan to make the allocation efficient.

Results, Discussion, and Policy Implications

Tables 1 and 2 show the results of our analysis. These marginal costs were calculated under the assumptions of (1) constant stumpage prices in perpetuity and (2) a 4 percent

Table 1. Costs of preserving currently occupied colony sites in perpetuity (4 percent rate of return, constant stumpage prices).

Dominant species	Site index	Acreage	Age	Cost($)
Longleaf	50	7	62	255
Longleaf	50	15	57	309
Longleaf	50	7	72	486
Longleaf	50	15	62	547
Longleaf	50	7	76	865
Longleaf	50	7	85	1241
Loblolly	70	7	50	1251
Loblolly	70	7	52	1338
Longleaf	60	7	67	1887
Longleaf	50	30	72	2082
Longleaf	50	15	93	2660
Longleaf	50	15	89	2660
Longleaf	70	7	52	3264
Loblolly	80	7	51	3379
Longleaf	50	20	92	3548
Loblolly	80	7	55	4028
Longleaf	50	15	132	4258
Longleaf	70	7	59	4434
Longleaf	60	15	72	4658
Longleaf	70	7	64	5495
Longleaf	80	7	52	5566
Loblolly	80	15	46	5790
Loblolly	70	15	67	5853
Loblolly	70	25	67	5853
Longleaf	60	15	82	5858
Loblolly	80	7	64	5927
Longleaf	70	7	67	6241
Longleaf	50	90	72	6247
Longleaf	70	7	69	6791
Loblolly	90	7	65	10326
Loblolly	80	15	72	11666
Longleaf	70	15	64	11776
Loblolly	100	7	52	12906
Longleaf	80	15	54	12985
Loblolly	90	7	63	13778
Longleaf	80	15	56	14130
Longleaf	70	15	74	15177
Longleaf	70	15	74	15177
Longleaf	70	15	74	15177
Longleaf	70	15	72	15177
Loblolly	90	15	47	15858
Loblolly	90	7	67	16907
Loblolly	80	15	82	17787
Longleaf	70	15	82	18005
Longleaf	70	15	82	18005
Longleaf	90	15	52	19597
Longleaf	70	15	92	20212
Longleaf	70	15	92	20212

Longleaf	70	15	95	21239
Longleaf	70	15	102	22303
Loblolly	90	15	63	30759
Loblolly	110	15	57	56529

Table 2. Per clan costs of extending the rotation length on the Croatan National Forest (4 percent rate of return, constant stumpage prices).

Dominant species	Site index	Cost($)
Longleaf	50	11,824
Loblolly	70	38,739
Longleaf	60	42,537
Loblolly	80	53,195
Loblolly	90	66,675
Longleaf	70	81,488
Loblolly	100	85,091
Loblolly	110	99,706
Longleaf	80	118,349

required rate of return. In addition to this price/interest rate scenario, we evaluated marginal preservation costs under a 7 percent and a 10 percent required rate of return and the assumptions of rising trends for relative stumpage prices over the next 50 years of (1) 3 percent per annum for sawtimber and 1.5 percent for cordwood and (2) 1.5 percent per annum for sawtimber and 0.75 percent per annum for cordwood. The 4 percent rate of return is used by the Forest Service in evaluating long-term investment projects. Most other federal projects require a 10 percent real rate of return, hence its inclusion. The 7 percent rate was tested for sensitivity. A rising relative stumpage price trend of 3 percent and 1.5 percent per annum, for sawtimber and cordwood, respectively, mirrors historical market conditions (Dutrow et. al. 1982). The intermediate rates of 1.5 percent and 0.75 percent were chosen to test the sensitivity of our results. As expected, we find that increasing the required rate of return lowers preservation costs, while increasing relative prices increases preservation costs.

The least costly sites are generally those characterized by low timber productivity. Projected harvest revenues (discounted to present value) on many of these sites are so low as not to cover site preparation and management costs, even on the 70-year rotation. This result has two policy implications: (1) assuming that low productivity is in no way deleterious to the bird, these poor timber producers should be set aside for RCW management before any other, more valuable sites; and (2) if the Forest Service is constrained to manage its timberlands on a 70-year rotation, we are better off if the land on these sites is left idle. In this case, the cost of RCW habitat preservation on these lands would simply be the value of the standing timber.

This finding points to an area where future research could result in a substantial reduction in RCW preservation costs. While preservation costs are directly related to site productivity, as measured by site index, the relation of RCW habitat suitability to site productivity is at this time unknown. Reasonable theories suggest it could go either way. On one hand, sites highly productive for timber are often capable of supporting more wildlife than less productive sites, suggesting advantages to bird preservation on these more costly areas. On the other hand, many RCW researchers agree that the bird favors trees with extensive heartwood formation. As the heartwood/sapwood ratio is inversely related to site productivity, it is possible that the bird may prefer low productivity sites to high ones, as the former contain relatively more heartwood.

Furthermore, our results indicate that within the same productivity class, loblolly sites are less costly to manage for the RCW than are longleaf sites. This observation, coupled with research pertaining to pine species preference exhibited by the RCW could also provide managers with improved information for determining both a given site's cost to society and its efficacy as potential RCW habitat.

Costs of extending the rotation length reflect an upward bias resulting primarily from two sources. First, the assumption that the RCW clan would relocate every six years to a new colony site within its 200-acre (81 ha) territory (an assumption we introduced to minimize the variance in the average recruitment stand age from the recommended mean) requires that a great many acres be managed on the extended rotation schedule in order to assure a perpetual supply of potential colony sites. In all probability, clan relocation will be a much more infrequent occurence. Colony abandonment is triggered by the death of the cavity trees. These in turn have an annual mortality rate of 4 percent to 9 percent. Thus, even assuming only one cavity tree per colony site, there is a 57–78 percent chance that the colony site will still be occupied after six years or when the next viable recruitment stand comes of age. So long as one other stand of the recommended age or greater exists as a recruitment stand, then other timberstands can be harvested on the normal 70-year rotation schedule, at no RCW preservation cost to society. This suggests yet another area where further research may contribute to preservation cost savings. As we learn more about colony site occupation (how sites are selected by the bird, means of prolonging the life of cavity trees, etc.), we can reduce the amount of acreage required for RCW preservation without subjecting the species to increased risk.

The second upward bias results from our assumption that, in the absence of the woodpecker management constraint, all Croatan timber would be harvested and sold upon reaching 70 years of age. In fact, only 14 percent of our projected timber yield was marketed in 1982, and 1982 was apparently a representative year. As market conditions reduce the utilization rate of timberlands on the Croatan, the opportunity costs associated with RCW habitat preservation decline in turn. Marginal cost analysis such as that performed herein can delineate the opportunity costs associated with alternative utilization intensities.

Thus we see that, at the level of the individual national forest, marginal cost analysis can be used to rank potential preservation sites according to their costs to society and determine habitat preservation costs under various utilization and management scenarios. On a broader scale, this type of analysis can be used to determine the value of additional information, and to identify areas where further biological research could suggest some of the greatest cost savings. As such, this sort of analysis may not only be a useful tool for policymakers choosing among management strategies, but it can provide powerful evidence for those trying to justify wildlife research budgets.

This work is preliminary to a larger project in endangered species economics. In the next phase, we are applying marginal cost analysis to investigate system-wide management options. As previously stated, the U.S. government has set demand on the national forests of the South at one colony per 200 acres (81 ha) pine forest. The costs of meeting this constraint will vary among national forests in direct relation to their highly productive land holdings. Marginal cost analysis can describe this relation directly, and indicate a means by which habitat for the same quantity of birds can be preserved, but in a manner that minimizes costs by varying the "density" of the woodpecker population among forests. An additional application of marginal cost analysis will focus on the appropriate risk/cost tradeoff for an endangered species like the RCW. The ultimate goal of RCW habitat preservation is to remove the threat of immediate RCW extinction. The probability of extinction is inversely related to available habitat, birth rate and survivability, and size of the present population, and directly related to death rate. Increasing the available supply of habitat therefore reduces the probability of immediate extinction. Insofar as we can accurately predict the reduction in extinction threat associated with incremental changes in the available RCW habitat, we can provide policy makers with an important tool for making resource allocation decisions which affect the supply of endangered species habitat. These two extensions of marginal cost analysis are the focus of our continuing research effort in endangered species economics.

Acknowledgements

The authors wish to thank David Newman and Anthony Becker for their technical assistance and George Dutrow, Michael Lennartz and Lynn McGuire for critical reviews. This study was funded by the U.S. Forest Service, Southeastern Forest Experiment Station.

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Concepts of Value, Nonmarket Valuation, and the Case of the Whooping Crane

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In a soon to be released book by Oldfield (1984) concerning the value of genetic materials, there is a section on economic issues which is titled "Priceless but not Valueless." That heading, as we choose to interpret it, may be an appropriate subtitle for this paper. There are indeed many goods and services which are priceless, in that they lack prices in the marketplace, but which nonetheless we would all agree do in fact have value. Whooping cranes, *Grus americana*, are but one example.

In this paper we take a trichotomous tack at organization. First, the motivations for and types of value placed upon resources of all types will be discussed. Following this discussion, causes of pricelessness will be briefly addressed. This will be done as a way of leading into a presentation of the nature and problems of several available methods for placing estimates of value upon *priceless* or, in the preferred terminology of resource economists, nonmarket commodities. Finally, in the concluding section of the paper we will present preliminary results from an application of the contingent valuation method to the estimation of economic value associated with the whooping crane resource.

Concepts of Values

During the past several decades, the basic concept of economic value has been challenged by many economists as being too narrowly defined (Arrow and Fisher 1974, Cicchetti and Freeman 1971, Krutilla 1967, Schmalensee 1972, Weisbrod 1964). Value, traditionally, was recorded as that amount changing hands when resources were exchanged in the marketplace. These values, because they resulted from transactions in the marketplace, were granted a presumption of legitimacy. Since these values were derived from exchange, they were also limited in that they seldom were recorded for resources which were not physically moved in transactions. Examples of such *in situ* resources are recreation sites, ambient air and free-roaming biological species.

As recognition of the potential consequences of wholesale modification of natural environments and the extinction of species became more widespread, traditional concepts of value became a topic of frequent discussion. Many argued that legitimate economic values could be derived from the option for future use, or just from the knowledge that a resource would continue to exist in its current state. The result of this discussion was that the concept of economic value was splintered into a variety of nonuniquely defined categories, e.g., use value, option price, option value, preservation value, bequest value, etc. Not only were these imprecisely defined, they were empirically elusive so that validation of resulting value estimates was often not possible.

In the remainder of this section, we will attempt to present a brief conceptual framework for viewing the concept of *total value* in an unambiguous fashion. This discussion is a condensed version of that presented by Randall and Stoll in a previous paper (1983).

The Components of Total Value

In economics, individuals are presumed to use resources because they gain satisfaction (or utility) from their use. These resources may be used in many different ways; ways which may also vary among individuals. One manner of viewing this process of use is to think of individuals as combining resources of various sorts to produce activities. These activities, then, fulfill some set of psychological and other needs, thus yielding satisfaction. This resultant satisfaction (utility) may be represented schematically as

$$U=f(Z) \tag{1}$$

where U signifies satisfaction or utility and Z is a vector of activities produced by the individual household using resources and other inputs.

The activities which can be produced and the manner in which they are produced are governed by the household's production technology (T) as well as the other constraints it faces. If we were to denote a specific natural resource input as Q and all other inputs to the household activity production process as a vector X, then the household's production function would be

$$Z=z(X, Q;T). \tag{2}$$

This natural resource input could be visualized as an ordinary lump of coal, a unique environment such as the Grand Canyon, a clear sky through which to view a scenic vista, or an endangered species such as the whooping crane. The essential point we desire to make is that the resource, Q, is used by itself or in conjunction with other resources and commodities to produce a satisfaction-yielding (utility-yielding) activity.

Where does the household obtain this technology (T) it uses to produce activities? Clearly, households develop skills in activity production through the "conscious acquisition of information and instruction and through the less deliberate process of 'learning by doing.' Past activity production influences the capacity to achieve satisfaction from current activities" (Randall and Stoll 1983: 266). Thus, the household's technology at a given point in time may be expressed as

$$T_t=h[z_{t0}(X, Q; T_{t0}), \ldots, z_{t-1}(X, Q; T_{t-1})] \tag{3}$$

where $t0$ denotes an initial time period, t the current time period, and $t-1$ the time period preceding t. Given this description of the technology formation process, it is clear that there is no reason to expect all households to possess identical activity production technologies. This, especially when combined with the expected differences in individual household preferences, gives us every reason to predict that which is commonly observed; households engage in different activities than one another and value these activities differently from one another.

Use and Non-use Values

The total value which any household places upon a resource can be divided into that value associated with resource use and that from non-use, i.e., existence (Figure 1). Use value can be further subdivided according to the type of use made of the resource; current

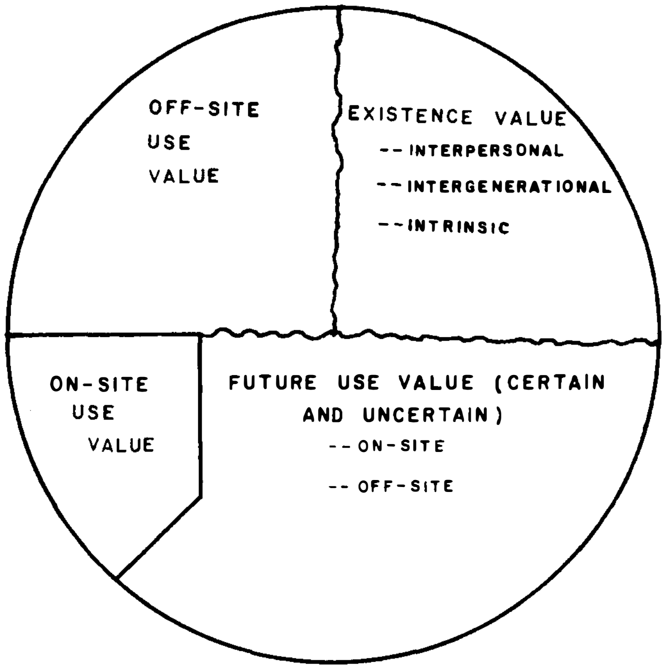

Figure 1. Total Value paradigm

on-site or off-site use and expected future on-site or off-site use. On-site uses include such examples as enjoying a scenic drive through a wildlife refuge wherein an endangered species resides or going for a nature walk through that species' natural habitat. Off-site use includes activities away from the species' natural habitat, e.g., reading about the species in magazines such as National Geographic or watching films of the species on television.

Not only do individuals obtain satisfaction from current resource uses, they also derive pleasure from the anticipation of future use. Even though one may have never seen a California Condor or the Grand Canyon, one may still hold some expectation of seeing these items in the future. For this reason, many individuals place value upon the assurance that these items will continue to exist in the future, a time when these expected behaviors may actually take place. Weisbrod (1964) was the first to draw attention to this *option value* associated with future use. Since that time, the concept has been a vastly refined topic of debate (Arrow and Fisher 1974, Bohm 1975, Conrad 1980, Henry 1974, Krutilla 1967, Schmalensee 1972) with a current consensus that option value is a risk-related component of the option price. The *option price* is defined as the sum of expected future benefits (consumer's surplus) and the value of the option for future use, a value which relates to the uncertainty of demand and supply. The crux of this debate among economists has centered on whether the option value will be positive, zero, or negative in magnitude and what conditions are necessary to determine this outcome (Bishop 1982, Freeman 1984, Graham 1981, Smith 1983). Although the debate continues, one fact does seem to be accepted: the option price, itself a composite of expected consumer's surplus and the option value, will be non-negative in most situations. In the present paper, our focus will be in part upon this composite concept of future use value, the option price.

Until this point, we have focused upon the value of satisfaction derived from use of a resource, yet, we initially stated that one also derives non-use or existence value from a resource. The concept of existence value can be schematically represented by rewriting equation (2) as a function of the resource Q alone, that is, by excluding the X vector of other inputs. It is expected that this will cause some consternation; what kind of activity can be produced without the use of other inputs than the resource Q itself? This question clearly presents a legitimate concern. Randall and Stoll (1983) argued that individuals produce *existence activities* and that the motivation for such production could be attributed to various types of altruism. They described three types of altruism: interpersonal, intergenerational, and Q-altruism (intrinsic). The first two types of altruism clearly relate to one's desire to make a resource available to others at the present time and in the future. The latter, intrinsic, refers to a desire to see the resource Q itself benefit from being left undisturbed, e.g., unique ecosystems or endangered species.

Nonmarket Valuation

Economists are among the first to admit that the competitive model is not without weaknesses. Most notable are the problems arising from the existence of economic actors with considerable market power capable of engaging in noncompetitive behavior. However, there are other weaknesses which are particularly relevant for discussions of wildlife and natural resources. These come under two broad categories: those associated with the existence of commodities which are nonrival in consumption and often nonexclusive in provision, and those which arise from the existence of external effects associated with consumption (or use) of resources. A nonrival resource can be used by two or more individuals without diminishing the quantity available for other individuals, e.g., viewing a scenic sunset. This sunset viewing example is also characterized by nonexclusivity: a situation where excluding additional viewers is practially infeasible. External effects of resource use, on the other hand, refer to interdependencies among the actions of individual economic actors which are not accounted for in the marketplace, e.g., acid rain resulting from industrial emissions. Both of these can indeed be sources of market failure because all the consequences, and thereby values, of resource use are not reflected in the marketplace. In these situations, market prices fail to reflect all of the costs or benefits associated with resource use and, thus, also fail as indicators of the marginal benefits received and the marginal costs borne. Without adequate indicators of costs and benefits of resource use, the marketplace cannot allocate resources *as if by an invisible hand* to their *highest and best* use.

For this reason nonmarket valuation methods have been developed. They reflect an attempt to estimate the values for resources which lie outside the marketplace and, thereby, to bring these nonmarket resources into the policy arena on a comparable footing with market items. Although there are a variety of approaches used to accomplish this task, two approaches are now widely used; the travel cost method (TCM) and the contingent valuation method (CVM). The travel cost method has been commonly used to value recreational resources and their use at specific sites which require the user to travel in order to engage in use. Demand relationships are estimated by using the variable expenditures of recreationists as a proxy for the nonexistent market price. Since users often come from a variety of origin sites, sufficient variation in travel costs (the primary variable cost component) exists to estimate a demand relationship. TCM has been widely used since its first inception by Hotelling (Prewitt 1949) and, as a result, has been substantially improved. At the present time, there are two basic approaches to applying TCM: (1) using user origin zones as the basic unit of observation (Brown et al. 1983) or (2) using the individual user as the basic observation unit (Gum and Martin 1975).

The contingent valuation method, on the other hand, is defined as any approach to valuation which relies upon individual responses to contingent circumstances posited in an artificially structured market (Stoll 1983). Although this definition encompasses a wide range of valuation techniques, bidding approaches are by far the most common. Bidding approaches to valuation have been used by economists for a shorter time span than the TCM method, having been initiated by Davis in 1963 and not really becoming popular until the mid 1970s with the work of Hammack and Brown (1974) and Randall et al. (1974). Currently, one can subdivide these bidding approaches into those which use iterative bidding and those which are noniterative in nature. Although the former has been argued to provide an incentive to reconsider one's value response, likely leading to more accurate responses, the latter is more amenable to forms of administration other than personal interviews (Randall et al. 1974, Stoll 1983)

Although TCM and CVM are generally accepted methods for assessing the economic value of nonmarket resources, both are not always applicable in a given resource setting. The TCM approach to valuation requires that travel be a prerequisite to use of the resource whereas the CVM approach does not. Thus, if travel is not required for resource use or if non-use of the resource is also expected to be a potentially significant source of resource value, then the TCM approach to valuation is incapable of estimating total resource value as defined in the previous section. The TCM approach could be used to estimate that portion of total value which is attributable to onsite use of the resource but would need to be augmented by some other approach to estimate off-site and existence components of total value.

The CVM approach, on the other hand, is capable of use in almost any setting which can be conveyed to respondents and can be used to estimate all components of total value. A major problem to be confronted with this approach, however, is the design of a credible contingent market which can be conveyed to respondents. Unlike the TCM approach, the CVM approach is not based upon actual revealed behavior of respondents. This has been one of the major and earliest criticisms leveled at the CVM approach: it's dependence upon behavioral intentions. The validity of this criticism is uncertain and is in need of further examination. Indeed, recent comparative studies between the CVM approach, TCM approach, and several other nonmarket valuation methods have found value estimates in the same resource problem setting to be statistically comparable (Brookshire et al. 1982, Sellar et al. 1984, Thayer 1981).

Aside from issues of applicability and actual versus stated behavioral intentions, other potential problems with both valuation approaches have been discussed (Stoll et al. 1984). However, the fact remains, if economic values are to be estimated for a given resource, some method must be chosen. Often, the characteristics of the resource itself will determine which particular method is most applicable. Such is the case for the study reported below. The whooping crane resource is a source of both on-site and off-site use values as well as non-use (or existence) values. For this reason, the CVM approach was adopted for estimating the components of total resource value.

The Case of the Whooping Crane

The whooping crane is but one of a variety of species classified as endangered under the Endangered Species Program. This program was established by legislation in 1966, 1969, and 1973 to address threats to species habitat and survival. Reasons put forth for the preservation of species include cultural heritage and spiritual benefits (Krutilla 1967, Randall 1981: 349), maintenance of genetic pool diversity (Holden 1982, Krutilla 1967, Randall 1981: 349;), environmental monitoring using species status as an indicator (Bishop 1978), and the potential for future benefits which are presently unrecognized (Bishop 1978, Holden 1982, Krutilla 1967, Randall 1981: 349). Widespead interest in the whooping crane is a result of increased public attention and recognition of these nonmarket benefits derived from endangered species in general.

The 1940s are believed to be the low point for the whooping crane population. At that time it is estimated that there were 21 birds in the world. The present population of 139 birds is argued to be a result of concerted preservation efforts put forth by public and private entities. The Aransas National Wildlife Refuge in Texas and Wood Buffalo National Park in Northwest Canada have been set aside as wintering and nesting grounds, respectively, for the world's only wild breeding flock. This flock currently includes 75 birds, 54 percent of the world population of whooping cranes. The remainder of the population resides in the Patuxent Wildlife Research Center in Maryland (34 birds), the International Crane Foundation Research Center in Wisconsin (1 bird), the San Antonio Zoo (2 birds), and a sandhill crane foster parent flock (27 birds) migrating between Idaho and New Mexico (Aransas National Wildlife Refuge, pers. comm. 1984). This latter flock is a result of research and management activities, activities which also include a migratory tracking project by the U.S. Fish and Wildlife Service and captive breeding programs in both private and public zoos and research centers. A recent occurrence is the establishment of a $7.5 million trust fund to protect land used by whoopers along their migration route in Nebraska (Bowen 1979).

Citizen demand for services provided by the existence of the whooping crane population are also reflected in other ways. A Whooping Crane Conservation Association has been formed. Also, approximately 60,000 to 100,000 people visit the Aransas National Wildlife Refuge each year, the majority during the whooping crane's wintering period. Several books and motion pictures have been written about or used whooping cranes, boat and bus tours of the Aransas area attract thousands of visitors annually, magazines devote articles to the species, and the Continental Oil Company has funded research, television commercials, and publications on the whooping crane. All of these activities are indicative of a broad interest in the whooping crane resource.

Research Approach and Preliminary Results

Several recent studies have attempted to estimate option and existence values associated with wildlife (Brookshire et al. 1983), wilderness (Walsh et al. 1984), and recreation-related water quality (Greenley et al. 1981). Each of these previous studies utilized the CVM method, as is done in the present study of the whooping crane resource. In our particular case, a noniterative bidding approach is adopted and the preliminary results presented in the form of weighted mean values.

The study itself was conducted during December 1982-March 1983, the whooping cranes' wintering period in Texas. Three specific subsamples were selected for administration of the survey instrument; (1) users of the Aransas National Wildlife Refuge, (2) residents of Texas, and (3) residents of four major metropolitan areas outside Texas, i.e., Los Angeles, Chicago, New York, and Atlanta. The survey instrument was designed for mail administration for the latter two groups and to be handed out to the former group for self-administration. There was no difference in wording or design of the survey instrument between groups, except for the removal of questions pertaining to on-site use for the latter two sub-groups of off-site respondents.

The mail survey instrument consisted of seven pages of questions and the on-site survey contained 11 pages of questions, both reproduced in booklet form and designed according to accepted standards (Dillman 1978). The on-site questionnaire was given to 800 visitors at the visitor center of the refuge on 11 different dates, including seven weekdays and four weekend days. A total of 1,200 questionnaires were mailed to Texas residents and 600 questionnaires were mailed to the four metropolitan areas (150 to each). Response rates were 67 percent for the on-site distribution to refuge users and 36 percent for the mail administration.

Information collected from respondents included personal characteristics, trip characteristics, previous exposure to information about the whooping crane, expectations regarding future visitation of the Aransas National Wildlife Refuge, and value responses to the contingent market scenarios. The contingent valuation questions used to collect on-site use values, option prices for future use, and non-use (existence) values are reproduced in Table 1. Both questions were administered to refuge visitors, but only the latter question

Table 1. Contingent valuation question formats.

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1. Currently, there is no direct charge for use of the Aransas National Wildlife Refuge. Suppose that increasing costs necessitated a system of annual permits for use of the refuge. One permit would be needed for each individual visitor. If an annual permit allowing you an unlimited number of visits during a one-year period had cost $_____, would you have purchased the permit and made this trip to the refuge? (circle number)

1 YES
2 NO

1a. Suppose that whooping cranes did not use the refuge. Would you still purchase an annual permit for $_____ per year? (circle number)

1 YES
2 NO

2. Suppose that economic pressures and policy changes resulted in a decision to no longer fund programs to maintain the whooping crane population—a decision which would virtually insure the extinction of the whooping crane.

Suppose than an independent foundation was set up for the purchase and maintenance of refuge land so that the species might be preserved for the future. Supporting membership in the foundation would be available for $_____ *per year* for each person. Future access would be set up so that only those *individuals* who desire to visit and who contribute to the foundation each year would have the option to use the refuge areas. These people would pay no additional fees for visitation at these refuges. Other individuals who contributed, but did not intend to visit the refuges, would still have the satisfaction that they helped preserve the whooping crane.

If a supporting membership cost $_____ per year, would you become a member and help ensure the continued existence of the whooping cranes? (circle number)

1 YES
2 NO

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was used with off-site respondents (mail survey). A series of questions was administered within the questionnaire to differentiate responses into the total value components described previously (Figure 2).

The average age of respondents was 47, 45, and 44 years for the refuge visitors, Texas mail survey respondents, and out-of-state respondents respectively. Most were males (59 percent of refuge visitors, 73 percent of Texas mail respondents, and 72 percent of out-of-state respondents). Most refuge visitors reported that their main purpose was to observe wildlife (42 percent) or to observe whooping cranes (22 percent). Approximately one-half of all visitors to the refuge had seen live whooping cranes at some time in the past. Fewer of the Texas residents surveyed by mail indicted that they had seen whooping cranes (29 percent) while an additional 21 percent were uncertain. For out-of-state residents surveyed by mail the figures were 19 percent and 20 percent, respectively.

Visitors who had seen cranes were asked to indicate where they had seen them. The Aransas National Wildlife Refuge and an associated tour boat were the most commonly given answers for refuge users. Texas respondents to the mail survey saw cranes most often at zoos or research centers and then on the refuge, while out-of-state respondents indicated that whooping cranes were seen almost exclusively at zoos and research centers. The most common source of information on whooping cranes for all three groups was television programs. Newspapers and magazines were the next most frequent sources. The out-of-state respondent subgroup was the only one having members which had never encountered any information on whooping cranes (18 percent).

Close-ended bidding procedures were used to determine on-site use value, option prices, and existence values from the two questions shown in Table 1. Each of the questions was administered with prespecified amounts ranging from $1 to $70 for the first question's permit cost and $1 to $130 for the second question's foundation membership. Each respondent then indicated an affirmative or negative response to the willingness-to-pay question. The dollar ranges used were determined from responses to a previous pretest of the survey instrument. Each amount (mail survey) or combination of amounts (on-site

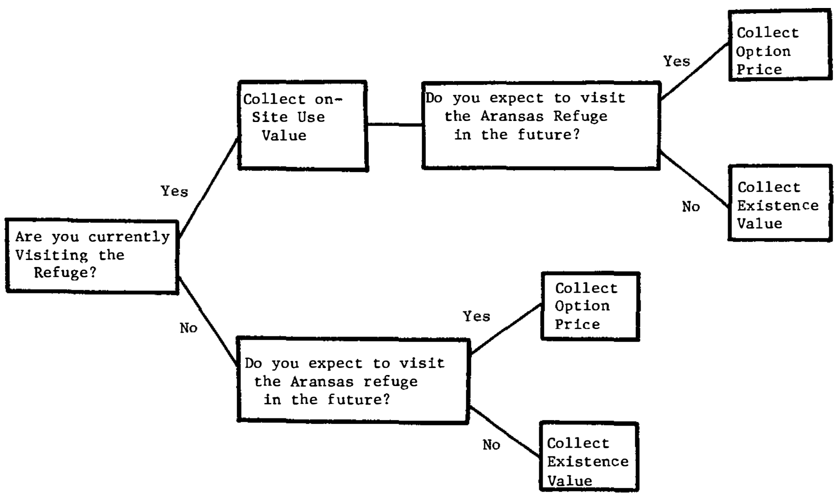

Figure 2. Survey respondent breakdown by value categories

survey) was offered an equal number of times in the subsample administrations. The values reported below represent a weighted mean derived from the proportion of *positive* (yes) responses at specific amounts.

Mean willingness-to-pay for an annual permit to visit the refuge was estimated to be $4.47 per person (Table 2). The mean bid for an annual permit to visit the Aransas refuge with no whooping cranes present was $3.07 per person. A combined annual option price and existence value was estimated to be $16.33 per person annually. When option price and existence value were estimated independently by separating those respondents who did not anticipate future visitation (30 respondents), option price was estimated to be $16.87 per person, while existence value was estimated at $9.93 per person annually. All estimates are derived after the elimination of *protest* bids (identified in the survey instrument), which are *negative* responses based on reasons other than economic value, e.g., lack of faith in management abilities or principles of species management, or objections to requiring fees for resource use.

Responses from the mail survey were used to estimate a mean combined option price and existence value for Texas residents of $7.84 per person annually. Controlling for anticipated future visitation to the Aransas refuge, mean option price was estimated to be $10.67 annually per person, while mean existence value was estimated at $1.03 annually.

Out-of-state residents surveyed by mail yielded a mean combined option price and existence value estimate of $7.13 per person annually. Approximately one-half of the respondents indicated that they did expect to possibly visit the Aransas refuge in the

Table 2. Estimated mean value for the whooping crane resource.

Type of value	Estimated mean	N	95% Confidence interval	
			Lower bound	Upper bound
Use value (with whoopers):				
Refuge visitors	$ 4.47	508	$ 3.39	$ 5.55
Texas residents	—	—	—	—
Out-of-state residents	—	—	—	—
Use value (without whoopers):				
Refuge visitors	3.07	510	2.15	3.99
Texas residents	—	—	—	—
Out-of-state residents	—	—	—	—
Option price/existence value:				
Refuge visitors	16.33	381	13.37	19.29
Texas residents	7.84	249	5.13	10.55
Out-of-state residents	7.13	126	3.92	10.34
Option price:				
Refuge visitors	16.87	351	13.76	19.98
Texas residents	10.67	176	6.90	14.44
Out-of-state residents	13.24	62	7.11	19.37
Existence value:				
Refuge visitors	9.33	30	−0.14	18.80
Texas residents	1.03	73	0.16	1.90
Out-of-state residents	1.24	63	0.09	2.39

future and their response was judged to be an option price. The mean option price estimate was $13.24 per person and the existence value estimate for the remaining respondents was $1.24 per person.

These estimated values are related to the previous discussion of household production technology. Given that this technology is affected by past activities produced and information possessed by the individual, one would expect both the option price and existence values held by past visitors to the refuge to be higher than those held by individuals who had not visited the refuge in the past. Table 2 illustrates that on-site respondents held higher values for both of these categories and the combined category than Texas residents (16 percent had visited the refuge) and out-of-state residents (four percent had visited the refuge).

A preliminary estimate of total use value for visitors to the Aransas refuge is $213,340 per year (47,727 × $4.47), based on a 1982 visitation of 63,000 visits and mean annual refuge visits of survey respondents (47,727 = 63,000 ÷ 1.32 visits per visitor). Combined option price and existence value for the same visitation rate is estimated at $779,382 per year (47,727 × $16.33), yielding a preliminary estimate of total annual value by users of the Aransas refuge of $992,722.

The combined option price for the Aransas refuge whooping cranes and existence value for the whooping crane among the 13.9 million Texas residents is estimated at $109.0 million (13.9 × $7.84). If one supposes that bids were for the entire household rather than for the individual as requested, then this combined value estimate is $38.7 million, based on 4.93 million Texas households.

Based on the 1980 U.S. population of 221 million people, total combined option price and existence value of the whooping crane resource in the United States is preliminarily estimated to be $1.58 billion (221 × $7.13). If bids represented household value for 80.4 million households, then this total value estimate is $573 million.

Summary and Conclusion

One of the on-going developments in the science of economics is a recognition that the total value of natural resources is a combination of several semi-distinct value components. Our attempt to value the whooping crane resource estimated three of these components: current use, anticipated future use, and non-use (existence). Our estimates were achieved through application of a method recently developed for valuing nonmarket commodities–the noniterative bidding form of contingent valuation.

Results revealed a significant, previously unquantified value for the whooping crane resource. In aggregate, the total for use, option, and existence values is estimated to lie in the range of one-half to one and one-half billion dollars annually for U.S. residents. Our value estimate does not consider expenditures for tour boat rides and travel or the indirect impacts of such expenditures, which would be appropriate for a regional impact analysis framework. The results indicate that contingent valuation offers the potential for estimating values which can be compared to the costs of programs having benefits which are customarily not directly associated with the marketplace. Perhaps most significant, however, is a realization of the magnitude by which the marketplace may fail to reflect the nonmarket value of specific natural resources and, thereby, underestimate true resource value.

The results of this study offer additional challenges in understanding the values individuals attach to nonmarket resources and the whooping crane in particular. Socioeconomic research has already attempted to undersand the relationship between personal backgrounds and attitudes towards wildlife. The framework presented here offers an interpretation of how this previous research can be integrated into an economic context to explain and predict the economic values individuals hold for these wildlife (and other) resources. As presented above, attitudes, information, and previous resource-related experience are all determinants of the household's production technology which allows individuals to produce satisfaction yielding use and non-use activities. Changes in any one of these factors would be expected to alter the values individuals place on these resources. What is needed in the future is an increased cognizance of these effects and a focussing of interdisciplinary research upon the manner in which these effects are exhibited.

Acknowledgements

This research was supported by the Texas Agricultural Experiment Station and is Technical Article No. 19360. Cooperation of the Aransas National Wildlife Refuge and the Texas A&M Undergraduate Fellows Program is gratefully acknowledged. Helpful comments were provided by John Bergstrom, Mike Bowker, Ron Griffin, Arden Pope, and Alan Randall at various stages of the research effort. Any remaining errors are the sole responsibility of the authors.

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The Importance of Including Costs of Full Mitigation in Benefit-Cost Analysis and Guidance for Planning Actual Mitigation

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This paper serves two related purposes. The first is to show that the cost of full mitigation must be included in project benefit-cost ratios or such ratios are misleading. Second is to go beyond project evaluation to determine under what conditions complete mitigation is likely to be economically feasible to implement. In determining the actual economic feasibility of complete mitigation the notion of "incremental analysis" and the USFWS's Mitigation Policy (1981) will be linked together. This provides USFWS and construction agency biologists with a common framework for planning actual mitigation.

The President's Council on Environmental Quality (CEQ) defines *mitigation* as: (1) avoiding the impact by not taking a certain action or parts of an action, (2) minimizing impacts by limiting the degree of the action, (3) rectifying the impact by repairing, rehabilitating or restoring the affected environment, and (4) compensating for the impact by replacing or providing substitute resources or environments (CEQ 1978). This definition is the one adopted by the USFWS Mitigation Policy (1981) and is used in this report.

Modification of the natural environment for water storage, flood control, and energy development normally results in losses of valuable wildlife habitats. These habitats provide many benefits to society in the form of food, recreation and aesthetics. In response to continued losses of increasingly scarce and valuable habitats, Congress has enacted laws or the Executive Branch issued regulations requiring mitigation of environmental losses and consideration of these losses in the planning process. The Fish and Wildlife Coordination Act (FWCA) and the National Environmental Policy Act (NEPA) are two such laws. In addition, the U.S. Fish and Wildlife Service has published a mitigation policy giving mitigation guidelines to its field staff.

The preceeding laws and guidelines have brought to the forefront of public decision making the question of "How much mitigation is enough?" Current answers by some economists (Shabman 1979, Peterson 1979) and development agencies (Robinson 1979) is that mitigation must also pass some informal benefit-cost test. In contrast, the Fish and Wildlife Coordination Act guidance and U.S. Water Resources Council Principles and Guidelines (1983) assert that mitigation is necessary and is an integral part of plan design and selection. This difference of opinion regarding degree of mitigation has become even more relevant with the issuance of U.S. Army Corps of Engineers Engineering Circular 1105-2-117 in July 1983 (U.S. Army Corps of Engineers 1983) and Presidents Private Sector Survey on Control (1983) investigation of whether current mitigation costs are justified.

One Source of Confusion

The source of some of the current difference of opinion about mitigation stems from a failure to recognize what benefit-cost analysis (BCA) is supposed to be measuring. When a project has a benefit-cost ratio greater than one or a net present value greater than zero, this is supposed to mean that a net increase in national well being takes place. The reason for this interpretation is that when the benefit-cost ratio is greater than one, in theory, the project gainers should be able to *fully* compensate the losers and still come out with a net gain. If the gainers cannot fully compensate the losers and still come out ahead, then the project does not even meet the necessary, let alone sufficient, conditions for an improvement in economic efficiency (Foster 1976). This criterion on which benefit cost analysis (BCA) is based on is called the Potential Pareto Criterion (Sassone and Schaffer 1978:11, Mishan 1976). Whereas some economists (Mishan 1973, Bromley 1980) argue for actual rather than potential compensation tests, all agree that the costs of 100 percent compensation of the losers *must* be included on the cost side for such a BCA to be meaningful.

Who could argue with such a logical criterion? A change or project, on average, makes everyone better off only if there is a net gain after the individuals who suffer from that change are brought back to their original level of well being. There is no justification for claiming that full mitigation is uneconomic because it would make the benefit-cost ratio become less than one. When the benefit-cost ratio becomes less than one with full mitigation then the project makes one group better off at the expense of another. The project is a transfer of resources from one group to another, not a creation of new national wealth as project proponents might claim or the National Economic Development (NED) objective requires. Without full mitigation costs included in the benefit-cost ratio, the benefit-cost ratio's approximation of the Potential Pareto Criterion is destroyed. That is, without full mitigation costs included in the benefit-cost ratio, it would be impossible to tell if the gainers could fully compensate the losers and still come out ahead.

A simple example should leave no doubt in the reader's mind that the Potential Pareto-Criterion is at least a minimum criterion which must be met for one to conclude that the project makes a contribution to National Economic Development. Suppose project net benefits are $15,000 and direct project costs (without mitigation costs) are $10,000. The benefit-cost ratio appears to be 1.5. But when we add in the necessary $7,000 of costs to offset wildlife losses one sees that the benefit-cost ratio is now less than one (0.88 to be exact). Once the gainers have paid the project costs and compensated for project losses, they are now worse off than they were before the project. There is just not enough project benefits generated to allow for a net gain in NED or economic efficiency. One solution is to redesign the project or alter its operating regime to reduce the compensation costs. While this discussion conceptually settles the issue as to whether the costs of full mitigation should be included in the BCA, it raises two pragmatic issues.

Measuring Full Mitigation Costs

These practical issues relate to: (1) measuring the cost of compensation for inclusion in benefit cost analysis; and (2) determining the amount of mitigation that should actually be implemented. Since resolution of the latter issue partly depends on measurement of costs, the discussion will first address measurement of mitigation costs. There are two ways to approach the measurement of the costs of compensation. The theoretically correct way would be to survey those citizens adversely affected by nonmarketed project losses such as losses in wildlife habitat or archeological sites (the marketed project losses, such as acquisition of private land, should have already been accounted for in the direct project cost category). In theory the survey should ask what is the minimum amount of money the adversely affected citizens would be willing to accept to allow the wildlife or wildlife habitat losses to occur. The sum of all these citizens' willingness to accept compensation would be compared to the actual cost of *in kind* replacement of the project losses in the same area to determine whether cash compensation or habitat replacement would be least costly. The body of techniques that allow quantification of the amount of dollar compensation citizens would be willing to accept is often referred to as Contingent Valuation or Bidding Method (Brookshire et al. 1983).

This scenario is becoming more realistic as the techniques of nonmarket valuation improve and Federal agency expertise in this area increases. (See the Economics Session of this conference for examples.) However, three factors may preclude its use in some cases. They are: (1) the Public Trust Doctrine; (2) difficulty in getting authorization and funding for Federal agencies to use state-of-the-art nonmarket valuation techniques; and (3) citizens' incomplete knowledge of the benefits of wildlife, wildlife diversity, and habitat preservation. Complete knowledge by those affected is one of the requirements for a voluntary exchange to result in a socially beneficial gain (Sassone and Schaffer 1978:57, Samuelson 1976:635, Mansfield 1970:224).

The two most important limiting factors are likely to be the Public Trust Doctrine and the current state of Federal agency valuation techniques. Federal agencies are beginning to abandon the largely discredited Unit Day Values and apply professionally accepted methods such as Travel Cost and Contingent Valuation in the estimation of wildlife *recreation* benefits. However, the value of wildlife to society stems not only from the recreation value but also from the satisfaction many people derive from knowledge that those species or habitats exist in a given area (existence value), satisfaction from knowing future generations will have the opportunity to see those species (bequest value) and from satisfaction of knowing that the structural and functional components of the ecosystem will be maintained (option, scientific and educational values). These latter elements of wildlife value such as existence, bequest, option, scientific, and educational can be collectively called "preservation values."

Miller and Menz (1979) demonstrate that both the recreation and preservation values can enter into an individual's level of satisfaction or well being. This was not the first time this assertion has been made, however. Krutilla, in 1967, made a similar proposition but did not provide the theoretical model that Miller and Menz (1979) developed. Meyer (1974), Brookshire et al. (1983), and Walsh et al. (1984) empirically demonstrated the dollar size of these preservation values for salmon, bighorn sheep, and wilderness, respectively.

One operational difficulty in measuring the dollars that citizens would be willing to accept to allow the wildlife losses to occur is that, currently, field offices of some Federal agencies have neither the trained personnel to design surveys to measure these preservation values nor budgets to contract with specialists to design and implement such surveys. As will be shown in the next section, performing such surveys and paying the citizens (or state game and fish agency) the resulting compensation could save the Federal agency (and taxpayers) a great deal of compensation costs in cases where cost of replacing the specific habitat exceeds individuals' willingness to accept compensation.

While the expertise of Federal agencies needed to design and conduct recreation and preservation value surveys is increasing, a legal issue known as the Public Trust Doctrine could possibly reduce the acceptability of citizens being paid cash compensation for wildlife losses. The Public Trust Doctrine establishes the state and Federal government as owners of wildlife. As interpreted by the courts, these governments can only allow the transfer or "sale" of wildlife or wildlife resources out of public uses when the interests of current and future generations are enhanced by such action (Ehrlich 1983). In some cases (especially where the monetary compensation did not go to wildlife management), it would be difficult to argue the public interest is served by allowing current residents of an area to "sell" the rights to wildlife for the next 50 to 100 years.

An Alternative Determination of Mitigation Cost

The practical implications of these technical and institutional difficulties in implementing the theoretically preferred solution for estimation of compensation costs bring us to habitat as an alternative basis for mitigation or compensation planning. For example, if a project results in a loss of 5,000 acres (2,025 ha) of prime elk habitat, replacing the carrying capacity equivalent of 5,000 acres of prime elk habitat will insure the losers are fully compensated. In this way both the recreation and preservation values are replaced without ever having to explicitly estimate those values. The Public Trust Doctrine is fulfilled since wildlife resources are conserved for present and future generations. This is precisely the approach implied by the Fish and Wildlife Coordination Act, the Mitigation Policy, and Mitigation Banking. Measurement of the habitat carrying capacity lost can be performed using Habitat Units, calculated by USFWS Habitat Evaluation Procedures (1980). The cost of full mitigation to be included in BCA becomes the minimum cost necessary to replace the Habitat Units lost for a particular species or group of species. In certain circumstances (to be discussed next), these replacement costs will exceed the theoretically correct willingness to accept compensations. This issue and the issue of how much actual mitigation is economically justifiable will be illustrated graphically to show the importance of including the cost of full mitigation in benefit-cost ratios.

Incremental vs. Full Mitigation

The USFWS Mitigation Policy (1981) specifies four different mitigation goals, depending on the resource category the habitat or species is classified in. Categories are as follows: Category #1: no loss of existing habitat value; Category #2: no *net* loss of in kind habitat value; Category #3: no net loss of habitat value while minimizing loss of in kind habitat value; and Category #4: minimize loss of habitat value. Full mitigation is called for in both Categories 2 and 3 since the goal is no net loss of habitat value. Mitigation Goal Number 2 in the Mitigation Policy means providing full replacement of habitat carrying capacity or productivity for the *same species* (in kind) as was negatively impacted by the project. Mitigation Goal Number 3 means full replacement of habitat carrying capacity or productivity for the same or different species as were negatively affected by the project. These species may be in a geographically different area than the project.

The "Interim Guidance on Mitigation Banking" (Jantzen 1983) established market areas for mitigation banks. Mitigation banks are generally large tracts of land set aside for management of the land's habitats to increase its habitat value. The increase in habitat value may be used to offset a loss in habitat value associated with some development. The market area is defined as the same ecoregion in the same state as the project impacts occur. This helps to define the geographic extent of the direct impact on citizens without compromising each state's responsibility toward its citizenry under the Public Trust Doctrine. The units of account for mitigation banking may be HEP Habitat Units (HU's) since HU's measure both quantity and quality of habitat relative to a particular species.

This definition of units of account and market area establishes the foundation on which one can evaluate the mitigation recommendations associated with incremental analysis. Figure 1 shows the "marginal benefit" of alternative amounts (acres or HU's) of habitat for a particular species within a given ecoregion and state. The marginal benefit curve reflects the additional benefits (in terms of recreation and preservation values) for alternative amounts of habitat for that species. The "marginal cost" curve reflects the additional opportunity costs of habitat preservation. This opportunity cost can be thought of as either the net development benefits foregone or the cost of replacing the habitat value associated with different levels of habitat. The shapes of the Marginal Benefit Curve (MB) and the Marginal Cost Curve (MC) reflects the shapes that usually result when the curves are empirically estimated.

The determination of just where an ecoregion and state are on these curves relates to the USFWS Resource Category. If the habitat type for a given species is relatively scarce

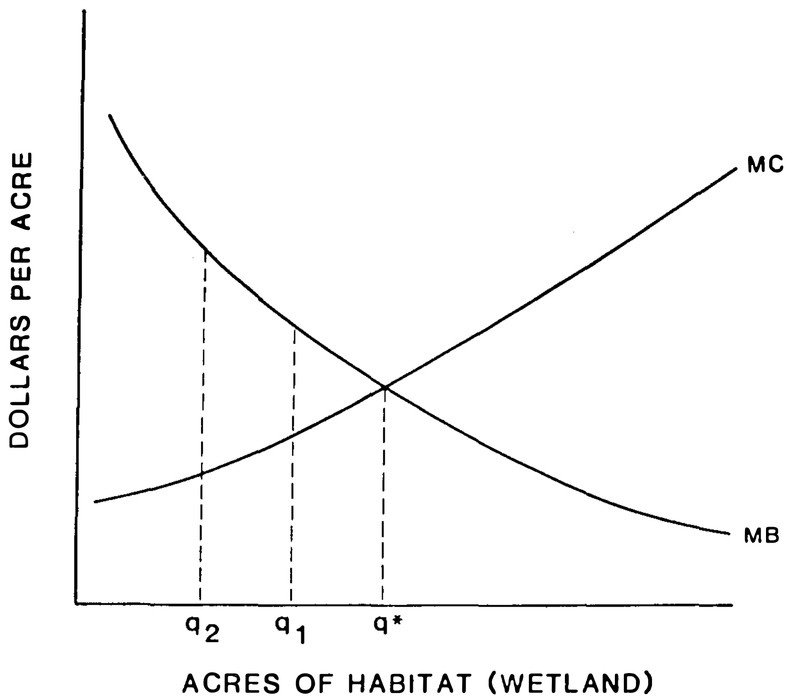

Figure 1. Mitigation of category two resources.

and over time it is becoming even more scarce, then it may be reasonable to conclude it is a Category 2 resource. A way to determine whether a habitat type for a particular species is "relatively scarce" is to determine whether Federal or state agencies are currently investing in enhancement or restoration of that habitat type in that ecoregion and state. Where they are, then it is likely that citizens in that ecroregion and state currently find themselves to the left of q^* in Figure 1. That is, a Category 2 resource could be defined as one in which the marginal benefits of additional HU's exceed the marginal cost of additional HU's (anadromous fish habitat in Washington and Oregon may be an example).

Using this economic interpretation of a Category 2 resource and Figure 1 we can compare mitigation recommendations of incremental and full mitigation approaches to in kind habitat replacement. By the above definition of a Category 2 resource, the people in this ecoregion are currently at q_1. Let a proposed project, if implemented, move society to q_2. Full compensation would require the replacement of q_2q_1 in kind habitat units so that the project losers are brought back to their before project level of habitat units for this species. The cost to do this must be included in the benefit-cost ratio or it is misleading.

Incremental analysis of mitigation for a Category 2 resource would require mitigating until the last increment of cost equals the last increment in benefit. In terms of Figure 1, this means mitigating until *MB* equals *MC* or q^*. Not only would full compensation be justified but so would enhancement under incremental analysis.

Before going to the most interesting case, Category 3 resources, it is useful to look at the other extreme of a Category 4 resource. Figure 2 has the same basic curves as Figure

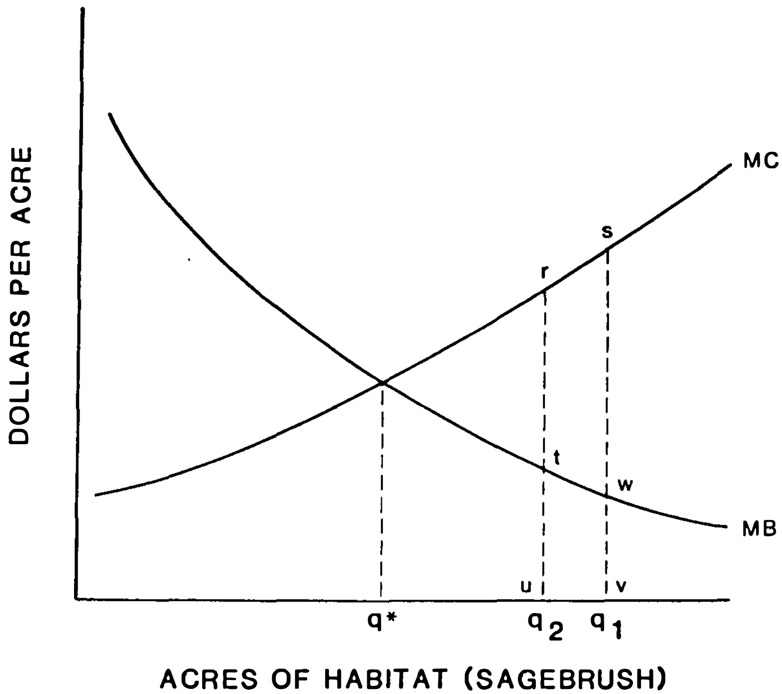

Figure 2. Mitigation of category four resources.

1 since what is a Category 4 resource in one state may be a Category 2 resource in another state. What determines whether or not one has a Category 4 resource is relative abundance of that habitat type in that state. An economic definition of a Category 4 resource might be that this habitat type for this species is abundant but becoming less abundant. Confirmation of this determination might rest on the fact that little or no enhancement or restoration of this habitat type is being undertaken by Federal or state agencies in that state (an example might be sagebrush in Utah).

In terms of Figure 2, citizens in this ecoregion in this state are at q_1 and the proposed project if implemented would move society to q_2. Full compensation would require replacement of habitat value lost. It would be uneconomical to actually replace q_2q_1 amount of this habitat since the *MC* so greatly exceeds *MB* that the construction agencies' resources are better invested elsewhere. In this case an incremental analysis would provide a better indicator of the optimum amount of actual compensation and is what is required under the Mitigation Policy. However, the benefits foregone to the citizens in this ecoregion and state from giving up q_2q_1 amount of this habitat type (area under *MB* curve between q_2 and q_1) ***must*** be included as a cost in the benefit-cost analysis. This cost should be measured as citizens' willingness to accept compensation using the bidding method. This distinction between the cost of potential compensation which ***must*** be included in the benefit-cost analysis and the determination of the *actual* amount of compensation to provide on the ground has confused some economists and decision makers. The benefits foregone must be included in the benefit-cost ratio to insure that the ratio reflects the Potential Parento Criterion. Incremental analysis is helpful in determining whether that actual amount of compensation, in the form of habitat replacement, is economically justified.

Category 3 resources represent a "gray area" in terms of whether the costs of full compensation which are to be included in the BCA should be incurred for actual full mitigation. We must explore the reasons that make Category 3 resources more difficult to come to unequivocal conclusions about as compared to Category 2 and 4 resources.

Figure 3 shows that society is currently at q_1 amount of this habitat type in this ecoregion in this state. This habitat type appears abundant but is becoming relatively scarce (that is tending toward q^*). While it is not so scarce that enhancement or restoration projects are undertaken, there is very little available habitat that might serve as a buffer before the resource may be considered for Category 2 and discussion of restoration begins in earnest.

Since there is so little surplus of this habitat, any significant project affecting this habitat type would, if implemented, move society to q_2 amount of habitat, effectively pushing it into a Category 2 resource. First the entire cost of full compensation (back to q_1) must be added to the cost side of the benefit-cost analyses. The theoretically correct costs are the marginal benefits foregone of q_2q_1 units of habitat. This can only be determined by a willingness to accept comepnsation survey. Alternatively, the marginal benefits foregone for q^*q_1 units habitat would be included as a cost in the BCA when q_2q^* amount of compenstion is actually implemented as mitigation. When such willingness to accept compensation surveys cannot be performed, an alternative measure of the cost of full compensation is the cost of 100 percent in kind habitat replacement back to q_1. As is seen in Figure 3, the marginal costs of the last few units exceed the marginal benefits of such a loss. We cannot, however, stop recording (in the BCA) mitigation costs at q^* just because incremental analysis indicates this is the economically feasible amount to replace. To do so ignores area *ebcd* of benefits foregone as project losses. In our real world of

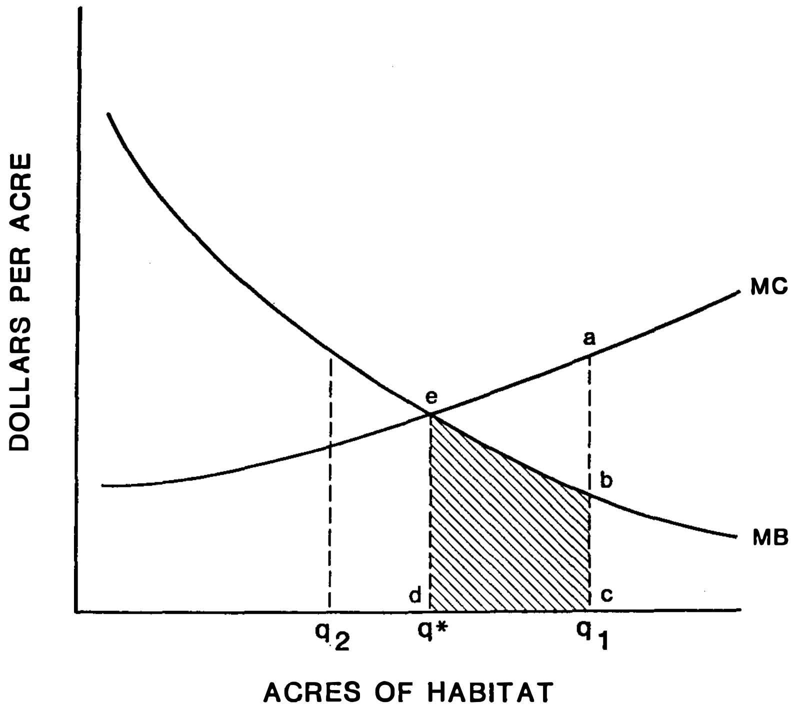

Figure 3. Mitigation of category three resources.

inadequate budgets, citizens' incomplete knowledge of habitat values, and the Public Trust Doctrine, we may have to incur *eab* worth of extra costs to insure *ebcd* of foregone benefits are not ignored in the benefit cost analysis. In the real world where there are also *irreversibilities*, including these extra costs in BCA actually transforms benefit-cost ratios into "fail safe" indicators of Potential Pareto Improvements. Only projects that make substantial increases in national well being (NED gains) will pass this fail safe test. Some projects that make borderline contributions to national economic development may be rejected by this new test but this is a price that is paid to insure no projects not contributing Potential Pareto improvements (when full compensation is included) pass the test.

When the project results in an irreversible loss of this Category 3 resource (or Category 2 for that matter) the extra costs required by this more stringent fail safe test may be economically justified as an option value tax (Hanneman 1982, Krutilla and Fisher 1975). These economists have shown that when the project would result in an irreversible loss a more stringent test is necessary to safeguard against making what appears to be an optimal choice today but one that turns out, in the next decade, to be suboptimal or inefficient. Bromley (1980) and Mishan (1973) go beyond the requirement that the premium be included in the BCA and argue that full compensation must actually be paid.

The desirability of including *eab* of extra cost, to insure *ebcd* of benefits foregone is not overlooked, in the BCA arises only when the agency does not perform a willingness to accept compenstion and the losses are irreversible. However, when surveys are not performed and when the loss of the Category 3 wildlife resources is *not* irreversible, there may be equal economic justification to err on the opposite side: a willingness to undercount benefits foregone of *ebcd* in order to avoid including uneconomic costs of *eab*. Comparison of benefit-cost ratios with *eacd* worth of costs included and excluded would at least provide a useful sensitivity analysis of project feasibility. If project feasibility changes under the two extreme conditions, then a willingness to accept compensation survey would be appropriate to more accurately establish the cost of compensation to be included in the BCA.

Conclusion

This paper has demonstrated that the costs of full compensation must be included as costs in the computation of benefit-cost ratios. If less than the full costs of compensation is included, the resulting benefit-cost ratios could mistakenly lead decision makers to choose projects that, on average, make "everyone" worse off. The measurement of compensation costs should be in terms of the minimum amount of money those affected are willing to accept to allow wildlife losses to occur. A realistic alternative would be the cost of 100 percent replacement of in kind habitat value. It was argued that in kind replacement of habitat value is more consistent with the Public Trust Doctrine. A simple graphical analysis was used to determine the type of wildlife resources for which it would be economically justifiable to undertake full mitigation. It was shown for USFWS resource Category 2 that incremental analysis of mitigation costs and benefits would require at least full in kind compensation and possibly enhancements. For Category 4 resource it is generally not economically feasible to actually implement full mitigation. For Category 3 resources, full in kind compensation would generally be economically feasible to actually implement when the project losses were irreversible.

The same theory that legitimizes the use of benefit-cost ratios as an input to project selection provides strong support for the requirement that 100 percent of the full compensation costs are integral project costs to be included in such benefit-cost ratios. The simple graphical frameworks provided in this paper should help to clarify discussions of how much mitigation is economically efficient to implement. Tools such as the USFWS Habitat Evaluation Procedures, when used in a cost effectiveness analysis of mitigation, should provide realistic estimates of the minimum costs necessary to compensate fully for project losses.

Acknowledgements

The ideas presented in this paper have been developed from discussions with Norman Starler, Bureau of Reclamation, Edward Dickey, U.S. Army Corps of Engineers, and Laurence Jahn, Wildlife Management Institute. Inevitably each will find different concepts they disagree with. Suggestions by Mel Schamberger, Rod Olson, Charles Solomon, Bill Krohn, and Mike Hay, all U.S. Fish and Wildlife Service, have significantly improved the clarity of thought and expression of this paper. The remaining errors and any judgements are my own and do not necessarily reflect the views of the U.S. Fish and Wildlife Service or the Department of the Interior.

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Innovative Responses to Conservation Challenges

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4-H Fish and Wildlife Programs: New Initiatives on Old Problems

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Speaking to the first North American Wildlife Conference, Dr. C.B. Smith (1936), Assistant Director of Extension, placed "the Extension Service squarely behind this great conservation movement . . . stimulating interest and knowledge . . . in the how and why of wildlife restoration and conservation." Those concluding remarks reemphasized his conviction that extension, particularly the 4-H youth component, would play a major role in the implementation of "the aspirations and wishes of this great conference." His brief remarks had outlined the then current activities of youth in conservation programs. Eleven states were singled out as having made significant efforts in wildlife fields. Several others were cited as doing some work in the area. Stocking programs, fire suppression, habitat preservation, conservation plantings, nest box programs, and natural history instruction were featured activities. By today's standards the projects outlined were as primitive as was the art and science of wildlife management at the time.

Several needs were cited in Smith's remarks. The need for a small group of fish and wildlife conservation specialists on the national extension staff was clearly outlined. He made a strong case for at least one fish and wildlife specialist in each state extension program as well. The fascination of young people for these activities awaited "only proper introduction, coordination, guidance, and literature to make it a significant part of extension work."

During the time since that first North American Wildlife Conference, the conservation and management fields have expanded explosively. The population of the nation has increased greatly. Demands on renewable resources have increased at an even greater rate. The degree of insulation and isolation from environmental realities has been magnified. The result has been the development of an ecologically illiterate population which mingles management decisioning with political expediency and the proliferation of well-intentioned, intuitively pleasing, and ecologically indefensible legislation, regulation, and policy. Activism has had a liberal admixture of sophomoric smugness, with media-generated constructs substituting for sound ecological knowledge. Both ecologists and managers have been frustrated in their efforts to reduce prodigal resource use, waste, inefficiency, and potential biological disaster. Removing the public from the decisioning process is a falsely appealling solution. Thomas Jefferson rightly stated that an ignorant, and therefore irresponsible, electorate cannot be disenfranchised, but must be educated to achieve responsibility. That objective remains the principal challenge in 1984, just as it was in 1936.

Substantial progress has been made in addressing some of the needs that Smith identified. With the recent passage of the Renewable Resources Extension Act (RREA) of 1978 and the establishment of the Natural Resources Unit in the Extension Service, USDA, the Cooperative Extension Service obtained a national coordinating staff in conservation and resource management. Currently 32 states employ at least one fish and wildlife specialist on their extension staff (Miller 1983). At least three states (New York, Indiana, and Michigan) have fish and wildlife specialists with primary and specifically defined 4-H youth responsibility. At least two other states, Massachusetts and Florida, are developing similar positions. Other Extension fish and wildlife specialists allocate a portion of their time to 4-H program leadership. The materials that are available to support youth and volunteer leaders form a reasonably comprehensive resource base for delivery of the conservation message.

The response of young people and volunteer leaders has been gratifying. Data from the statistical summaries of 4-H participation, while subject to changes in reporting systems and considerable variation in the selection of categories for reporting at the county level, provide an index of the participation levels. The number of youths participating in fish and wildlife projects in fiscal 1969 was 109,764. By 1980, 4-H enrollment in fish and wildlife projects had grown to slightly over 205,000 (Miller 1981). In 1983 that number had increased to at least 258,852, and a total of 321,517 could be assumed if related categories that were not used in 1969 are included. Similarly, participation in the aggregation of projects included in the natural resources program area increased from 372,365 to 855,546 youths over the same 15 year period. These dramatic increases (from approximately 2.3 to nearly 3.0 times their 1969 values) took place in the face of declining support bases and, in some cases, declining 4-H populations as well. For example, natural resources 4-H participation in New York increased more than 500 percent during the 1970s; while club enrollment for the same period showed a moderate decline, as did staffing levels and maintenance and operation budgets (Decker and Howard 1980, 1981).

The enthusiasm of the youth audience awaited only adequate leadership to generate a benevolent giant. Volunteer leaders needed to be identified, recruited, and adequately supported by literature in their areas of interest. Thus, maintaining growth in both participation and program quality demanded increased efficiency. The traditional modality of individual specialists operating in isolation and developing provincial project materials could not complete the remaining remedial tasks and develop the materials to address emerging problems at the same time. The specialist was faced with the choice of becoming a reactive programmer, working with program needs only as they developed or of seeking means of pooling programming expertise. Cooperative efforts at program development were the far more desirable choice.

The National Workshop of Extension fish and wildlife specialists in 1977 helped initiate the process. For 4-H specialists, however, one of the key elements in cooperative programming came as the side effect of the 4-H Fish and Wildlife Conferences (in 1977, 1978, and 1979) sponsored by the Atlantic-Richfield Foundation under the auspices of the National 4-H Council. Both 4-H and fish and wildlife specialists were able to communicate common needs, program successes, and cooperative ventures that had proven fruitful for them. Three major efforts have developed from those discussions. The small grants that were associated with the conferences aided in the production of the project materials cooperatively written by specialists in Tennessee and North Carolina for the Southeast region. Although that region formed the primary audience, applicability for other areas of the nation was intentionally planned. Discussions of the fledgling Shooting Sports Program led to the formation of a national program development committee. Finally, the Natural Resources Developmental Committee was constituted to examine the status and needs in the entire program area. Their initial report (Anon. 1982) poses a challenge to the extension system that is strongly reminiscent of Smith's comments in 1936.

Strong support for a Natural Resources unit in the Extension Service, USDA, was rewarded in 1979. The first position filled was that of a national program leader for fish and wildlife. That position has helped to develop a coordination of effort with the 4-H Unit, National 4-H Council, other resource agencies and national organizations, and with state Cooperative Extension specialists.

In addition to these internal mechanisms for cooperation, several external linkages also have developed. Interactions and funding support from other national or state agencies and private industry have enabled the production of materials and trials of potentially powerful mechanisms for efficient leader training. On the national level a formal cooperative agreement has recently been updated between Extension Service, USDA, and the U.S. Fish and Wildlife Service (USFWS). Mutually beneficial programming has come from that alliance. Endangered species unit funding, for example, has enabled the New York extension staff to develop a major program in raptor education (Bonney et al. 1981, Howard et al. 1981). An excellent predator-prey instructional unit for youth was included in that package. In addition, through the coordination of the program leaders in the Extension Service (Fish and Wildlife Program) and USFWS (Extension Program), the extension unit of the Fish and Wildlife Service, USDI, has provided funding for several intensive regional leader training workshops for 4-H fish and wildlife volunteers and agents. To date, these workshops have been held in four states with more than 250 leaders receiving training. Another workshop is planned for August 1984. These numbers grossly underestimate the impact of the programs since the communication process that took place when the specialists met in other conferences has shown some evidence of taking place among specialists and leaders at the workshops. Highly trained leaders with confidence in their knowledge and teaching skills are initiating projects, seeking out local support bases, and educating other leaders. Thus they are acting as key leaders or master instructors, increasing the efficiency of the specialist through volunteer support (e.g., Howard and Kelley 1982). The Fish and Wildlife service has provided cooperative funding support for a national 4-H Wildlife and Fisheries Program as well. The program has provided recognition for 4-H volunteer leaders since 1980.

Similar cooperative efforts have taken place with state agencies. The development of the trapper training program in New York is an excellent example. The 4-H program had been involved in furbearer management, both as an effort at aiding rabies control programs and as a mechanism to increase farm family income, since the late 1930s. The original teaching materials were judgemental of predators and incomplete. In an effort to reduce the amount of trial and error learning on the part of neophyte trappers and to enhance wise use of the furbearer resource, a voluntary trapper training program was instituted using a new training bulletin. Furbearer management specialists on the conservation agency staff and leaders of the two state trappers organizations were included in the developmental process. After several years of voluntary training, the state agency was able to promulgate a regulation requiring a training course for all first-time license applicants. Specialists from the extension staff, members of the trapper associations, and representatives of humane organizations worked with management biologists to develop an improved instructional package (Howard et al. 1980). Continuity was maintained by retention of the basic program materials and by the participation of 4-H agents as county coordinators. The state benefitted from the program development skills of the specialist and the multi-year testing of the process. The extension program benefitted from the state's provision of program materials and the interactions with a new set of leaders.

The involvement of private organizations and industry should not be overlooked in citing cooperative programming efforts. The 4-H Shooting Sports Program is a case in point. The Texas 4-H leadership, working with the intensive cooperation of the National Rifle Association (NRA), piloted the program in the mid-1970s. Sharing of interests in the program coupled with the successes that it had had in attracting particular audiences caused its exportation to other pilot states.

The acceptance of the program by 4-H audiences in New York, Virginia, and Minnesota led to the formation of a national program development committee under the auspices of the National 4-H Council. The committee recognized their program was commonly applicable, and they developed both a training strategy and a club-approach model for delivery of the materials to key leaders. The successes experienced with their model have inspired a current effort at similar program development for sport fishing. Only the support of NRA and a consortium of manufacturers enabled the generation of these materials and training of leaders.

The impacts of these initiatives have been significant. These new programs proved attractive to leaders and previously unreached young people, with adult leaders sometimes outnumbering the youths with whom they worked, and the effects have gone beyond the immediate impact upon any specific program. Leaders attracted to the 4-H program through activity in a peculiarly attractive area have frequently provided assistance with related offerings. Similarly the proven models for program delivery may be providing a glimpse of the future: leader training through intensive, on-site workshops for key leaders.

The future for 4-H extension programming looks both bright and challenging. Young people represent a strongly motivated and educable audience. Acceptance of natural resources programming is high, and young people are both willing and able to come to grips with complex issues. The impact of their learning, as Dr. Byford (1984) will demonstrate, can have considerable impact upon the central question—ecological illiteracy. To conclude that the activity recently experienced must be duplicated is a weak analysis of the future need, but it is certainly valid. The ideas advanced in the report of the National 4-H Natural Resources Developmental Committee report remain to be implemented. If they are vigorously pursued, Natural Resources 4-H programming may look forward to a continuation of the exponential growth demonstrated in the past few years. The support of all elements of the management, research, and educational communities is the minimum requirement. In the next few years programs will be needed in contaminants, endangered species, species enhancement, and consumptive uses of renewable resources. With anticipated increases in leisure time, programs aimed at the enhancement of recreational uses of resources will be in demand. Finally, the 4-H program needs to keep pace with the development of computer-assisted resource management decisioning that will reach fruition in the next few years. These potential areas for involvement do not exhaust the potentials for 4-H fish and wildlife specialists, but they should hold enough challenge to occupy the next decade.

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Attitudes on Wildlife and Knowledge Retained by 4-H Alumni

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Overview

This paper reports a study to determine knowledge and attitudes about wildlife of young Americans who attended a week-long 4-H Wildlife Conference from one to nine years earlier. Data from the population were compared with similar data from a cross-section of the American public, as reported by Kellert and Berry (1980). Both groups were asked the same knowledge and attitude questions.

Introduction

The Need for Conservation Education Recognized Early

The conservation movement in the United States is relatively young in comparison with many other countries. In 1936, President Roosevelt called together the first meeting of the North American Wildlife Conference, in order to address the problem of restoring and conserving America's wildlife resources. In the Thursday morning session, chaired by Ira N. Gabrielson, the chief of the U.S. biological survey, five speakers addressed the need for conservation education of the public as one means to solve the nation's wildlife conservation problems (Gabrielson 1936).

Today's Needs are the Same

The situation has improved some since 1936, but the scale of improvement has not kept up with the population increase and the increasing complexity of today's conservation problems. Dr. Stephen Kellert, in a series of reports in the early 1980s (Kellert 1979, 1980, Kellert and Berry 1980) rocked the conservation community back on its heels. His study, in which he surveyed a generous cross-section of Americans, found that most Americans know relatively little about animals. Most see wild animals only on television or in zoos, and most interactions with animals are with pets. Reflective of this, the attitudes of most of the American public were, to a great degree, based on unrealistic ideas about how animals actually live in their daily struggles for survival.

4-H—What It Is

At the first North American Wildlife Conference, Dr. C.B. Smith indicated that one form of conservation education was being carried out by the Extension Service through 4-H clubs (Smith 1936). The Smith-Lever Act of 1914 created the Extension Service as an educational agency, designed to reach out from one 1862 Land Grant university in each state, teaching the general public the latest technologies in agriculture, natural resources, and home economics. Later, similar programs of the 1890 colleges were combined into one program for black and white Americans. The Smith-Lever Act instructed Extension to teach both adult groups and youth groups, with the primary youth group being the 4-H clubs in this nation. Nearly every county or parish in the country has one or more Extension agents who have B.S. to Ph.D. degrees in one or more areas of agriculture, home economics, natural resources, or related areas. With the help of a large network of adult volunteer leaders, these agents conduct educational programs for 4-H youth in all areas of agriculture, home economics, and natural resources. Faculty members at the 1862 and 1890 colleges and universities who are assigned Extension responsibilities condense research into programs the public can understand, and disseminate these programs through county Extension offices.

History of 4-H Wildlife/Conservation Projects

4-H started out as educational programs to teach young people how to grow corn and hogs, and how to can (Kendrick 1926). It wasn't until the early 1930s that the 4-H educational program in conservation became a reality. The Indiana Agricultural Extension Service was one of the first to have a 4-H conservation program; this began in 1930 with the formation of the Purdue Department of Forestry and Conservation (Krauch 1970). Other states quickly followed suit. By 1936, substantial programs in 4-H wildlife conservation were being conducted in 17 or 18 states (Smith 1936).

4-H Wildlife Education in the United States Today

4-H wildlife education has grown to be a very substantial part of the total 4-H program in this country. In the last 14 years, (1969 through 1983) this country's 4-H wildlife enrollment has increased from 1.6 percent to 5.2 percent of the nation's total enrollment of nearly 5 million 4-H'ers (4-H Office, Extension Service USDA, Washington, D.C., 1984, personal communication). The wildlife project (only one of 62 4-H projects in Tennessee) has always held fascination among young people. There is no problem getting their interest in this subject. The problem has always been, heretofore, a lack of resources and people to do the job. We are a long way still from where we'd like to be, but significant progress has been made. Several things have happened in recent years. First, generous support has come from the U.S. Fish and Wildlife Service, as a result of cooperation with the Extension Service at the Federal level. This support has resulted in grants to state Cooperative Extension Services to develop innovative program ideas, fund pilot programs, regional leadership training conferences for both adult volunteer and teen leaders in all regions of the country, awards, recognition, literature and audio/visual development. The Fish and Wildlife Service has also sponsored a National 4-H Wildlife and Fisheries Recognition Program since 1980. This cooperation has been a tremendous shot in the arm for 4-H programs across this country. In addition, aggressive support by the Office of Natural Resources, Extension Service, USDA, working in cooperation with the National 4-H Council, has now secured a nationally sponsored awards and incentives program. As of 1983, there are four national co-sponsors of this program—National Wildlife Federation, Gulf Oil Foundation, Tenneco, Inc., and the Union Pacific Foundation. Another factor becoming increasingly important is a new comprehensive set of 50 units of 4-H wildlife literature put together by the Southern Regional 4-H Wildlife Literature Committee and produced by the National 4-H Council. These units, including Members' and Leaders' Guides, have been in use all around the country for several years during their development, and will be available as a complete set this spring. Their development was made possible through a grant by the Atlantic Richfield Company. A final ingredient that has made this project come to the forefront is that there are, as of 1980, 70 professional fish and wildlife specialists in 30 of the 50 states and one Extension Fish and Wildlife Program leader in Washington, D.C. (Miller 1981). The presence of these people is absolutely essential before a state can have a successful 4-H wildlife eductation program.

What The 4-H Wildlife Project Is

Extension education is a "demonstration method" type of education, and 4-H is a "learn-by-doing" educational program. The wildlife conservation teaching/learning process involves several approaches. To give you an idea, a few of these are listed. During community 4-H club meetings (one county may have 50 to 100 community 4-H clubs) Extension agents and adult volunteer leaders, as well as older 4-H'ers themselves, present demonstrations on various topics, such as how to build a bluebird nest box. Four-H'ers receive wildlife literature that explains a particular wildlife topic and lists several hands-on things to do. After 4-H'ers complete some of these tasks, they often give demonstrations to other groups (civic clubs, their own 4-H club, etc.). There are 4-H wildlife food plot contests where 4-H'ers plant wildlife food strips and enter competition for various awards. Four-H wildlife judging contests involve teams of 4-H members making wildlife management decisions for a particular farm. These contests also involve evaluation of the quality of wildlife habitat from aerial photographs and identification of wildlife foods. Four-H'ers frequently enter public speaking contests, giving their speech on wildlife topics. Many counties have 4-H wildlife project groups that have meetings throughout the year just on wildlife topics. These will often include field trips and tours, as well as overnight wildlife camping trips. The various 4-H camping programs across the country are usually heavily involved in wildlife and nature interpretation. Many states have week-long wildlife conservation camps in which intensive wildlife training is conducted by state, federal, and university biologists and educators.

Tennessee 4-H Wildlife Conference

The Tennessee 4-H Wildlife Conference is conducted in much the same way that many other week-long 4-H wildlife or conservation camps are conducted in other states. Since the population for this study involves alumni of this conference for nine years, it would be appropriate to describe the conference. The Tennessee 4-H Wildlife Conference was established to train two young people from each of Tennessee's counties each year. In order to be eligible to attend the conference, 4-H'ers must be 13–15 years old, must have shown an interest in wildlife, and must be approved to attend by their county

Extension agents. Each 4-H delegate may attend only one time, unless he/she is selected in future years as one of eight conference assistants. Each morning and early afternoon of the conference is highly structured, with educational classes in game management, fish management, reptiles and amphibians, wildlife ecology, predation, wildlife identification, hunting safety, wildlife management methods, wildlife photography, and taxidermy. Each class is one and one-half hours long and all delegates must attend. A study manual is provided at the beginning of the week, and an exam is given at the end of the week on subjects discussed. Instructors of these classes are professional wildlife biologists and educators, representing most of the state and federal agencies in Tennessee that deal in any way with wildlife conservation. During the afternoons, evenings, and early mornings, 4-H'ers have the option to attend any of several field trips and special high adventure activities, such as exploring a beaver pond, snake hunting at night, cave spelunking, live trapping, etc. The week is climaxed by recognizing high scorers on the examination with various awards, a wildlife quiz bowl (similar to the College Bowl) among high examination scorers, a large wildlife stew dinner, sponsor recognition, and a challenge softball game between delegates and instructors. These young 4-H'ers generally become intensely motivated, and during the week we encourage them to go back home and assist their adult leaders and Extension agents in organizing, conducting, and leading 4-H Wildlife Project groups.

Purposes of This Study

The purposes of this study were two-fold:

1. To measure, by retesting conference alumni, how much knowledge presented at the conference was retained and how long this knowledge is retained. An approximately equal number of alumni selected at random from each year's conference were retested; some had attended the conference as recently as one year before and some as long as nine years ago.
2. To compare conference alumni with the American public as to (a) their general wildlife knowledge and (b) their attitudes about wildlife. Data from this study were compared with results reported by Kellert and Berry (1980). The same questions were asked of the conference alumni that they asked a cross-section of the American public.

The hypothesis was that youngsters, ages 13–15, exposed to Extension 4-H wildlife education, and an intensive week of wildlife training and motivation, not only retain a significant amount of knowledge from this training, but also embark upon a new road of motivation for learning throughout the rest of their lives—one that will result in attitudes about wildlife different from the American public.

Methods

The population used in this study (alumni) were 1,519 men, women, boys and girls, 14–25 years old, who attended the Tennessee 4-H Wildlife Conference—all when 13–15 years old—from the years 1973 through 1981. During each of the annual state wildlife conferences, a comprehensive exam was given at the end of the week on wildlife and fisheries material provided in the formal classes. Each year's exam consisted of 50 multiple-choice questions with four choices; the exams were changed every year. During the 1982 and 1983 conferences, a pre-conference exam, consisting of 25 questions similar to, but not duplicate of, questions on the post-exam, was given at the beginning of the week. The study population was stratified by year of conference attendance, and an equal random sample was selected from the conference delegation each year (1973–1981). Questionnaires were mailed to these alumni with three sets of questions:

1. Thirty-three multiple-choice questions (four choices), which were common to all nine 4-H Wildlife Conference exams, were asked.
2. Twenty-seven true-false questions relating to general wildlife knowledge were asked. These questions were identical to those asked of a cross-section of the American public (Kellert and Berry 1980).
3. Seventeen attitude statements, with answers to be given on a scale from slightly agree to strongly disagree, were listed. These statements were identical to those used to determine the American public's attitudes about wildlife—ones the researchers listed to illustrate nine attitude and knowledge scales (Kellert and Berry 1980).

The age of 4-H Wildlife Conference alumni varied from approximately 14 through 25 years of age. Since the Kellert and Berry study involved people of all ages, only results from their respondents in the 18–25 age category (Kellert and Berry, pers. comm. 1984) were used for comparison in this study.

Results and Discussion

Percent Questionnaire Return

A total of 571 questionnaires were mailed to alumni and a total of 226 responded, giving a 39.6 percent return. A breakdown of number of respondents by year of conference attendance is given in Table 1.

Knowledge Retention

The Tennessee 4-H Wildlife Conference proved successful in increasing knowledge. Mean scores on post-conference exams were significantly different from pre-conference exams during the years 1982 and 1983. These differences reflected an increase in knowledge during the two conferences of 48 percent and 54 percent respectively (Figure 1).

The conference alumni retained a surprising amount of knowledge over the years. Knowledge retention was high, not only for recent alumni, but for alumni who attended

Table 1. Number of alumni responding to survey by yearof 4-H Wildlife Conference attendance.

Year attended conference	No. of alumni responding
1973	24
1974	24
1975	21
1976	31
1977	28
1978	27
1979	39
1980	24
1981	8
Total	226

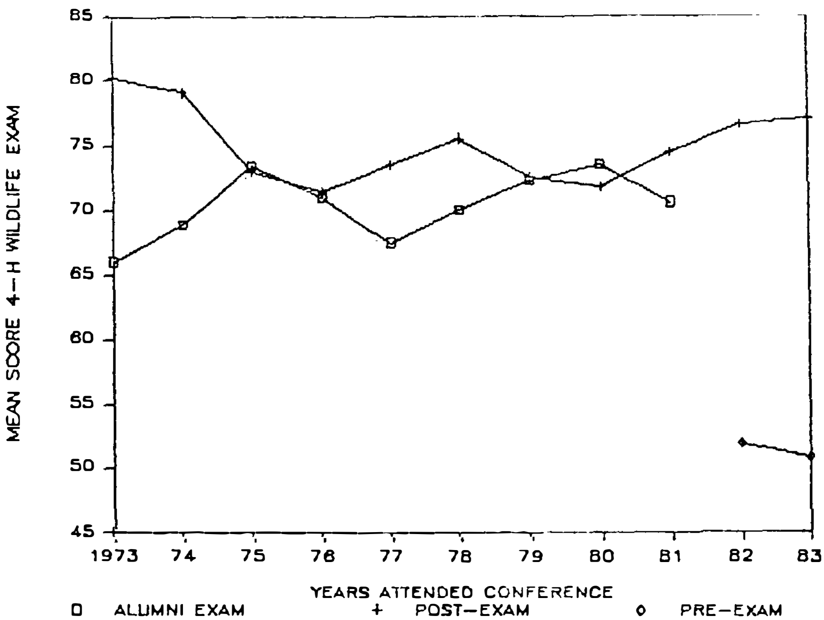

Figure 1. Mean scores of pre- and post-conference exams given during nine Tennessee 4-H Wildlife Conferences compared to mean scores of 1982 alumni exam, given to alumni of all conferences.

the conference as long ago as nine years (Figure 1). For all nine years, scores on the exam given at the close of each conference (post-conference exam) were very close to scores on the exam given in 1982 to alumni of all conferences (alumni exam). In fact, in four of nine (44 percent) of the alumni groups, alumni scores were as high or higher than post-conference exam scores—and half of these were alumni from conferences they attended six and seven years ago! These results demonstrate the effectiveness of the Tennessee 4-H Wildlife Conference as a teaching technique to teach wildlife concepts.

Comparison of Alumni With the American Public

In comparing alumni with the American public as to their general wildlife knowledge and attitudes about wildlife, it is important to consider similarities and differences between the two groups. Even though the American public population covered all ages 18 years and older, only the 18–25 year old group were used for comparison to the 14–25 year old alumni group in the study. So ages were comparable, even though some in the alumni group were younger. This slight age difference could give somewhat biased results, in that the younger members would not be as highly educated. Kellert and Berry (1980) found that educational level was the variable which had the highest correlation with general wildlife knowledge. This slight age difference should tend to depress alumni scores on general knowledge questions. As will be pointed out later, however, alumni scores, even in the younger age groups, were still higher than the American public scores.

Samples from both populations were taken at random—except in the case of alumni an equal number (also selected at random) were sampled from each year of conference attendance. Both the survey in this study and the survey of the American public were taken during the same general time period (early 1982 and late 1978, respectively). Thus, exposure to public education through television and other mass media should be about the same. Delegates to the annual Tennessee 4-H Wildlife Conference came from a complete cross-section of rural, suburban and urban backgrounds. And since the American public sample was also taken (by design) from a varied background, results should be comparable.

There is one important difference between the two groups that may have some bearing on the results. Most of the alumni before attending the 4-H Wildlife Conference were known to have an interest in wildlife, whereas the American public sample may or may not have had an interest in wildlife. However, even though most of the 4-H'ers before attending the conference were interested, pre-conference exam scores when compared with post-conference exam scores indicate they knew little about wildlife before attending the conference (Figure 1).

General Wildlife Knowledge

Alumni scored consistently higher than the American public on general wildlife knowledge questions (Figure 2). In fact, out of 27 questions, alumni scored higher on all except one, and on that one the American public scored only 0.1 percent higher. The mean difference between alumni and American public scores—on all 27 questions—was 18.2 percent. It is interesting to note that the relative difficulty of most questions was the same for both groups. For example, high scoring questions for the alumni were also high scoring questions for the American public—even though absolute scores were lower for the American public (Figure 2).

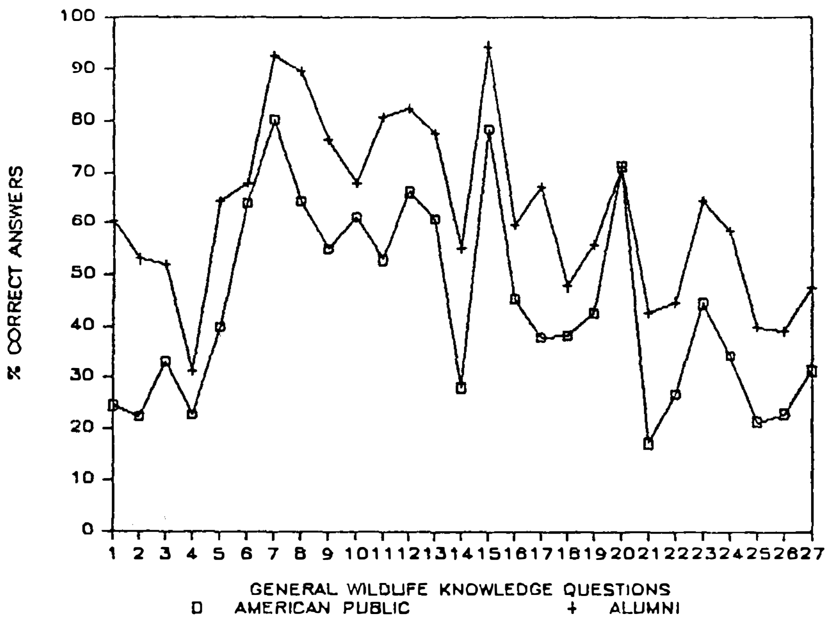

Figure 2. Percent correct answers to general wildlife knowledge questions—American public compared to Tennessee 4-H Wildlife Conference alumni.

The mean alumni score by year of conference attendance was 61.0. There was no significant difference when comparing alumni scores on general wildlife knowledge questions by year of conference attendance (Figure 3). Apparently any forgetting of concepts (not much according to similar scores on post-conference exam and alumni exam in Figure 1), may be offset by increased educational levels and other new learning experiences. It is felt that the wildlife conference stimulates a motivation for continued learning that may continue throughout life.

Attitudes About Wildlife

Differences of responses between alumni and the American public to 17 wildlife attitude statements ranged from 0 to 34.5 percent. Differences were calculated as follows (using the statement, "I would be afraid to touch a snake"): 48 percent of the American public agreed to this statement and 13.5 percent of the alumni agreed. By subtraction, there is a 34.5 percent difference. Looked at another way, 3.5 times as many of the American public ". . . would be afraid to touch a snake" as alumni. On over half of the attitude statements (9 out of 17), the two groups were very close (0 to 6.1 percent difference). These statements were:

1. I find insects fascinating.
2. I think love is an emotion which people should feel only for other people, not animals.
3. I have owned pets that were as dear to me as another person.
4. I see nothing wrong with using steel traps to capture wild animals.
5. Zoos should provide more natural conditions for their animals, even though this means much higher entrance fees.

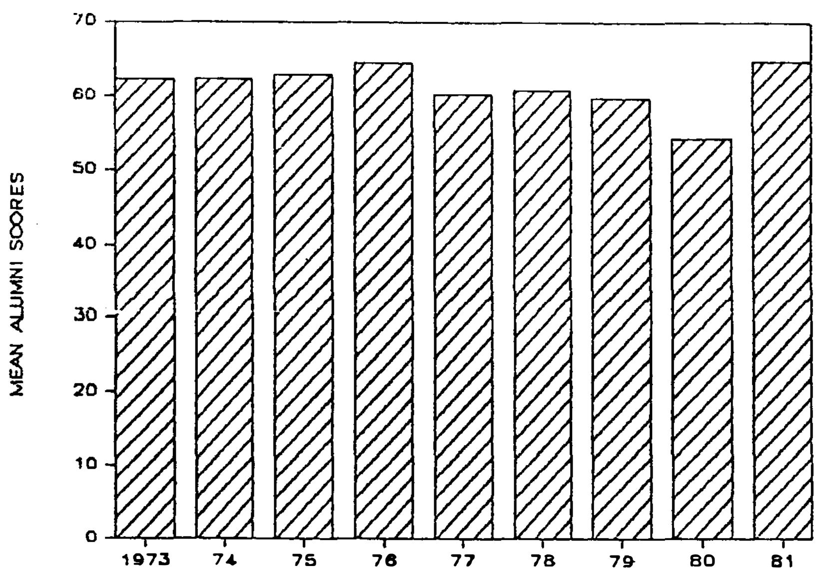

Figure 3. Mean scores of Tennessee 4-H Wildlife Conference alumni—by year of conference attendance—to general wildlife knowledge questions (Kellert and Berry 1980).

6. I have little desire to study vertebrate zoology or population genetics.
7. A dog trained at a task, like herding sheep, is generally a better dog than one owned just for companionship.
8. I admire a person who works hard to shoot a big trophy animal, like a 600# bear.
9. I think a person sometimes has to beat a horse or dog to get it to obey orders properly.

On the eight remaining attitude statements, the two groups disagreed considerably (15.2 percent to 34.5 percent difference). These statements, along with percentages of agreement for the two groups are presented in Table 2, with the magnitude of difference between the two groups arranged in descending order. It is interesting that in all eight cases, fewer alumni agreed with the statements than the American public. The following characterizations can be made from the results:

1. Fewer alumni are afraid to touch a snake.
2. Fewer alumni think rats and cockroaches should be eliminated.
3. Fewer alumni approve of building on marshes.
4. More alumni feel they know a little about ecosystems or wild animal population dynamics.
5. More alumni would prefer camping where wild animals can be found, as opposed to staying in a modern campground.

Table 2. A comparison of attitudes between Tennessee 4-H Wildlife Conference alumni and the American public on selected wildlife-related statements.

% Alumni who agree	% American public who agree	Difference in who agree	Attitude statement
13.5	48.0	34.5	I would be afraid to touch a snake.
48.6	72.1	23.5	I think rats and cockroaches should be eliminated.
13.0	36.1	23.1	I approve of building on marshes that ducks and other non-endangered wildlife use if the marshes are needed for housing development.
53.1	72.5	19.5	I know little about ecosystems or the population dynamics of wild animals.
27.8	45.9	18.1	If I were going camping, I would prefer staying in a modern campground than in an isolated area where there might be wild animals around.
40.5	58.6	18.1	I have little interest in learning about the taxonomic classification of animals.
46.8	64.7	17.9	I dislike most beetles and spiders.
36.0	51.2	15.2	I care more about the suffering of individual animals than I do about species population levels.

6. More alumni have a little interest in learning about the taxonomic classification of animals.
7. More alumni like most beetles and spiders.
8. Fewer alumni care more about the suffering of individual animals than about species population levels.

Using the attitude scales devised by Kellert and Berry (1980), the following comparisons can be made between the two groups. Alumni were: (1) *less* negativistic, (2) *less* utilitarian, (3) *more* ecologistic, (4) *more* naturalistic, and (5) *more* scientistic than the American public. Differences in attitudes between the two groups to *all* eight statements (Table 2) led to this conclusion.

They Remembered the Sponsor

Since the sponsorship of any 4-H wildlife educational program is vital to such a program, one of the questions we asked the alumni was, "who sponsored the conference you attended?" The Tennessee Wildlife Resources Agency has been the sponsor for scholarships to the conference every year of its existence, and 91 percent of the respondents remembered this.

The Payoff

The total operating cost (except salaries) for conducting the 1983 Tennesse 4-H Wildlife Conference was $6,618.50. Most of the salaries for instructors were contributed by cooperating agencies (U.S. Soil Conservation Service, Tennessee Valley Authority, Tennessee Wildlife Resources Agency). Dividing $6,618.50 among 189 4-H delegates who were trained gives an operating cost of $35.02 per 4-H'er. This is a small cost indeed, considering that we are making tomorrow's leaders aware of wildlife concepts and critical natural resource issues. A nationwide study conducted in 1981 of 4-H'ers and 4-H natural resource alumni (Byford 1981) revealed some interesting data. First, out of 142 people responding from 21 states, 86 percent of the ones employed *did not* have natural resource-related employment. Instead, 31 vocations were represented by the respondents; 14 percent were farmers and ranchers (highest category) and 9 percent were teachers (2nd highest). The rest included attorneys, doctors, college educators, engineers, a judge, a U.S. congressman, and 23 other vocations. When asked the subjective question, what their 4-H natural resources training meant *most* to them, 58 percent responded " . . . awareness, appreciation, and understanding of natural resources."

Not only are we training tomorrow's leaders, we are, as a result, training their parents and their adult volunteer 4-H leaders. (A youngster can motivate a parent to act much more effectively than an adult can.) Further, many of these young people go back to their home counties and become leaders of younger 4-H'ers, teaching them important concepts. In 1977, we conducted a survey of 577 former 4-H Wildlife Conference delegates from three conferences and found that 68 were responsible for forming new county 4-H wildlife clubs.

We think most professionals would agree that education is a vital key to minimizing America's increasingly complex natural resource/people conflicts. We must meet this challenge on all fronts. Adult education, primarily through mass media, is essential, but we must also plan ahead. In terms of cost effectiveness, youth education has much the greater payoff. Youth are easier to motivate and their minds are not yet cluttered with misinformation. Let us meet the challenge!

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Wildlife Population Viability: A Question of Risk

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Introduction

The requirement to manage National Forest System habitats to maintain viable populations of wildlife and fish (36 CFR 219.19) is a challenge to keep all the vertebrate parts of forest and rangeland ecosystems in good working order. It invokes a land ethic: that society conveys to all species a "right to continued existence, and, at least in spots, their continued existence in a natural state" (Leopold 1966:240).

It has been noted by many conservationists that this nation's national parks and wildlife refuges are too small and few in number to sustain populations of the largest vertebrates. Soulé (1980) and Schonewald-Cox et al. (1983) present good reviews on the subject. The prime importance of the viable population requirement is that it is now the clear policy of the United States that the full network of national forests and grasslands will be managed to augment parks and refuges as this country's Federal reserve system for wildlife and fish.

It has also been noted by leading conservationists that habitat protection alone is not likely to conserve the nation's full biotic diversity (Soulé 1980, Frankel 1983, Schonewald-Cox 1983). Maintenance of viable populations of all native vertebrates requires that resource managers actively plan and manage lands, habitats, populations, and human uses to minimize or mitigate the biological and environmental factors that can cause local extinction of forest wildlife and fish populations (Terborgh 1974, Frankel 1983). It calls for large doses of common sense application of experience, empirical knowledge, theoretical knowledge, and adaptive management.

No two species, populations, or management situations are identical. Hence, universally valid generalizations about minimum population sizes to meet the requirement are not possible (Frankel and Soulé 1981). Each case must be judged on its merits, and each case will be clouded with uncertainty. We always lack full knowledge of a species' biology, habitat needs, and population dynamics. We can never be certain that habitats will respond to treatments exactly as expected. And, of course, many events in nature are random and beyond our control. Add to this the fact that decisions about land uses continually change the face of the land and its wildlife communities.

Lack of knowledge or *laissez faire* conservation will not prevent these changes. To make prudent land use decisions regarding viable wildlife populations we must use existing knowledge and experience to convert uncertainty into actions designed to meet the goal.

Population viability is the likelihood (or probability) that a population will continue to exist in an area (Shaffer 1981); the converse is the probability of local extinction. Estimating the likelihood of losing a species from a particular area of land requires that biologists augment empirical knowledge on a species' response to environmental change with knowledge from ecological theories. In this case theories concerning species biology, population genetics, and biogeography are most relevant. Their use must be tempered by local knowledge and caution.

Inadequate empirical knowledge combined with a liberal application of theories could jeopardize a species' continued existence on a forest because too little habitat is provided. The conservative extreme could cause unnecessary costs in the loss of other resource values. The possible loss of spotted owls (*Strix occidentalis*) from a forest in Oregon and the timber opportunity costs of mature forest habitat protected for each pair of owls are examples of some risks and costs over a range of land use decisions (Heinrichs 1983). This kind of situation holds for many species with narrow habitat adaptability and whose habitats have a high value for other uses.

In this paper we discuss how the U.S. Forest Service interprets the requirement to maintain viable populations of all vertebrates on the national forests and grasslands. We review briefly the biological theories that are being used to plan habitat management to meet the requirement. The main purpose of the paper is to present a process for using empirical knowledge and ecological theories to plan and manage habitats, and to design a monitoring system that reflects the risk that alternative amounts and distributions of habitat will fail to provide for population viability of a given species. The process is illustrated by the case of spotted owls on the Willamette National Forest in Oregon.

Meaning and Intent of the Viable Population Requirement

The legal basis for maintaining viable vertebrate populations on national forests and grasslands derives ultimately from the Organic Administration Act of 1897 (16 U.S.C. 473), ". . . to protect and improve the forest within the boundaries." Recently, the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976 (16 U.S.C. 1601 (note)) clarified this intent, ". . . provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives . . ." (Sec. 6 (g) (3) (B)).

The specific goal for viable populations is presented in the regulations for planning pursuant to the National Forest Management Act (36 CFR 219.19), *"Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area."* The planning area can be a single national forest, or several forests being planned as a unit.

Viability of individual organisms is the likelihood of their survival to successfully reproduce (Hartl 1980, Chambers 1983). By extension, population viability is the likelihood of survival (continued existence) through sustained reproduction at or above a balance with deaths and emigration. This is consistent with Webster's dictionary meaning of the word viable: capable of living, growing, working or functioning, or existing and developing as an independent unit.

Viability implies that vertebrate populations shall continue to function naturally within national forest and grassland ecosystems. Maintenance of the habitat conditions to support viable populations, as part of the National Forest Management Act diversity goal, thus encompasses the recovery of threatened or endangered species populations and the maintenance of all other vertebrate populations above threatened status. The intent is simply to conserve the full vertebrate diversity of each national forest and grassland (Salwasser et al. 1984).

The Forest Service planning regulations give general guidance on providing habitats for population viability but leave the issues of exact population number and habitat distribution to regional and forest, species-specific resolution, (36 CFR 219.19) "*For planning purposes a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area.*"

Forest Service policy interprets well distributed as meaning, ". . . throughout its existing range in the planning area."[1] The Secretary of Agriculture's Policy on Fish and Wildlife also supports this interpretation, ". . . to ensure the continued existence of a species throughout its geographical range."[2] The implication is that forest managers will not purposefully cause erosion of a species' range through either loss of habitats at the fringes or creation of large tracts of unoccupied lands on otherwise suitable areas within the range. The 36 CFR 219.19 requirement and these two policies together ensure a permanent role for national forests and grasslands in the nation's nature reserve system.

Review of Population Viability Concepts

Population Extinction Factors

Factors that can cause extinction in vertebrate populations have been reviewed by Hester (1967), Ziswiler (1967), Terborgh and Winter (1980), Frankel and Soulé (1981), and Soulé (1983). Their conclusions are that currently natural competition, predation, parasitism, and disease are rarely actual agents of extinction. Factors resulting from man's actions, including isolation of populations and habitat alteration, are ultimately more significant.

When man is a direct agent of extinction, e.g., grizzly bear (*Ursus arctos*) and wolf (*Canis lupus*) the cause and rate of effects can be identified and corrected. It is man's indirect effects, through population isolation and habitat alteration (a form of competition for resources), that hold the greatest danger for most species (Terborgh 1974, Soulé 1980, 1983). It is more difficult in these cases to know how and at what rate we are affecting population viability.

Several things are certain about the factors that can lead to local extinction of wild populations. Man dramatically changes the natural patterns of habitats through land use decisions. This often isolates wildlife and fish populations. And man alters the habitats within a particular land use situation. This often fragments and reduces the populations of some species. It is not likely that either of these effects will decline.

Isolation and reduction of populations make two categories of extinction factors important to resource managers (Terborgh 1974, Shaffer 1981, Soulé 1983; Table 1): (1) internal

[1]USDA Forest Service Memorandum 1920/2620: (J.B. Hilmon) Feb. 24, 1982.
[2]USDA Secretary's Memorandum 9500-3: Policy on Fish and Wildlife (J.R. Block) July 20, 1982.

factors that affect small populations—random demographic events, social or behavioral dysfunction, and genetic drift and inbreeding; and (2) external factors that can extirpate small or isolated populations—chronic environmental factors such as predation, habitat change, and competition, and acute or catastrophic environmental events such as fire, drought, and floods. The geographic structure of a population and time are the important criteria in determining the likelihood of continued existence in the face of these factors.

Geographic Structure of Populations

For planning purposes, all the individuals of the same species that occupy a national forest or grassland at a particular time are considered to be the forest population. This is consistent with delimiting wild populations for resource management purposes (Caughley 1977). Usually, all the individuals in a forest population are capable of interbreeding—that is, no biological or geographical barriers exist. Exceptions to this might occur for small animals with limited dispersal abilities. A fully interbreeding forest population is also a biological population as described by Wilson (1975).

There is considerable variety in the geographic structure of wildlife populations (Figure 1). The extremes are isolated local populations, on the one hand, and a continuous distribution of individuals over a wide area, on the other. In some cases a forest population may be composed of several local interbreeding populations. Levins (1970) refers to a biological population that is composed of fragmented local populations that have periodic interchange among them as *metapopulations.*

A well distributed population is mandated by planning regulations. But many situations will confront the manager. Past land uses or nature will force some managers to start with isolates, or nothing, as is the case with grizzlies and wolves on many forests. The important planning issue is how the expected population distribution and number under alternative land uses might affect the risk of losing the species from the national forest.

Population Number: Resilience, Fitness, and Adaptability

Shaffer (1981) has aptly made the case that population viability is a probability issue. With high numbers and widespread distribution the probability (risk) of extinction is low. It increases as numbers drop or isolation occurs.

Demographic changes, social dysfunction, and genetic factors principally affect viability in relation to population size, sex ratio, and age structure dynamics in isolated or small populations. Environmental factors affect existence in relation to the degree to which they reduce population numbers or isolate local populations. Each land use decision, in that its expected habitat patterns and amounts provide for different population numbers

Table 1. Factors that can cause the extinction of local populations.

1. Factors internal to the population
    —Random demographic changes
    —Social or behavioral dysfunction
    —Genetic drift and inbreeding
2. Factors external to the population
    —Chronic environmental factors, e.g., predation, habitat change, competition, disease
    —Acute, catastrophic environmental factors, e.g., floods, fire, windthrow.

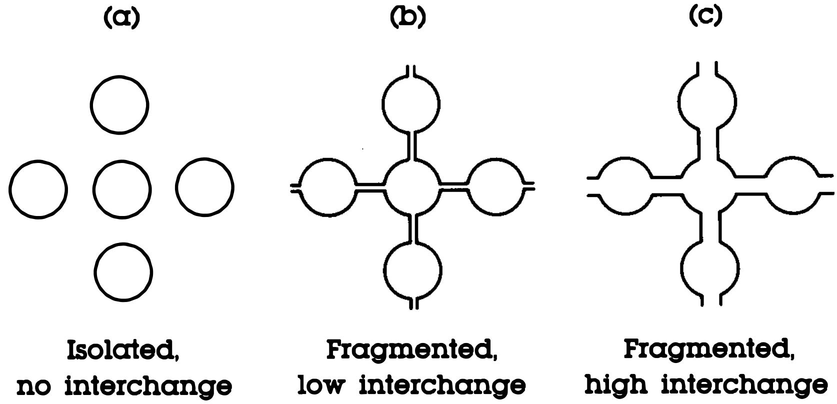

Figure 1. Barriers to interbreeding can fragment a forest population into local populations. Each local population is composed of potentially interbreeding reproductive or social units. The amount of interchange between local populations varies. It is represented here by different "widths" of the connections between the units (after Hartl 1980).

and geographic distributions, provides different likelihoods for the continued existence of a given population.

The concepts of population resilience, fitness, and adaptability are useful in assessing the likelihood of continued existence. Resilience refers to the short-term ability of a population to survive in the face of normal, random birth and death events. Resilience may be provided by relatively few adults—May's (1973) theoretical treatment suggests perhaps as few as 10 adults of each sex, though Shaffer (pers. comm.) believes 40 to 50 total adults would be needed to ensure resilience for at least several decades for many species. In real populations the minimum number that provides resilience would depend on the social system, reproductive potential, and generation length of the species (May 1973), and the nature of random environmental events (Shaffer 1981).

Fitness refers to short-term and medium-term survivability of a population—decades (Soulé 1980). It implies a population number that sustains sufficient genetic variation that the individuals in the population can maintain normal fecundity and viability (Chambers 1983).

Adaptability provides for survival over the long-term—centuries (Soulé 1980). The genetic variability of a very large population allows for continual adjustment to environmental change; evolution over very long periods. A well distributed population with adaptability should be resilient to normal fluctuations in births and deaths and maintain full fecundity and survivability for the species.

The emphasis in national forest habitat planning and management is on a habitat distribution that (1) precludes isolation of local populations, and (2) supports a population number that maintains at least resilience at the forest population level and adaptability at the species level. For many species with small to moderate sized home ranges the forest population may possess adaptability in its own right.

Populations at high numbers and a continuous distribution over the network of national forests and other lands are considered to have a high likelihood of continued existence throughout their distribution. If the numbers or distribution are expected to decline under alternative land uses, the risk of extinction on a particular forest would increase. At the extreme of very low population number or a high degree of isolation, genetic and demographic factors would become important determinants of viability.

Population Genetics

Genetic variation is the key to fitness (Soulé 1980). Populations lose genetic variation through random change in gene frequencies caused by sampling of gametes in reproduction (Kimura 1983). They gain genetic variation through the addition of new alleles (mutant gene substitution). The rate of drift exceeds substitution in proportion to the number of individuals engaged in reproduction; at low numbers drift rapidly reduces variation. The net result of genetic drift in a small population is an increasing likelihood of extinction caused by (1) inbreeding depression—loss of fecundity and survivability often caused by fixation of deleterious genes, and (2) reduced genetic variability that can result in loss of adaptability to environmental changes.

The principal factors useful in assessing the risk of extinction due to genetic changes are time and effective population number. The fewer adults that pass genes to future generations, the faster random sampling will cause a critical loss of genetic variation and fixation of some genes. Theoretically, at some large number of adults, the random loss of genetic variation can be offset by mutant gene substitution, which contributes new alleles.

The concept of effective population number, N_e, is used by geneticists to represent the fact that few real populations meet the criteria for a genetically ideal population (Wright 1931, 1938, Kimura and Crow 1963, Hill 1979, Hartl 1980, Kimura 1983). N_e is usually less than the actual number of adults because of the effects of: unequal sex ratio, variance in survival of offspring to reproductive age, fluctuation in population size over time, and overlapping generations (Kimura 1983). Formulae for estimating the effects of these demographic parameters on N_e are presented in Franklin (1980), Hartl (1980), Frankel and Soulé (1981), Kimura (1983), and Thomas and Ballou (1983). Unfortunately, several of the formulae use variables for which data on wild populations are not readily available. It is, no doubt, for this reason that Soulé (1980) cautioned biologists to use population genetics in viability analyses as "rules-of-thumb" rather than precise relationships.

In this light, Franklin (1980) and Soulé (1980) suggested that an N_e of 500 or more may approach the balance point between random loss and addition of genetic variation. Consequently, they proposed the effective population number of 500 as the minimum threshold size for a biological population to maintain long-term adaptability. They considered an effective number of 50 to be a minimum threshold for local population fitness, i.e., survival given the effects of inbreeding over the short-term (several decades). These threshold numbers are only starting points for assessing viability. In actual application the life history and structure of different populations will cause the threshold numbers to be variable.

Empirical data on the actual effects of inbreeding in small populations of normally free-ranging mammals are unequivocal. They show that inbreeding in a normally outbred species correlates with reduced fecundity and viability of offspring (Ralls et al. 1979, Ralls and Ballou 1982, 1983). Free-ranging populations normally employ behavioral and ecological strategies that keep natural inbreeding at very low levels.

Soulé (1980) proposed that the cumulative inbreeding coefficient, F_t, can be used as an indicator of the likelihood that loss of genetic variation endangers a population. He further proposed that an inbreeding coefficient of 0.50 would be a probable point of extinction in wild populations due to genetic factors. Extinction can, and probably will, occur at lower or higher coefficients in some populations.

The formula for estimating the inbreeding coefficient of a small reproductively isolated population of vertebrates at some point in time is:

$$F_t = 1-(1-1/2N_e+0.5))^t \quad (1)$$

(Hartl 1980), where F_t is the inbreeding coefficient in generation t, t is the number of generations from time 0, and N_e is the effective population number during the time period being assessed. Formula 1 does not consider the mitigating effects of mutant gene subsititution or migration between demes in large populations. Figure 2 illustrates how F_t would increase over time at different effective population numbers.

Relatively few local populations of wide-ranging species are fully and permanently isolated. Periodically, individuals migrate between local populations. When this occurs, assuming that the individuals successfully reproduce, alleles from the immigrants are added to the receiving populations. Migration (in the sense used by population geneticists) can have a powerful effect on maintaining genetic variation and reducing the effects of inbreeding and drift in local populations that are not completely isolated (Figure 3) (Hartl 1980, Kimura 1983). A basic strategy of habitat management emerges: keep the biological population as large as possible (preferrably over 1,000 adults on the average), and maintain a distribution of resilient local populations so that periodic migration occurs between them.

Levels of Protection Based on Population Number and Distribution

If a wildlife or fish population on a national forest or grassland is not isolated from other populations of the species, or isolation is a temporary situation (several generations

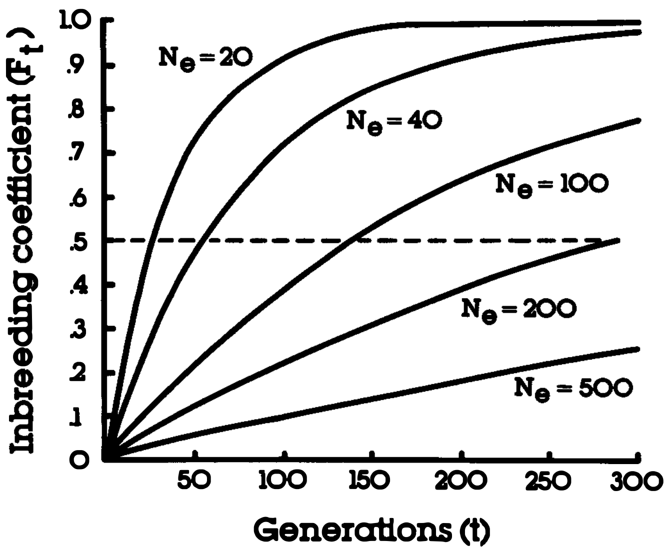

Figure 2. Inbreeding increases as a function of effective population number, N_e, and the number of generations. At low N_e the inbreeding coefficient, F_t, rapidly approaches the 0.50 probable extinction point (after Hartl 1980).

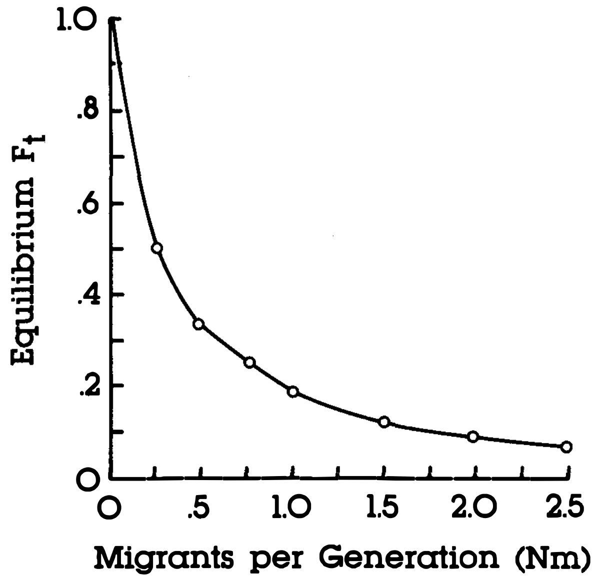

Figure 3. Equilibrium inbreeding coefficients under different rates of immigration.

only), the effective number of the forest population is that of the entire interbreeding population—on-forest as well as off-forest (Kimura 1983). Further, if planned habitats are likely to maintain continuity with off-forest populations throughout the period during which the plan is in use, the likelihood of continued existence on the forest will depend on how local environmental factors affect population number, *N*. This assumes, of course, that the larger biological population has a high N_e, perhaps greater than the 500 threshold that Franklin (1980) and Soulé (1980) originally proposed.

Some species, especially threatened or endangered species, with small total populations will require a regional or total range determination of the N_e that should be maintained by the sum of all local populations. Each national forest in such a case would be assigned responsibility for some portion of the species' total N_e.

Relationships between habitat amounts and distributions as they affect population number, resilience, fitness, and adaptability support the notion of a population viability gradient (Table 2, adapted from Schonewald-Cox 1983). Protection levels 1 and 2 would be the extreme conditions of the last remaining individuals of a species in captivity, or isolated individuals at the margin of the species' geographic range (or limits of ecological adaptability). Levels 1 and 2 are extremely high risk situations for maintaining the continued existence of a species on an area.

Protection levels 3 and 4 are only slightly better than 1 and 2 in meeting a viability goal. They would provide only resilience in an isolated local population, that is short-term protection from normal, random birth and death events. Protection levels 1 through 3 are not considered to be sufficient to meet the population viability goal for species on national forests or grasslands in the main part of their geographic range. Level 4 protection should be considered as marginal protection, and allowable only in extreme cases.

Table 2. A hierarchy of population viability levels for use in national forest and grassland resource management planning (adapted from Schonewald-Cox (1983)).

Protection level	Viability of the population	Habitat amount and pattern capable of supporting:
1	Individual viability; few years to a decade	1 to several individuals isolated on the Forest
2	Individual viability; up to several decades	Isolated family, social group, or very small population on the Forest; $N<50$
3	Short-term population viability; several decades depending on N	Several social or reproductive units isolated on the Forest, but with the ability to interchange; $N>50$, but $N_e<50$
4	Short-term population viability; 5–10 decades depending on N_e	A small, but well distributed isolated population on the Forest; $50<N_e<100$
5	Legislated protection of the species; viability depends on population number and distribution	A legally determined number deemed necessary for "recovery"
6	Mid-range population viability; 100 years or more depending on N_e	A medium sized, well distributed Forest pop. ($50<N<100$) in a large interbreeding population ($N_e<500$)
7	Long-term population viability; probably greater than 150 years depending on N_e	A large, well distributed Forest population ($N>100$) in a large interbreeding population ($N_e>500$)
8	Long-term population viability; probably longer than several centuries	A very large, well distributed Forest population ($N<500$) in a very large interbreeding population ($N_e \gg 500$) whose local demes could diverge genetically
9	Long-term population viability; probably on the order of millenia	Several very large local populations ($N>$ 500 each) on the Forest in a very large interbreeding population ($N_e \gg 500$) whose local demes could diverge genetically

$<$ means less than
$>$ means greater than
$\gg$ means an order of magnitude greater than

Protection level 6 is the minimum necessary in most cases for national forest and grassland vertebrates. It provides resilience and fitness in the forest population, and probably a high likelihood of continued existence for 100 years or more. Level 7, habitat to support a moderately large local population as part of a very large biological population, would provide adaptability, long-term survival well beyond the 150 year sustained yield projection period being used in national forest planning. Levels 8 and 9 would both ensure continued existence with something on the order of Shaffer's (1981) original proposal of 99 percent certainty for 1,000 years of continued existence. Levels 8 and 9 are, in fact, what is provided for most North American vertebrates by the network of national parks, national forests, wildlife refuges, and private and other public lands put together.

A Procedure for Viable Population Planning and Risk Analysis

The viable population issues to be resolved in forest planning are clear. We must provide an acceptably low risk of species loss from a forest by assuring a sufficient number of breeding adults and an appropriate distribution of suitable habitats. The requirement applies to all vertebrates. A typical national forest has more than 300 vertebrate species, only a few of which might be in danger of extinction at the forest level. Therefore, planners need a process that combines factual knowledge with appropriate theories and concepts, to focus on the species of highest concern. The process begins with a statement of underlying assumptions.

Assumptions

1. In this round of planning only relatively rare or declining species with the largest home ranges and with special requirements for rare or transient habitats will be selected for viability analysis. Habitats provided for such species will also provide for other species associated with the habitats. All other vertebrates will be supported well above minimum levels by the habitat diversity that results from natural conditions and the planned mix of land uses.
2. A well distributed population, i.e., a network of reproductive or social units, each located within the species' normal dispersal abilities of one another, will (1) keep the risk of extinction due to local environmental and catastrophic factors at an acceptably low level, and (2) maintain the forest population as part of a larger biological population.
3. The risk of extinction due to man's predation and competition is kept acceptably low by establishing and enforcing necessary laws, regulations, and policies.
4. Monitoring activities will be inversely proportional to the level of protection provided each vertebrate population. Land-use decisions that provide lower levels of protection (e.g., levels 3, 4, 5, or 6) will include higher investments in monitoring to alert managers to the need to amend management activities.
5. General monitoring and future research will test the validity of these assumptions in order to correct errors for the next round of planning (about 10 to 15 years from now).

The first 4 of the 6 planning steps (Figure 4) are designed to maintain a well distributed population at sufficient numbers. Step 5 is the risk analysis of local population extinction. Step 6 is design of the monitoring system. The process begins by selecting the species of concern.

Step I. Species Selection

Criteria for selecting species for viability concern could include a forest population of less than 100 adults, a total species population N_e of less than 500, fragmented distribution into small local populations, or the expectation that man or nature could cause these to occur in the foreseeable future. The number and distribution criteria used in this step should be established by State and Federal biologists responsible for the species' conservation. Obviously, threatened or endangered species should be high priorities for concern. Most common game and nongame species will not be a viability concern, although they may be management indicators for other reasons. The product of this step is the subset of management indicator species selected because viability of their populations is a current issue.

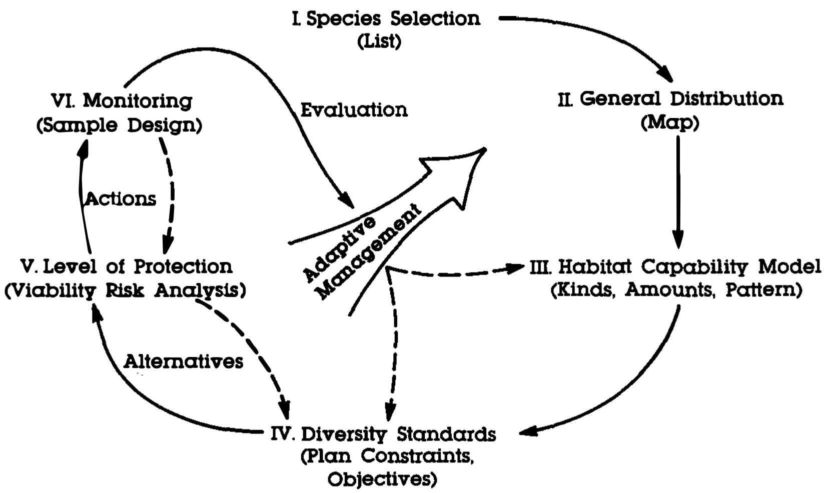

Figure 4. The 6 step process for planning and analyzing viable populations. The process is iterative, as indicated by the information feedback arrows from Steps V and VI to Steps IV and V. Through time knowledge gained from research and management experience should make the process more reliable.

As an example, the criteria that led to selecting spotted owls on the Willamette National Forest in Oregon were:

1. An inventoried population of 150 pairs on the forest (probably not sufficient, in itself, for immediate concern),
2. Evidence of dependency on rare, mature and old growth forest stands (Forsman et al. 1984), and
3. The expectation that timber management actions could further reduce and isolate suitable habitats for the owls on the forest (this is the major reason for selection).

The spotted owl is also a Forest Service regional issue because most forests along the Cascade Range have a similar management situation. An interagency agreement was made to maintain 500 breeding pairs on State and Federal lands in Oregon and Washington. Each national forest population will be a part of that total.

Step II. Map General Population Distribution

The second step is to delimit the general area on each forest within which the suitable habitats will be well distributed. This does not imply that occurrence must be maintained on every existing site within the area. Nature does not permanently maintain occurrence on all sites, and neither can man. The product of Step II is a map of the existing and/or potential geographic range for each species of concern on the forest (Figure 5).

Step III. Document Species' Habitat Needs and Distribution Pattern

The purposes of Step III are to (1) identify the functional unit of the population, i.e, the social or reproductive unit through which individual survival and reproductive success are maintained, (2) specify the habitat conditions needed to support each functional unit,

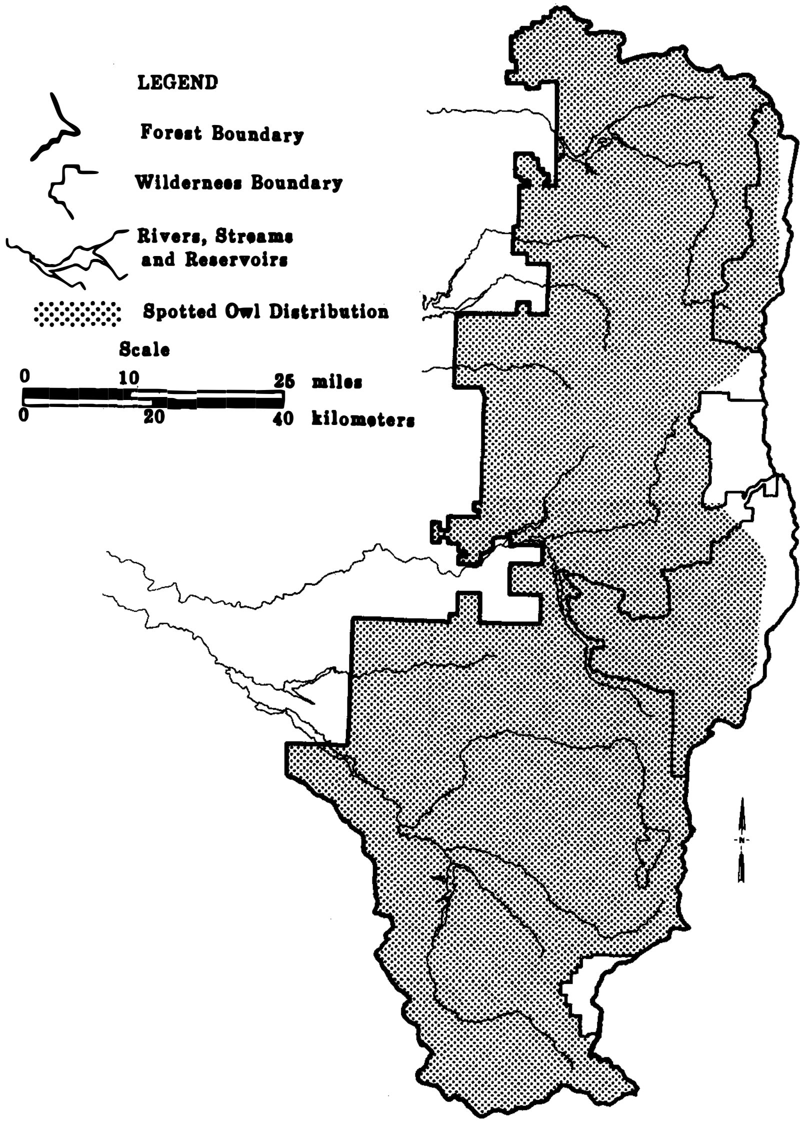

Figure 5. The general population distribution of spotted owls on the Willamette National Forest.

and (3) identify the pattern of such habitats that ensures a well distributed population in which all the individuals have the ability to interact.

The key concern in documenting a species' habitat needs is identification of the range of conditions over which survival and successful reproduction can occur. The key concerns in developing the general habitat distribution pattern are to prevent extirpation from large areas of the current range, and minimize the possibility that loss of habitat patches from the pattern could cause permanent isolation of local populations.

In a linear distribution of habitats the loss of several habitats along the line could isolate local populations. A pattern based on habitats with three to four connections to other habitats, i.e., a hexagonal or grid pattern, would require loss of at least three to four adjacent habitats to isolate local populations. The prudent strategy, therefore, would avoid linear patterns and keep habitats sufficiently close that loss of several patches does not cause permanent isolation.

For the spotted owl in the Pacific Northwest, a breeding pair is the functional unit upon which habitat needs are based. Suitable "pair habitat" is considered to be 300 contiguous acres (120 ha) of mature to old-growth forest with a crown closure of 70 percent or more, and 700 additional similar acres (280 ha) within 1.5 miles (2.4 km) of the nest site (Forsman et al. 1984). Optimum habitat would be areas with more than 1,000 acres (405 ha) possessing the above vegetative characteristics within a 1.5 mile radius of the nest site.

To maintain interchange between members of the population, and a high likelihood that suitable habitats will be continuously occupied, each habitat should, at the minimum, be located within the normal dispersal distance for the species. This is considered to be 1 to 3 miles (1.6 to 4.8 km) for sets of up to 3 "pair habitats" and 6 to 12 miles (9 to 19 km) between the 3 pair sets (U.S. Forest Service Region 6 Planning Requirements). At the extreme a dispersing owl should be able to find suitable pair habitat within 12 miles of its origin. On average that would limit areas devoid of pair habitat on capable lands to no larger than 72,000 acres (30 000 ha). All distances are measured from the centers of suitable habitats.

Step IV. Translate Habitat Needs into Diversity Standards

Step IV is the conversion of habitat conditions described in Step III into variables and standards that can be used in the integrated forest planning process. Examples of planning standards are minimum stand areas, snag densities, and percent of each watershed in mature stands.

The goal of this step is to ensure that habitat needs will be effectively represented in the planning analysis so that all management alternatives ensure continued existence of the population. This does not imply that unilaterally developed standards for viable populations would constrain all alternatives. In fitting the habitat standards to a real land base, and its existing conditions and other resource uses, there will be adjustments in both the standards and the needs of other resources. Alternative habitat distributions and numbers of adults that can be supported will result from those adjustments. These will, of course, have differing implications for population viability.

Several habitat management options are being considered for spotted owls on the Willamette National Forest; preservation (no timber harvest activities) on 1,000 acres (405 ha); preservation of 300 acres (120 ha) with stand management on 700 acres (280 ha); and stand management on the entire 1,000 acres. Each habitat management option results in slightly different planning variables, such as minimum stand areas, different rotation lengths for managed stands, or no-harvest options for unmanaged stands. The option that preserves 1,000 acres is outlined in Table 3.

Step V. Viability Risk Analysis: Level of Protection Provided

Three sub-steps are used to assess the risk of local species extinction with each management alternative (1) estimate species habitat capability, *N*, on the forest, (2) estimate

Table 3. Planning standards and variables under consideration by the Willamette National Forest to ensure spotted owl habitat distribution and population viability.

Option: Dedication of 1,000 acres[a]

Dedicate minimum stand area of 1,000 acres containing characteristics of suitable habitat for each spotted owl pair to be maintained.

Locate site-specific areas ("occupied habitat") for each pair within distances specified by the distribution model.

Dedicated areas selected to receive a FORPLAN[b] prescription of a single "no-harvest" option during the 15 decade planning horizon.

[a] This option makes areas planned for spotted owls unavailable for timber harvest. Location of the areas is site-specific to ensure continuous distribution. Total "unavailable" acres would vary according to the number of pairs planned by an alternative: i.e., 98 pairs = 98,000 acres; 75 pairs = 75,000 acres.
[b] FORPLAN is the linear programming optimization model used to assess the feasibility of management alternatives.

the effective population number, N_e, and (3) assess the likelihood of continued existence based on the level of protection (Table 2) provided by the alternative.

Sub-step 1: Habitat Capability (N)

Habitat capability is a function of the amount of suitable habitat and the number of adults that it can support, estimated for the current situation and for each alternative. The current situation on the Willamette National Forest is a known population of 150 or more pairs. One alternative being considered uses a Regionally-assigned number of 98 pairs of owls located on the forest according to a preexisting spotted owl inventory.

Location of the 98 pairs in known occupied habitats results in a grid pattern of habitats with average interpatch distances of less than 6 miles (9 km) (Figure 6). Another alternative that uses the 6–12 mile (9–19 km) dispersal distance guideline and the existing spotted owl inventory, results in 75 pairs. Both alternatives take into account the possibility of unplanned habitat losses, but each supports a different number of adults.

It would take at least two decades to harvest enough old-growth forest habitat to reduce the existing 150 pairs to either the 98 or 75 pair levels. The forest thus has a minimum starting N of 300 in the mid-1980s, and possible N's of 196 or 150 by the year 2000.

Sub-step 2: Effective Population Number (N_e)

In both examples here, the forest population is continuous with spotted owls on other lands. The assignment of 98 pairs to the forest was part of the regional (Oregon plus Washington) minimum population of 500 pairs. We will assume that the alternative for 75 pairs on the forest could reduce the regional population to 477 pairs (of course this depends on what happens on other lands). If none of the Willamette pairs is permanently isolated from the Regional population the eventual forest N_e must be based on the planned biological population of 1,000 (or possibly 954). In reality, this analysis should consider the total net effect of expected land-use patterns on all habitats within the spotted owl range.

To estimate the N_e of the biological population we assumed that the net effects of population parameters are as originally proposed by Wright (1931, 1938), and more recently by Franklin (1980) and Frankel and Soulé (1981). Adult sex ratio in spotted owls is assumed to be 1:1. It would have no effect on N_e. Variance in the number of offspring surviving per parent is assumed to be moderately high at 4.0 (inferred from

Crowe and Morton 1955, though no empirical data exist for this). This would cause N_e to be only 66 percent of N. The extreme of population fluctuation from mean habitat capability is predicted to be −50 percent on a frequency of 50 times during a 250 year period. Assuming it would take 3 years for the owl population to recover from a decline, N_e would only be 76 percent of N.

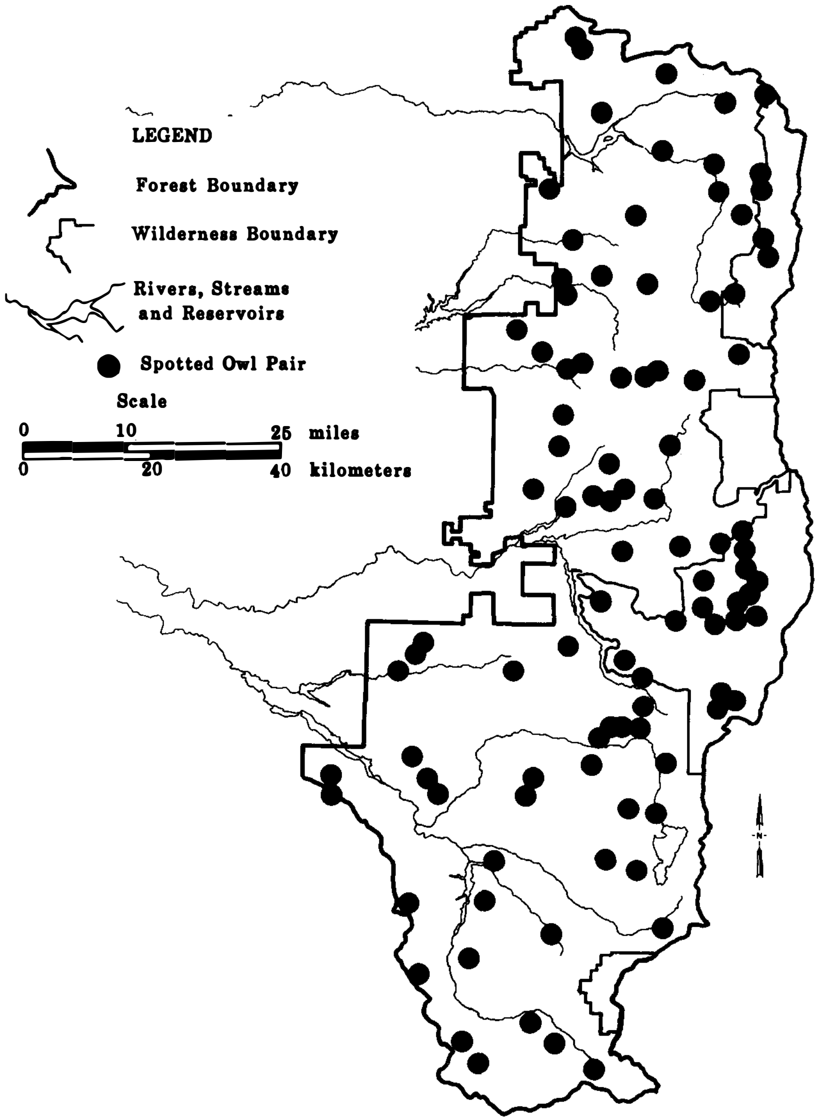

Figure 6. The expected distribution of spotted owl habitats on the Willamette National Forest under a 98 pair alternative. Weak points in a habitat distribution pattern would be where a few adjacent habitats are critical for the whole habitat network; there do not appear to be such weak points in the planned pattern.

The cumulative effect of population parameters on N_e is assumed to be multiplicative, giving a total N to N_e coefficient of 0.50. A worksheet describing this analysis is available from the senior author. Therefore, the initial N_e that applies to the owls on the Willamette National Forest is at least 500 based on a minimum Regional population of 1,000 owls (1,000×0.50). It may well be 50 to 100 percent larger than that currently.

If the regional population is reduced to 500 pairs by the year 2000, and the Willamette part of it to 98 pairs, the effective number would in fact drop to 500. An alternative for 75 pairs on the Willamette, if it maintained a continuous distribution but dropped the regional population to 477 pairs, would have an effective number of 477. It is important to keep in mind that the actual N_e at a particular point in time should be based on total population estimates. The spotted owl also exists in Canada and California. If those owls are part of the total interbreeding, biological population N_e could be even larger than estimated here.

In this example, the predicted effective numbers of 500 and 477 would not occur until some time after the year 2000. Therefore, the analysis in the next sub-step projects extinction risks from that time forward, not from 1984.

Sub-Step 3: Level of Protection Provided

It is not expected that permanent isolation of spotted owls will occur on the Willamette National Forest. Therefore, based on the expected forest and regional numbers and habitat distribution, at least Level 6 (mid-range viability), and possibly Level 7 (long-term viability) protection is provided.

An effective population of 500 or 477 from the year 2000 on along the Cascades in Oregon and Washington would both have an inbreeding coefficient of approximately 0.02 (rounded to 2 decimal places) by the year 2050. This assumes that 500 pairs is the entire population and planned numbers and distribution are maintained. A 3-year generation time is also assumed (Forsman pers. comm.). The inbreeding coefficient for both population numbers is very low.

Both alternatives for spotted owls on the Willamette National Forest, because of the regional population number and distribution, have a very low risk of genetic problems occurring. The alternative for 75 pairs does reduce habitat distribution from the alternative for 98 pairs, but both appear to maintain enough adults that the forest population should have demographic resilience, and a high likelihood of genetic interchange with off-forest owls.

If analysis of the proposed habitat distribution for an alternative, or the current situation, indicates a high likelihood of isolation of local populations, sub-steps 1 through 3 of Step V should be repeated for each potential isolated local population. The important task in this analysis is to assess the likelihood that planned or unplanned events will eliminate adjacent habitats at the weakest points in the distribution pattern.

Step VI. Act, Monitor, Adapt

The final step in the planning process is to implement a monitoring system. Monitoring is the key to adaptive management. It can be viewed as the "price" we pay for flexibility in developing lands and waters. Monitoring should reflect the risks (level of protection) and costs of the management actions to be taken, and the significance of key planning assumptions (Salwasser et al. 1983). The risk of population extinction increases as the level of protection declines. Costs can be foregone opportunities for other resources or mitigation investments. What to measure, how often, and how reliably depends on the risks and costs (Jameson 1981). Key assumptions in spotted owl planning are dispersal ability and the degree of dependency on large patches of old growth forest for reproductive success. They are currently being tested through research.

Because owl habitats have large opportunity values for timber management, monitoring of any alternative should include testing the assumption of dependency on old-growth habitats. The alternative for 75 pairs slightly increased the risk of isolation in comparison with the alternative for 98 pairs. Monitoring an alternative with higher isolation possibilities should focus on potential weak spots in the habitat pattern and on the species' dispersal ability. Because it is possible that the total number of spotted owls could eventually (perhaps in 30 to 50 years) be reduced to levels at which inbreeding could become significant in local populations, research should begin to examine empirical evidence for inbreeding effects in small populations of raptors.

Summary

Maintaining viable populations of wildlife and fish on the national forests and grasslands draws upon knowledge, assumptions, judgements, and theories. Some of the information needed for planning is "hard", e.g., general population distribution. Other information can be quite soft, e.g., the relationship between genetic variation, fitness, and continued existence. The planning process described applies knowledge and theories to shed light on a complex problem. It emphasizes the use of factual information to develop a land use plan, and of theories and concepts to assess the level of protection provided by the plan.

When judgement or theory dominate planning for a viable population, the plan should be considered as an hypothesis. Monitoring is the process of testing management hypotheses. We believe the process described is responsive to the "save all the parts" aspect of a land ethic, yet provides considerable management flexibility to meet other resource goals. It will not work without a full commitment to monitor the effects of management actions and adapt management to future knowledge, goals, and environments.

We are not hesitant to use theories and quantification of genetic effects in assessing the likelihood of continued existence for any species. However, scientists and managers are just beginning to understand the most important determinants of population viability. This whole business most certainly needs further refinement and testing.

Acknowledgements

Contributions to this paper have come from many people. Michael Soulé's lucid writings on conservation biology prompted the approach described. E. Forsman, R. Canutt, D. Carrier, and J. Hurley worked out the basic method for specifying suitable habitats and distribution (Step III). J.W. Thomas showed how to use the species habitat niche to represent resource needs in a practical way (Step III and IV). K. Siderits and R. Radtke pioneered the use of diversity standards to provide for the habitat needs of all wildlife (Step IV). J. Lehmkuhl, E. Harshman, and D. Jerry tested the application of population theories to determining the number of individuals needed (Step V). M. Soulé, D. Goodman, M. Gilpin, J. Brown, L. Joyce, T. Hoekstra, M. Shaffer, C. Flather, R. Holthausen, B. Burbridge, B. Gilbert, C. Phillips, M. Beckstead, T. Burke, and P. Brouha assisted in workshops, brainstorming, and the process of developing the planning strategy. Critical review of this paper by R. Canutt, M. Gilpin, F. Samson, M. Shaffer, M. Soulé, and J. Verner is much appreciated.

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Managing Forested Lands for Wildlife in Colorado

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Introduction

A major project between the USDA Forest Service, Rocky Mountain Region, and the Colorado Division of Wildlife has been completed (Colorado Division of Wildlife. In press). The System: Managing Forested Lands for Wildlife, will greatly benefit wildlife and fish management in Colorado and surrounding areas. The *information base* and *process* developed enable on-the-ground managers to identify, design, and prescribe the specific tree stand treatments needed; schedule these treatments, over time, to emphasize wildlife; and express quantified outputs and effects. Criteria for management of other resources are incorporated. A specific and detailed field management action plan results.

The purpose of this paper is to describe primarily the *process*. Detailed discussion of the *information base* and further discussion of the *process* are presented in Colorado Division of Wildlife (In press).

Challenges and Needs

Public demand for wildlife is increasing greatly in the central Rocky Mountain Region. Demand for elk hunting will double by the year 2015, and demand for deer hunting will double by the year 1995. Human population increase, energy development, urbanization, and development of private lands will mean less wildlife habitat and that public land wildlife habitats must be managed more productively (USDA Forest Service 1980).

The Colorado Division of Wildlife is responsible for managing wildlife species in Colorado. Goals have been established for most species. The Forest Service is responsible for providing habitats needed by all wildlife and fish species on national forests and national grasslands (Salwasser and Tappeiner 1981).

Integrated multiresource management plans for each Forest Service administrative unit are mandated by the National Forest Management Act of 1976 (NFMA). Individual multiresource land and resource management prescriptions are applied to specific land areas. In the Forest Service Rocky Mountain Region, each prescription emphasizes one resource, while providing for specified management for other resources (USDA Forest Service 1983). If wildlife habitat is to be emphasized on an area, wildlife habitat needs must be the primary design criteria for management. Regardless of prescriptions applied, Forest Plans must express outputs and benefits in quantitative terms (USDA Forest Service, 1984).

The partnerhsip role of the States and the Forest Service is very important in providing wildlife for the future. Wildlife population goals established by the States (Colorado

Division of Wildlife 1983) are primary input into Forest Service planning. It is very important that States provide these goals (Eastman 1982). Forest plans identify management indicator species (Salwasser and Nelson 1982, Mealey and Horn 1981), some of which are emphasis species identified by the States, and some are to ensure species richness or recovery of species classified as endangered or threatened.

These requirements have particularly challenged biologists, managers, and planners. Biologists must now be proactive rather than solely reactive. They must be quantitative and comprehensive and must plan habitat management over time. They must assume a leadership role. In multiple-use management, biologists have historically been reactive. Assessments have focused on how species will react, or have reacted, to habitat changes planned by other resource management activities. If the Forest Service is to meet the future challenges and NFMA requirements, proactive planning and project implementation must occur (Capp et al. 1982). Purposeful, specific, and practicable habitat management must be designed and implemented through comprehensive, multi-year, management action plans. On publicly-owned forested lands, this requires that biologists become quite familiar with silviculture, vegetation associations, vegetation succession, modeling, and how to interpret and practice this knowledge on the ground in concert with other resource specialists.

It is quite clear now that a silviculturist must not be a "forester" and that silviculture is not always for "wood fiber production" or for a "fully stocked stand." On National Forest System lands, the silviculturist's job is to help design and implement complex multiple resource management prescriptions. The wildlife biologist and the silviculturist must be working partners.

Information Base

To provide an *information base* for managing forested lands for wildlife, background information was developed for several subject areas. The *information base* consists of 13 parts. *Part 1* describes the concepts and ecological principles relative to wildlife in the coniferous forest ecosystems. Cover, edge, diversity, community organization and classification, habitat factors, and indicator species are included. The important forest ecosystems in the Central Rocky Mountains are described in *Part 2*. Vegetation and silvical characteristics are discussed in detail. *Part 3* describes wildlife habitat requirements.

Silvicultural systems, vegetation succession, and tree harvest methods recommended for the Central Rocky Mountains are described in *Part 4*. Discussion focuses on wildlife habitat changes and silvicultural limitations. This theme is continued in *Part 5*, with discussion of how silvicultural practices can be applied to create desired habitat conditions. Aquatic and riparian habitats and silvicultural treatment opportunities are discussed in *Part 6*. Alternative silvicultural prescriptions are described in *Part 7*.

Other Information Base Parts

Other parts of the *information base* are:

8. Wildlife species distribution by forest ecosystem and structural stage.
9. Production of structural stages and other tree stand characteristics in unmanipulated tree stands.

10. Relationships between habitat structural stage and tree stand basal area.
11. Wildlife uses of dead and dead/down trees.
12. Relationships between costs and logging operations in the Central Rocky Mountains.
13. Computer programs for calculating wildlife habitat capability.

Wildlife Habitat Requirements

In part 3, detailed habitat requirement profiles were developed for 60 terrestrial wildlife species that occupy forested lands. Each profile includes a distribution map, narrative description of basic habitat requirements, matrices that show habitat and acreage requirements for viable populations plus structural stage ratings relative to habitat requirements, and references for additional information.

The matrices for each species are in two formats. The viable population and area requirements matrix (Figure 1) identifies the minimum population size for a healthy, viable population. The acres (portion of the total required) needed by an individual animal and the population, by summer and winter, are identified according to feeding, cover, and space needs.

In the second matrix format (Figure 2), each structural stage is rated for feeding and cover, by season, for each wildlife species and forest ecosystem. Tree stand structural stages are the same as described by Sheppard et al. (1982): Stage 1 is grass/forb, Stage 2 consists of seedlings (<1″ dbh) and browse, Stage 3 consists of sapling and pole trees 1″–9″ dbh, Stage 4 is 9″+ dbh mature trees, and Stage 5 is old growth 9″+ dbh trees. Stages 3 and 4 are further divided into canopy closure classes of *a*(<40 percent), *b*(40–70 percent), and *c*(70 percent).

In the structural stage value matrix, the four values used are *1, 2, 5,* and blank. A blank indicates the stage has little or no value to the species. A *1* rating indicates optimal habitat value, that which is needed to satisfy the habitat requirements on a one-to-one basis. That is, one acre of a structural stage rated *1* will provide one acre of the required acreage. A stage rated *2* is less than optimal and considered one-half the value of optimum habitat. Therefore, two acres of a stage rated *2* are required to satisfy a one-acre requirement in the viable population and area requirements matrix. Similarly, a stage rated *5* is considered one-fifth as valuable as a stage rated *1*.

Structural stages were rated comparatively among ecosystems as much as possible. This means all stages rated *1* for feeding are equal; all stages rated *1* for cover are equal;

Rocky Mountain Elk

Viable Population: 75

Minimum Habitat Area in Acres: 3,000

Area Required For	Per Individual		Per Population	
	Summer	Winter	Summer	Winter
Feeding	24	24	1,800	1,800
Cover	16	16	1,200	1,200
Space	40	40	3,000	3,000

Figure 1. Viable population and area requirements matrix for Rocky Mountain Elk (*Cervus elaphus nelsoni*) in the central Rocky Mountains.

Rocky Mountain Elk									
Ecosystem: Lodgepole Pine									
Season of Use: Summer									
Type of Use	Structural Stages								
	1	2	3A	3B	3C	4A	4B	4C	5
Feeding	1	1	1	2	5	2	5	5	5
Cover			2	1	1	2	1	1	1

Figure 2. Structural stage value matrix for Rocky Mountain Elk during summer, in the lodgepole pine forest ecosystem.

and the same for *2* and *5* rated stages. Therefore, equal-rated stages can be substituted for each other, both within and among ecosystems.

These ratings are critical in order to estimate habitat capability in terms of animal numbers. It is, however, intended that the user evaluate the ratings on a case-by-case basis and modify them, if needed, based on professional skill and knowledge of local habitat conditions.

Alternative Silvicultural Prescriptions

A broad range of practicable silvicultural prescriptions (part 7) are provided, for each forest ecosystem, from which the manager can choose to manage forested lands in the central Rocky Mountains. Simple to complex prescriptions are included. Each prescription is described, as demonstrated in Figure 4, and the percent of the total area in each structural stage produced is summarized separately.

For each prescription, two primary outputs, or results, were calculated: (1) Animal density (habitat capability) and (2) Wood volume. The animal density/acre was calculated for 60 wildlife species. The process used is demonstrated in Table 3 (prescription evaluation worksheet). This is the degree of departure from the maximum possible density in the viable population and area requirements matrix.

The wood volume produced by each silvicultural prescription was estimated using the RMYLD simulation model (Edminster 1978, pers. comm. 1984). Volume estimates allow the manager to select a prescription(s) that is more economically efficient, and one that can be used also to meet a wood volume goal. Tree and tree stand characteristics are included, along with wood volume. This process predicts occurrence of habitat components such as snags, tree density, tree basal area, and tree height.

Process

Five steps are followed in development of a management plan to manage forested lands for wildlife emphasis.

Step 1. Identification and description of the management area.
Step 2. Consideration of different options and selection of wildlife habitat goal.
Step 3. Selection of emphasis and indicator wildlife species.
Step 4. Development of habitat objectives.
Step 5. Prescribing and scheduling tree stand treatments.

This process has been applied to the Roaring Creek Management Area, Roosevelt National Forest, Colorado, for demonstration purposes. The remainder of the process description will focus on this example.

Identification and Description of Management Area

Seven actions are completed in the identification and description of a management area (Step 1):

1. Identification of forest ecosystems present.
2. Delineation of operable and inoperable areas.
3. Delineation of the influence zone (the inoperable areas that will be influenced by treatments to adjacent operable areas).
4. Identification of the current structural stages of operable areas, by current tree stand.
5. Determination of current other silvicultural characteristics of operable areas, by tree stand.
6. Summarization of the habitat inventory, in terms of operability and forest ecosystems.
7. Identification of wildlife species present and potentially present.

The 1,235 acre (500 ha) management area is entirely covered with lodgepole pine (*Pinus contorta*) except for 43 acres (17.4 ha) of permanent Stage 2 (willow), and a 4-acre (1.6 ha) pond (Figure 5).

Inoperable areas are those with slopes greater than 40 percent. The forested portion of the management area is comprised of 784 acres (317.5 ha) of operable area 252 acres (102 ha) of inoperable area, and 152 acres (61.6 ha) of inoperable area influenced by treatments (Figure 5). Current tree stand boundaries are also delineated, for the operable area. The influence zone width is 600 feet (182.9 m), based on our judgement and information in Thomas (1979) that most deer and elk use occurs within 600 feet of cover/opening edge.

Key tree stand silvicultural characteristics needed depend on the forest ecosystem(s) and wildlife species selected. Key characteristics inventoried within the Roaring Creek area are: average stand dbh, age, basal area, volume in commercial size trees, annual mortality, dwarf mistletoe infection levels, percent canopy coverage, and percent of trees with the serotiny characteristic.

Consideration of Different Options and Selection of a Wildlife Habitat Goal

Three goal options are available for selection in Step 2. The (1) *emphasis species–species richness goal*, rather than the (2) *emphasis species goal*, or the (3) *species richness goal* was selected.

Selection of Emphasis and Indicator Species

Nine wildlife species were selected (Step 3) and their habitat requirements were used in development of the management plan. Mule deer (*Odocoileus hemionus*), elk, and blue grouse (*Dendragapus obscurus*), in order of priority, were selected as emphasis species. Selection and assignment of priorities were based on State of Colorado priorities (Colorado Division of Wildlife 1983). Six other species were selected as indicator species based on their differences in habitat requirements and that their habitat requirements are similar to those of several other wildlife species occurring on the area. Indicator species selected include the goshawk (*Accipiter gentilis*), mountain bluebird (*Sialia currucoides*), northern three-toed woodpecker (*Picoides tridactylus*), pine grosbeak (*Pinicola enucleator*), sharp-shinned hawk (*Accipiter striatus*), and southern red-backed vole (*Clethrionomys gapperi*). The emphasis and indicator species selected represent a broad spectrum of early to late vegetation succession-oriented species.

Development of Habitat Objectives

In the development of habitat objectives (Step 4), silvicultural prescriptions are selected that maintain specific amounts of structural stages on the management area. These habitat conditions, plus management criteria selected later, should provide the habitat capability necessary to sustain the nine selected species, at stated levels, over time.

Six actions are required in Step 4:

1. Establish minimum acceptable habitat capability levels for all selected species.
2. Determine habitat capability provided from inoperable areas outside influence zones and thus required from the operable areas and influence zones.
3. Select silvicultural prescriptions that best provide the habitat capabilities needed.
4. Consider prescription adjustments that may be necessary.
5. Define structural stage production expected to result from the prescriptions.
6. Calculate habitat capabilities expected to result.

The manager selects minimum acceptable habitat capability (percent of maximum possible animals/acre) levels according to local needs. Minimum levels for the nine species are shown in Table 1. The northern three-toed woodpecker and pine grosbeak "usable acres" are less than 1,231 (498.6 ha) because these two species do not use the 43 acres (17.4 ha) of structural Stage 2 (permanent willow).

In this case, 20 percent of the maximum possible was selected for all species, with the goal of maximizing emphasis species habitat capabilities as much as possible above the 20 percent level. The maximum possible number of animals per acre is derived from the viable population and area requirements matrices. For example, the maximum possible density for elk (from Figure 1) is 75 ÷ 3000 = .0250 elk per acre.

Table 1 also displays calculation of habitat capability required for the operable forest and influence zone (*action two*). This calculation follows estimates of capability from the inoperable area. The inoperable area was considered old growth. However, any structural stage(s) can be assigned to an inoperable area, using the *information base* unmanipulated tree stand growth model (USDA Forest Service 1979).

The *third action* is selection of silvicultural prescriptions to provide the needed habitat capability for each forest ecosystem. Each acre is assigned to only one prescription. This is initiated by visual evaluation of wildlife species density production (habitat capability) for each prescription in the *information base*. The prescriptions that show the greatest production of the emphasis species and/or provide habitat for all indicator species are selected.

Once the choices have been narrowed to a few prescriptions, an objective function decision rule is used to select the prescription that maximizes wildlife values:

$$\textit{Maximum Value} = V_1 \times P_1 + V_2 \times P_2 + \cdots + V_n \times P_n$$

where "V_1" is the relative value (assigned by the manager) of wildlife species "1", and "P_1" is the animal density (habitat capability) of species "1" listed for the silvicultural prescription. For Roaring Creek, the choice of prescriptions was narrowed to three: LP-2, LP-6, and LP-10. Relative values of 1.0, 2.0, and .05 were assigned to mule deer, elk, and blue grouse respectively, based on Colorado Division of Wildlife (1983). In other words, the manager would be equally satisfied with 2 deer, 1 elk, or 40 blue grouse. One elk is worth 2 deer, or 40 blue grouse.

Prescription LP-10 was selected (Figure 3), based on a highest objective function value of 0.109. This prescription is defined as: 80 year rotation, thin at years 30 and 65, and

Table 1. Minimum acceptable habitat capabilities, habitat capabilities provided by inoperable forest, and habitat required from operable forest plus zone of influence.

								Minimum acceptable population level			Production from inoperable area					Production needed on operable area plus
Species	Season	Maximum density animals per acre		Usable acres		Maximum possible no. of animals		% of maximum		No. of animals	Usable inoperable acres		Density (animals per acre)		influence zone No. animals	no. animals
Deer	Summer	0.0670	×	1231	=	82	×	20	=	16	252	×	0.022	=	6	10
Elk	Summer	0.0250	×	1231	=	31	×	20	=	6	252	×	0.008	=	2	4
Blue grouse	Summer	0.0390	×	1231	=	48	×	20	=	10	252	×	0.023	=	6	4
	Winter	0.0390	×	1231	=	48	×	20	=	10	252	×	0.023	=	6	4
Goshawk	Summer	0.0003	×	1231	=	<1	×	20	=	<	252	×	0.0003	=	<1	0
	Winter	0.0003	×	1231	=	<1	×	20	=	<	252	×	0.0003	=	<1	0
Mountain bluebird	Summer	0.2500	×	1231	=	308	×	20	=	62	252	×	0.075	=	19	43
Northern three-toed woodpecker	Yearround	0.0100	×	1189	=	12	×	20	=	2	252	×	0.0152	=	4	0
Pine Grosbeak	Winter	1.0000	×	1188	=	1,188	×	20	=	238	252	×	1.00	=	252	0
Sharp-shinned hawk	Yearround	0.0004	×	1231	=	<1	×	20	=	<1	252	×	0.04	=	<1	0
Southern red-backed vole	Yearround	50.0000	×	1231	=	61,000	×	20	=	12,200	252	×	50.00	=	12.600	0

[a]Density supported by information base silvicultural prescription LP-1 (old growth lodgepole pine).

clearcut at year 80. A short rotation is needed to provide optimum forage for the three emphasis species. Early vegetation succession-oriented species require shorter rotations. Prescription LP-10 is assigned to the operable area and influence zone. Prescription LP-1 (old growth) was earlier assigned to the inoperable area.

Action four is consideration of prescription adjustments. Usually, knowledge of local conditions and silviculture suggest adjustments. Local adjustments normally are due to: (1) shorter or longer growing time periods required for structural stage development, (2) presence of significant amounts of permanent nonforest, or (3) additions of inoperable areas that will be influenced by the prescription(s). The objective function should be used to evaluate modified prescriptions. Prescription LP-10 was modified, and effects are shown in Figure 4.

The *fifth action* in development of habitat objectives is identification of structural stages that will be produced from the silvicultural prescription(s) selected for operable areas and influence zones. Again, any modification of one or more prescriptions, or presence of any permanent nonforest must be accounted for. On Roaring Creek, the 43 acres (17.4 ha) of permanent Stage 2 and the 152 influence zone acres (16.6 ha) are added to the structural stage production of the modified prescription LP-10. The structural stage production from the LP-10 (modified) area is identified in Table 2.

The *sixth action* is calculation of habitat capability produced by the final silvicultural prescriptions applied to the operable areas and influence zone. This calculation can be done by completing a prescription evaluation worksheet for each species, by season of use and prescription. The percent of area in each structural stage is divided by the structural stage value matrix ratings to calculate a percent of area contributing to the species need for space, cover, and feeding. Table 3 demonstrates the calculations for elk, for prescription LP-10 (modified).

The lowest *percent* of needs met will govern the capability of the area to support the species. Table 3 indicates elk will be supported at 90 percent of maximum possible density. Feeding area is limiting in this example.

Prescription evaluations are then summarized for all species for each prescription (Table 4).

	Deer				Elk				Blue Grouse				Objective
Prescrip. No.	Relative Value	x	Animals/ Acre	+	Relative Value	x	Animals/ Acre	+	Relative Value	x	Animals/ Acre	=	Function Value
LP-2	1.0		.050		2.0		.019		.05		.018		.089
LP-6	1.0		.056		2.0		.021		.05		.023		.099
LP-10	1.0		.062		2.0		.023		.05		.027		.109

Figure 3. Selection of Prescription LP-10 for Roaring Creek using the objective function decision rule.

Year	0	10	20	30	40	50	60	70	80
Treatment				thin				thin	clearcut
Structural Stage		1	1		3b	3c		3b	3c
Proportion of Rotation		19%	19%		12.5%	31%		12.5%	6%

Figure 4. Silvicultural Prescription LP-10 (modified) as planned for the Roaring Creek Management Area.

Table 2. Structural stage production for operable area and influence zone for Roaring Creek Management Area (Ha in parentheses).

Structural stage	% of operable forested acres	Operable acres	Other acres	Total acreas	Percent of operable area & influence zone
1	19	149 (60.4)		149 (60.4)	15
2	19	149 (60.4)	43 (17.4)	192 (77.7)	20
3b	25	188 (76.1)		188 (76.1)	19
3c	37	298 (120.7)		298 (120.7)	30
5	0	0	152 (61.6)	152 (61.6)	16
Totals	100	784 (317.6)		979 (396.5)	100

Table 3. Evaluation of prescription LP-10 (modified) for providing elk summer habitat needs on the 979 operable and influence zone acres (396.5 ha) on the Roaring Creek Management Area.

Structural Stage	Rating		Percent of Area in Stage	Percent of Area Contributing to Need		
	Cover	Feeding		Space	Cover	Feeding
1		1	15	15	0	15
2		1	20	20	0	20
3b	1	2	19	19	19	9
3c	1	5	30	30	30	6
5	1	5	16	16	16	3
Totals				100	65	53
÷ by optimum of[a]				100	40	60
= Percent of need met				100%	163%	90%[b]

[a] From *information base* Viable Population and Area Requirements Matrix.
[b] Limiting for elk.

The habitat capability provided by prescription LP-10 (Modified) on 979 acres (396.5 ha) and the capability provided by prescription LP-1 (old growth) on 252 acres (102.1 ha) are added together for total capabilities produced by the management plan. This is then compared with the minimum acceptable habitat capability levels established earlier. If minimum levels are not met, further prescription adjustments (and evaluations) are needed. Table 5 displays results for the Roaring Creek Management Plan. A comparison can be made with habitat capability that would be produced with no treatment (all old growth in this example).

With implementation of the proposed management plan, habitat capability for all species will exceed the minimum acceptable levels. Habitat capability for deer and elk is increased approximately 240 percent compared to no treatment. Habitat capability for blue grouse during the summer is approximately the same with proposed treatments and no treatment. In winter, blue grouse habitat capability will be above the minimum acceptable level but less than if no treatment occurred. Habitat capability for the mountain bluebird, northern three-toed woodpecker, pine grosbeak, and southern red-backed vole will be significantly

Table 4. Habitat capability provided by prescription LP-10 (modified) on the Roaring Creek Management Area.

Species	Season	Maximum density animals per acre	Percent of needs met	Revised animal density per acre	Acres Prescrip. applied to	Final habitat capability (no. animals)
Deer	Summer	0.0670	90	0.0603	979	59
Elk	Summer	0.0250	90	0.0220	979	22
Blue grouse	Summer	0.0390	63	0.0246	979	24
	Winter	0.0390	6	0.0023	979	2
Goshawk	Summer	0.0003	92	0.0003	979	11
	Winter	0.0003	73	0.0002	979	11
Mountain bluebird	Summer	0.2500	24	0.0600	979	59
Northern three-toed Woodpecker	Yearround	0.0100	12	0.0012	979	2
Pine grosbeak	Winter	1.0000	16	0.1600	979	157
Sharp-shinned hawk	Yearround	0.0004	100	0.0004	979	11
Southern red-backed vole	Yearround	50.0000	52	26.0000	979	25,474

Table 5. Habitat capability provided by the Roaring Creek Management Plan.

Species	Season	Minimum acceptable population levels	Habitat capability (with mgmt. plan)	Habitat capability (no treatments)
Deer	Summer	16	65	27
Elk	Summer	6	24	10
Blue grouse	Summer	10	30	28
	Winter	10	10	38
Goshawk	Summer	<1	<1	<1
	Winter	<1	<1	<1
Mountain bluebird	Summer	62	78	92
Northern three-toed woodpecker	Yearround	2	5	18
Pine grosbeak	Winter	238	409	1,231
Sharp-shinned hawk	Yearround	<1	<1	<1
Southern red-backed vole	Yearround	12,600	38,000	62,000

above the minimum acceptable levels, but considerably below levels with no treatments. Capabilities for the goshawk and sharp-shinned hawk will remain about the same with or without the proposed treatments. With the above capabilities created by treatments, it is concluded that the emphasis species–species richness goal will be achieved with implementation of the proposed management plan.

Habitat capability changes and wood volumes harvested from decade 1 through decade 8 treatments were calculated but not included in this paper. By calculating these, progress can be identified and evaluated at any time relative to current habitat capability, effects of individual treatments, and present net values.

If the manager is particularly uncomfortable describing habitat capability in terms of animal numbers, then the percent of needs met calculated on the prescription evaluation worksheet can be used. Other index techniques are available (Salwasser and Tappeiner 1981, Sheppard et al. 1982). However, these techniques do not provide the specificity, numbers, and linkages needed for proactive and definitive planning.

Prescribing and Scheduling Treatments

The final step (*Step 5*) is prescribing and scheduling treatments. This is an art which requires use of the *information base* and other resource management information. The selected prescription(s) are applied to the ground to provide the habitat structural stage needs. Other habitat characteristics must be provided: cover, edge contrast, tree stand size and shape, dead trees, travel corridors, and seclusion. Silvicultural limitations and other resource management considerations often must be included, such as tree regeneration, soil protection, road design, tree disease, damage by insects, commercial harvest tree size, wind damage, visual quality plus treatment efficiency, and economics. As a result of all these, the manager may see further need to modify the prescriptions selected, requiring repeat of step four.

These limitations, considerations, and habitat requirements result in *management criteria* developed by the manager. These are criteria that are adhered to as much as possible in development and implementation of the Management Plan.

The first action in step 5 regards *juxtaposition of structural stages*. Edge contrast among tree stands is key in providing habitat needs through distributing regeneration treatments uniformly in time and space. A method to accomplish needed juxtaposition is described by Mealey et al. (1982), and was used in development of the Roaring Creek Management Area. A three-decade edge contrast criterion was selected, to optimize deer and elk cover next to forage. Decade assignments along contiguous strips of tree strings of tree stands were made in the order 1–5–8–2–6–3–7–4.

The second action regards design criteria for *tree stand size and shape*. Some of the criteria utilized were:

1. Shape stands so widths are no greater than four to five tree heights, where nonserotinous lodgepole is present (Alexander and Edminster 1981).
2. In serotinous lodgepole stands, maintain stand widths no greater than 1,200 feet (365.8 m).
3. Shape stands so their long axis is perpendicular to prevailing wind and oriented in an uphill-downhill pattern.
4. Provide stands, or stand groups, that provide deer and elk hiding and thermal cover of at least 300 feet (91.4 m) in radius.
5. Design new stands to simulate natural stand and topographic boundaries.

A common practice is to react to and maintain stand boundaries created by previous treatments. This practice often results in less than optimum habitat conditions. To emphasize wildlife habitat, new stand boundaries must be drawn, as needed by wildlife, even though complexity or traditional thinking must be overcome. New stand boundaries may need to cross old created stand boundaries.

Other management criteria that were developed for the Roaring Creek Management Plan were based on wood volume harvested, tree size needed for commercial harvest, dead tree density, management of road use, protection of aquatic and riparian habitat, and priority for stand treatment due to tree current mortality, insect damage, disease (mistletoe), tree age, tree volume, logging costs, and treatment economic efficiency.

New stand boundaries were drawn and treatments were scheduled (Figure 5). Decade 1 treatments (clearcuts) and road construction were also delineated. In total, 73 stands of operable area were delineated, and treatments (by decade) were assigned. Decade 1 treatments were concentrated in the lower half of Roaring Creek Area in order to pay for road construction through treatment of stands higher in wood volume and closer to existing roads.

It is important to recognize that, utilizing the structural stage value matrices, tree stands used by deer and elk for cover, do not necessarily need to be single stands. The 300 foot (91.4 m) radius criterion used for Roaring Creek, or the 26 acre (10.5 ha) circle optimum cover size (Thomas 1979), can be achieved by two or more contiguous tree stands in structural stages that are both rated optimum for cover. How this can be accomplished depends on the tree stand rotation schedule and decade edge contrast criterion selected. If the Roaring Creek Management Plan were instantly implemented, an evaluation would indicate stands assigned to decades 4 through 8 (Figure 4) would be providing optimum cover for elk (structural stages 3b and 3c are rated *1* for elk cover, Figure 2). In reviewing Figure 5, it can be seen that several multiple stand cover areas would be occurring.

Treatments assigned should be documented so the manager has a written record as part of the management plan. Table 6 presents part of the documentation for the Roaring Creek Management Plan.

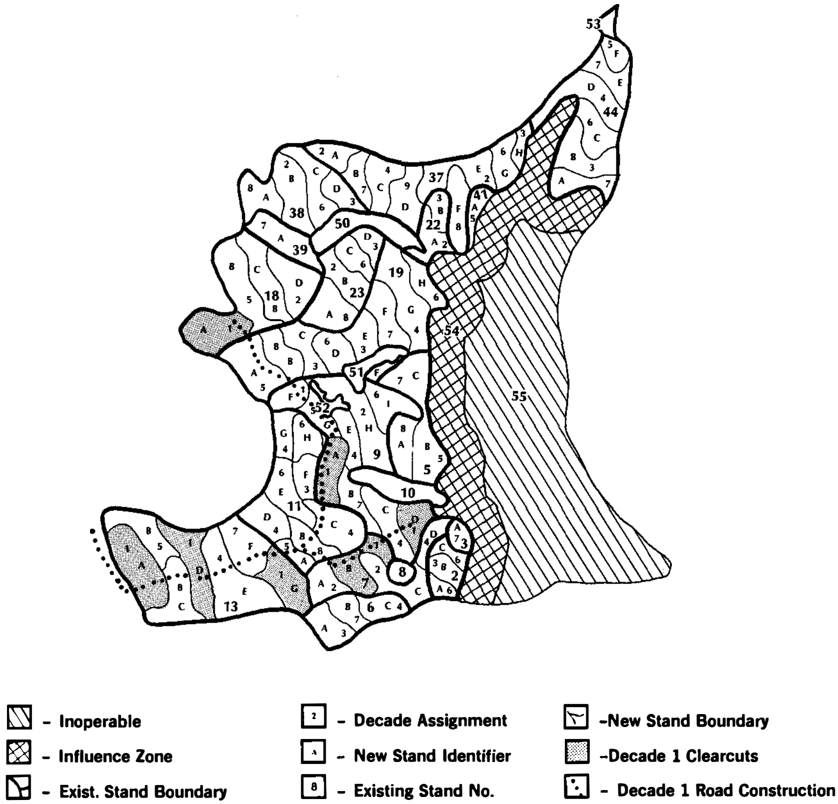

Figure 5. New tree stands and treatment scheduling for the Roaring Creek Management area with decade 1 clearcutting and road construction delineated.

It is important that the number of acres treated each decade be nearly equal. This prevents significant fluctuations in habitat capability through time.

The manager needs to *monitor* the suitability of the plan and how the plan is being implemented. Have resource values, goals, or policies changed? Is significant needed information available on wildlife habitat requirements? Is the treatment schedule being adhered to? Are the management criteria being followed? Is the habitat capability really there? Is stand regeneration or tree growth occurring as predicted? Answers to these questions and others determine if midcourse adustments are needed in design or implementation of the management plan.

Conclusions

The management plan developed by use of this process should provide the habitat capability to meet the wildlife goal. The *information base, process,* and plan are practicable, action oriented, proactive wildlife, and are customized to the specific site. The field manager develops the plan, so on-the-ground ownership is there. The described process

Table 6. Documentation of treatments assigned to new tree stands within old stand 13 (Figure 5), on the Roaring Creek Management Area.

New Stands		Current decade		Other decades			
ID	Acres	Decade of treatment	Treatment	Decade of treatment	Treatment	Decade of treatment	Treatment
A	16	1	Clearcut	4	Thin	7	Thin
B	16			5	Clearcut	8	Thin
C	14			8	Clearcut		
D	15	1	Clearcut	4	Thin	7	Thin
E	22			4	Clearcut	7	Thin
F	13			6	Clearcut		
G	13	1	Clearcut	4	Thin	7	Thin

bridges the gap between saying, "I don't know," or "I can't say," and today's demands for numbers, economics, and leadership. The most meaningful wildlife goals cannot be achieved with reactive or risk free professionals.

The *process* and effects described in this paper are designed for the proactive practitioner. Methodology such as described by Boyce (1981) will be utilized in the future, where practicable and purposeful for the field manager.

Acknowledgements

Special recognition is extended to Craig W. Rupp, Regional Forester, USDA Forest Service, Rocky Mountain Region, and Jack R. Grieb, Director, Colorado Division of Wildlife, who saw the need for proactive wildlife management on forested lands. Their foresight, support, and direction were critical to project completion. Robert L. Hoover provided important review of this manuscript.

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Fee-Hunting on the Public's Lands?—An Appraisal

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The Call for Fee-Hunting on Public Lands

Should hunters pay for hunting on lands managed by the USDA Forest Service (FS) or the U.S. Department of the Interior, Bureau of Land Management (BLM)? The Public Land Law Review Commission (1970:169) recommended ". . .A Federal fee . . . for hunting and fishing on all public lands open for such purposes." The National Research Council's Committee on Impacts of Emerging Agricultural Trends on Fish and Wildlife Habitat (1982:182–183) observed that ". . .the trend toward charging fees for wildlife production will have to increase if wildlife habitats are to be protected or developed . . . The users-pay concept should also be extended to public lands. . . ." Secretary of Agriculture John R. Block said that economics requires the FS to recover more costs of meeting recreation demands (Peterson 1982). The FS has long desired to operate with income exceeding expenditures (Steen 1976). John B. Crowell, Jr., Assistant Secretary of Agriculture, (1983:5) said ". . . We believe the National Forests can turn a profit . . . and . . . the American people should expect such a profit. . . ." FS Regional Forester Craig Rupp (Findley 1982:313) was quoted as saying "The times are changing. Today its a matter of dollars and cents. That makes it tough on uses that don't produce income, such as recreation."

Fee-Hunting on Private Lands

Hunters paying land holders for hunting is common. The best example is Texas (Teer 1963, Teer and Forrest 1968) where most land is privately owned. The development of fee-hunting from 1930 to 1960, assisted by the Texas Game and Fish Commission, was the salvation of big game hunting. Hunters paid landowners $108,000,000 in 1971 (Berger 1974) and probably more than $200,000,000 in 1983. Good hunting can cost $5 or more per acre each year, with demand still exceeding supply (Teer et al. 1983). Fee-hunting is spreading across midwestern and western states, primarily on lands in private ownership (Severson and Gartner 1972), but is developing more slowly in states with much publicly owned land (Dill et al. 1983, Teer et al. 1983).

Fee-Hunting: Why Now?

The public's view of big game hunting on public lands is changing, and fee-hunting is increasingly discussed There is an ". . .increasing enthusiasm for the use of economic analysis. . ." in public land planning (Convery n.d., p. 46) as encouraged by the Forest and Rangelands Renewable Resources Planning Act of 1974 which requires ". . .identification of . . . outputs, results . . . and benefits associated with investments . . . such . . . that . . . costs can be compared with . . . benefits and . . . returns to the Federal Government."

Such planning was pursued from 1979 to 1983 during a recession that was particularly evident in locales reliant on forest products industries. This planning emphasized the importance of commodities produced on public lands to those communities and increased awareness of the costs and benefits of various management alternatives. Simultaneously, decreased tax revenues and government budgets led to more users paying for goods and services formerly provided through taxes (Peterson 1982). It thus seems timely to examine effects of land-use planning by the FS and BLM on big game and hunters, including questions of equity, impacts of fee-hunting on decision making, potential revenues, and consequences for big game and hunters.

Limiting the Discussion

Why discuss only big game hunting—why not all wildlife? Game became a commodity when states began charging for hunting licenses. Yet, these fees do little to make game a commodity in the eyes of planners and managers as fees are small and do not accrue to the FS or BLM. How can game receive equal consideration with commodities such as wood and livestock in land-use planning?

Jackson (1980:5-6) said:

> . . .The essential difference between game and non-game . . . is the degree to which . . . property rights are . . . obtained . . . When you have it in your creel or bag, it's yours . . . non-game wildlife never becomes the property of an individual. . .The "lucky" hunter converts a capital item to non-durable goods . . . title . . . is transferred from the state to the . . . individual . . . [Hunters] privatize the commons.

Leopold (1949:210) said: "One basic weakness in a conservation system based wholly on economic motives is that most members of the land community have no economic value . . . Yet these creatures are members of the biotic community . . . [and] are entitled to continuance." Legislation concerning public land management reflects this philosophy (National Environmental Policy Act of 1969, the Endangered Species Conservation Act of 1969, and the National Forest Management Act of 1976). For example, the FS must insure viable populations of presently occurring species. This mandate to consider all species is a constraint in land-use planning. Species given disproportionate attention include those hunted, trapped, or identified as threatened or endangered. Big game are manipulated and their habitats controlled to sustain hunting. This *is* commodity production and a different objective than maintaining viable populations.

Fee-hunting is examined through a discussion of production and hunting of elk (*Cervus elaphus*) and deer (*Odocoileus* sp.) on FS and BLM lands in the western states, Oregon, Wallowa County, and the Wallowa-Whitman National Forest in northeast Oregon. Principles and concepts could apply to all hunting and fishing. How fee-hunting might alter the consideration of big game in planning is examined by a look at joint production of livestock and deer and elk. The process and conclusions could apply to other commodities.

The Private Public Land Connection

Oregon's private landowners can and sometimes do charge for hunting, though it is less practical than in states where most land is privately owned. Free hunting on public lands is severe competition (51 percent of the land in Oregon is owned by the Federal government).

Management is complicated by the movement of elk and deer between summer and spring-fall ranges (areas commonly in public ownership) and lower elevation winter ranges (often in private ownership). Most elk and deer are on public lands during hunting seasons. Hunter access to private lands is frequently denied because of perceived disincentives to owners including: damage to roads, fences, and range and forest lands; vandalism; and gates left open. When there is more to lose than gain by allowing hunting, denial of hunter access increases. In addition, some landowners consider elk and deer themselves a problem citing competition with livestock, trampling of forage and wet soils, and damage to crops and fences.

Many landowners in the vicinity of FS and BLM lands graze livestock on those lands for a fee ($1.40 per Animal Unit Month in 1983).These "rights" are, in practice, transferred with ownership of private land. This seasonal grazing may enhance the value of the private land (USDA and USDI 1977). Some analysts maintain that enhancements were absorbed by the first seller and no longer exist (Winter and Whittaker 1981). The FS and BLM control periods of grazing and livestock numbers and cooperate with graziers to enhance grazing.

Over the past 40 years, elk have increased in numbers and occupied new range in northeast Oregon. The number of mule deer has fluctuated and, coincidentally, the number of livestock grazed on public lands has declined. Some people perceive a cause-and-effect relationship: others do not. There are insufficient data on forage availability, utilization, or range condition and trends to settle the dispute.

Jackson (1980:3) said the United States is a mixed economy (production of goods and services is shared by public and private sectors). Wildlife is state owned while individuals *and* government (Federal, State and local) own the land. ". . .This . . . mixture of public and private responsibility . . . lies at the heart of most . . . wildlife management problems." Having recognized this, how can it be corrected? Changing wildlife ownership is unlikely as is large scale transfer of FS and BLM lands into private ownership. There may be other ways: fee-hunting is one.

Big Game and Land-Use Planning

The FS and BLM are carrying out land-use planning and resource allocations with second generation plans to be completed in 1983–1985. Planners present alternatives for consideration by users, citizens, and decision makers. The alternatives contrast mixes of products with associated social, economic, and environmental effects. One alternative is "preferred." After public comment, the decision maker selects an alternative or has a new one created to guide management.

These alternatives usually project inverse relationships between high levels of timber production and elk numbers and between livestock and elk and deer numbers. Elk welfare seems to have evolved into a surrogate for amenities to be contrasted against timber and livestock as commodities. Differences of opinion over appropriate allocations between those whose interests are in amenities and those whose interests are in commodity production seem to focus on disputes over elk versus timber and livestock.

Livestock and wood have market values, and economic effects of decisions influencing these industries are discernible—particularly at local levels. Leontief's (1955) input-output models have been used to trace alterations within an area's economy caused by changes in levels of livestock and wood production (Obermiller et al. 1981, Obermiller and West 1983). The FS and BLM have not used these methods, but the burgeoning debate over land-use allocations for northeast Oregon have been influenced by such analyses.

Deer and Elk: Commodities or Amenities?

Because big game on public lands are not market valued, values have been indirectly assigned by various techniques (Brown et al. 1973, Langford and Cocheba 1978) including: hunters' expenditures; hunters' willingness to pay; revenue forgone (opportunity costs) from commodity production to produce elk and deer; value of the meat; valuation of each day of recreation; direct costs of big game production; and travel costs. These methods yield varying values (Loomis and Sorg 1983) and are for hunting; not for big game and habitats *per se*. Methods can be chosen and values manipulated to alter contrasts between commodities and big game production.

Ostensibly, these values are treated similarly to those derived from market values. Yet, everyone knows "real dollars" (derived from market value) from "estimates." Such estimates fare poorly when contrasted against revenues and do not measure monetary impact but welfare or consumer surplus. Comparing such estimates against market determined values is dubious (Gum and Martin 1975, Bishop and Heberin 1979). Only when game values are expressed as revenues can they receive the same respect as commodities. Other expressions of value will, I suspect, always be viewed incredulously.

With no market value, elk and deer are considered amenities by planners and decision makers who must consider cost:benefit ratios. Demands for and values of commodities will grow as the land base shrinks (USDA FS 1980a) and population increases (USDA FS 1980b). Likely there will be pressures to enhance and exploit foreign market opportunities, stimulate natural resource based industry, address balance of payments problems, and increase revenues from the public lands while cutting costs. Therefore, amenities are apt to suffer, increasingly and over the long-run, in tradeoffs against enhanced commodity production (Ophuls 1977).

Questions of Equity

Maintaining big game to support current or greater levels of hunting will be made difficult by questions about equity: who wins and who loses in the planning-allocation game? Planning is most specific at the lowest level (National Forests) where impacts on people, economies, and environment are most discernable. Receipts (25 percent) from FS timber sales and livestock grazing are paid to counties within which a Forest lies. Further, timber management and harvesting, grazing, and production of wood products contribute to local economies through employment, business, and taxes. Regional and national impacts are more difficult to identify.

When wood production or grazing is constrained to benefit big game, local communities bear most of the cost (Obermiller 1980). Opportunity costs include payments to local government; job income associated with growing, harvesting, and processing trees; income to local ranchers; investments in plants; and profits to suppliers, shippers, and entrepreneurs. Of course, elk and deer benefit local hunters. But, most hunters come from more affluent, heavily populated, extensively developed, and economically diversified regions. Opportunity costs are likely to be much less for hunters from distant communities.

Obermiller and West (1983) examined a FS planning alternative that reduced timber cutting and cattle grazing in Wallowa County in favor of recreation—including big game hunting. Of 21 economic sectors, 4 gained and 17 lost. There were losses anticipated in household and business income of 1 percent of total transactions. Gains and losses up to 4 percent were anticipated in some sectors. Consider, then, Jackson's (1980:4) statement, ". . .It is this transfer of resources from taxpayers in general through bureaucracies to their constituents that characterizes the non-market portion of the mixed economy. The lack of *quid pro quo* arrangements automatically infers wealth transfers."

Advocacy Planning—A Win-Lose Game

When demand exceeds supply, supplies are allocated among competitors. The playing board is delimited by "multiple-use" requirements—wood, water, wildlife, recreation, and forage will be provided. But flexibility exists in how resources may be allocated (i.e., equality among resource interests is not implied). Policies, such as aiding economic and social stability of local communities, have bearing. Direction from the Executive Branch or Congressional mandates (usually in the form of funding) influence the mix and amounts of "products." Laws and regulations govern permissible levels of activity or impact; i.e., the size of clearcuts or maintenance of viable populations of native wildlife. Funding determines, to large extent, the emphasis of management. Current planning produces "win-lose games:" when one player wins another loses. Win-lose gaming encourages and sharpens competition while discouraging cooperation.

Consider forage allocation between livestock and big game, for example. Planners commonly convert animals to Animal Units (AUs)—one 1000-pound cow or its equivalent. An Animal Unit Month (AUM) is one AU grazing one month. Other ungulates are converted to AUMs on the basis of weight (2.5 elk/AUM and 5 deer/AUM). Though such comparisons overestimate competition (Flinders, n.d.), the process has become traditional. Allocation procedures usually call for limiting AUMs while maintaining or progressing toward specified range conditions. AUMs are divided between domestic livestock and wild ungulates.

Wildlife: A Federal/State Responsibility

Determining how many big game animals are to be killed and when, where, how, and by whom is a state prerogative (Peek et al. 1982). Whether the Federal government could exercise such authority (Bean 1977) is moot here. There is no desire to disrupt existing arrangements. The FS and BLM set goals for AUMs but regulate only livestock. A state may or may not choose or be able to manage big game numbers at levels specified.

This produces a win-lose game between graziers and big game enthusiasts. If AUMs are distributed between livestock and big game, and substitutability assumed, one group gains only at the other's expense. When planners allocate forage on public lands to big game they, to some extent, allocate forage on private lands that support those animals for part of the year. In the debate over forage allocations between elk and livestock in northeast Oregon, elk have been called "welfare animals" by graziers; i.e., they do not pay their upkeep in revenue to landowners. By extension, those who hunt elk are "welfare recipients." This perception, true or not, may gain adherents if conflicts intensify.

Sustaining hunting influences planners and decision makers only if it is a land management objective. Demand for big game hunting is anticipated to increase (USDA FS 1980a). Viable populations (the current minimum requirement) could be maintained with many less animals than currently present and with no adjustments in practices to enhance timber and livestock production.

No "Free Lunch"

Consider two of Commoner's (1971) "laws" of ecology: everything is connected and there is no "free lunch." There is increasing competition for resources (Ophuls 1977). Land-use planning will likely continue and intensify. Commodity production is apt to become more dominant with each planning cycle. Hunting may decline over the long run. Chances of maintaining *status quo* could improve if big game became a commodity that competed effectively in a game where points are scored with superior cost:benefit ratios. Or, as Jackson (1980:8) put it, ". . .In many instances, major wildlife costs will not show up in an agency budget. These costs are simply forgone income. Any attempt to ignore these costs represents a fallacious free lunch. Perhaps the recent mandate to use economic decision criteria . . . demonstrates that the price tag . . . is starting to emerge."

Fees From Hunters: Slicing the Pie

The application of user-pay concepts to hunting on public lands is *the* point here. My purpose is to stimulate consideration; not to prescribe. Receipts may vary widely by locale. The following is one of many possible approaches. The Sikes Act of 1974 provides opportunity for states to take the lead in prescribing fees for hunting on Federal lands. Such fees are presently charged by Virginia, West Virginia, and Arizona.

Hunters could be required to purchase a Federal stamp to be attached to their state hunting license for each big game species hunted on public land. The price should, at least, reflect opportunity and direct costs of producing the big game. Then, if that price is less than full value, prices could be increased to insure competitiveness with other commodities. Why not charge full value? Equity problems are reduced if users pay full value, but determining full value for some uses in a generally acceptable way is difficult, and those who lose in competition for resources will not be mollified merely because the winner payed full value. No system of charges will dampen desires of user groups to obtain their wants and needs (Clawson 1975).

Receipts could be allocated to make the scheme more acceptable to various levels of government, those who profit from using natural resources, hunters, and the public. A portion (25 percent) of timber and grazing receipts go to counties for schools and roads. Such payments should not decline if big game is favored at some cost over timber and livestock interests. Desired big game habitats in managed forests and rangelands are achieved largely through modifications in practices that could be used to increase timber and livestock production. This may cost livestock and timber interests by reducing production potential.

Management of public lands can affect big game use of adjacent private lands. Therefore, one-quarter of receipts could be allocated to states to enhance management on private lands that provide seasonal habitat for big game residing partially on public land. This should make fee-hunting more acceptable to the states and private landowners.

Some percentage of revenues (say 25) could be treated similarly to funds reserved from timber sale receipts for forest establishment and improvement. There is a similar allocation of grazing receipts. A portion of hunting fees could be similarly dedicated to timber sale design, habitat management, establishment and maintenance of hunter facilities, road management, and enforcement.

The remaining 25 percent of revenues (less administrative costs) could go to the Federal Treasury. There are no guarantees, but those who frame and legislate budgets seem more inclined toward expenditures that produce revenue. If so, all or part of this money might be dedicated to wildlife management.

What would fee-hunting do for big game and hunters? Big game would move from amenity to commodity status. Hunter fees would go to local governments (to support schools and roads), to state governments (to mitigate problems for private landowners), to the land management agency (to manage wildlife habitat), and to the Federal Treasury (perhaps to be appropriated for wildlife management). Such contributions might enhance the image and influence of hunters.

Potential Revenues

Deer and elk harvest data (Table 1) and the potential revenues from fee-hunting on public land (Table 2) were derived for the western states, a state, a county, and a National Forest. Experience with increases in elk hunting license fees (Potter 1982) indicates that demand is elastic; i.e., demand drops with price increases. There is limited experience, however, with fee-hunting on public lands. Potential revenues are presented so that declines in demand with various fees can be estimated.

Table 1. Elk and deer killed by hunters on public lands in the western states, State of Oregon, Wallowa County, and the Wallowa-Whitman National Forest[a].

	Elk	Deer
Location of kill:		
Western states[b]	79,406[c]	1,298,000[d]
Oregon	14,379[e]	62,812[d]
Wallowa County	3,000[e]	1,755[e]
Wallowa-Whitman NF	4,296[e]	4,743[e]
Number of hunters		
Western states	566,962[c]	4,475,862[d]
Oregon	99,578[c]	189,619[e]
Wallowa County	15,262[e]	6,167[e]
Wallowa-Whitman NF	25,288[e]	16,522[e]
Percent hunter success:		
Western states	14[c]	29[d]
Oregon	15[e]	33[e]
Wallowa County	20[e]	28[e]
Wallowa-Whitman NF	17[e]	29[e]

[a] Statistics on mule deer and black-tailed deer for the western states are from 1975.
[b] The "western states" include Alaska, Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming.
[c] Derived from data in Potter (1982). It was assumed that 80 percent of all elk killed were taken from public land.
[d] Derived from data in Conolly (1981).
[e] Derived from data in Oregon Department of Fish and Wildlife (1980).

Table 2. Potential income from sale of hunting stamps for deer and elk hunting on public lands at various price levels based on 1979 data (in $thousands).

			Percentage of 1979 hunters that will hunt at the price indicated					
			100		80		60	
		Price/stamp	Total	To States, Counties, Forests, and Districts, Treasury	Total	To States, Counties, Forests, and Districts, Treasury	Total	To States, Counties Forests, and Districts Treasury
ELK	Western states[a]	$100	$ 56,696	$14,174	$ 45,357	$11,339	$ 34,018	$ 8,504
		50	28,348	7,087	22,678	5,670	17,009	4,252
		25	14,174	3,544	11,399	2,835	8,504	2,125
		10	5,670	1,418	4,536	1,134	3,402	851
	Oregon[a]	100	9,960	2,490	7,968	1,992	5,976	1,494
		50	4,980	1,245	3,984	996	2,988	747
		25	2,490	623	1,992	498	1,494	374
		10	1,000	250	800	200	600	150
	Wallowa County[b]	100	1,526	382	1,221	305	916	229
		50	763	191	611	153	457	114
		25	382	95	305	76	229	57
		10	153	38	122	31	92	23
	Wallowa-Whitman NF[b]	100	2,529	632	2,203	506	1,517	379
		50	1,264	316	1,012	253	759	190
		25	632	158	506	126	379	95
		10	253	63	202	51	152	38

DEER	Western states[c]	50	223,799	55,950	179,039	44,759	134,279	33,570
		25	111,897	27,974	89,518	22,379	67,138	16,785
		10	44,759	11,190	35,807	8,952	26,855	6,714
	Oregon[c]	50	9,480	2,370	7,584	1,896	5,688	1,422
		25	4,740	1,185	3,792	948	2,844	711
		10	1,900	475	1,520	380	1,140	285
	Wallowa County[b]	50	308	77	247	62	185	46
		25	154	39	123	31	93	23
		10	62	15	50	12	37	9
	Wallowa-Whitman NF[b]	50	826	207	661	165	496	124
		25	413	103	330	83	248	62
		10	165	41	132	33	99	25

[a] Derived from data presented by Potter (19082).
[b] Derived from data provided by Mike Kemp and Vic Coggins of the Oregon Department of Fish and Wildlife.
[c] Derived from 1975 data (Connolly 1981).

Return Per AUM

Returns per AUM could be used in contrasting land-use alternatives involving forage allocation between livestock and big game. Graziers paid $1.40/AUM to the Federal government in 1983. Fees vary yearly considering livestock prices and production costs. Potential revenues per AUM for deer and elk are shown in Table 3. These revenues exceed those from livestock, with elk stamps at $5.00 and deer stamps at $10.00, assuming no decline in hunter numbers (Table 3). The actual value of livestock grazing is higher than grazing fees—$7.90 in 1979 (USDA FS 1980C)—because the fee is set through non-market mechanisms that include consideration of leasee labor, management, and equity capital costs. At these prices, elk produce more revenue at a stamp price of $20 and deer at a price of slightly more than $50.

Advantages to Private Landowners

AUMs would not be allocated considering only revenues. Multiple-use mandates, contributions to community stability, tradition, established use, and political realities would enter in. It is not likely that livestock numbers would be reduced substantially to favor deer and elk. Pressures would likely develop for techniques to determine AUM

Table 3. Estimated value per AUM of elk and deer on public land at various stamp prices and hunting levels for the State of Oregon, Wallowa County, and Wallowa-Whitman National Forest, 1979.

	Price/ stamp	Location	Percentage of hunters continuing to hunt at this price			
			100	80	60	40
Elk	$100	Oregon	37.38	29.90	22.43	14.95
		Wallowa County	25.22	20.18	15.13	10.09
		Wallowa-Whitman NF	25.12	20.10	15.07	10.05
	50	Oregon	18.69	14.95	11.21	7.48
		Wallowa County	12.61	10.09	7.57	5.04
		Wallowa-Whitman NF	12.56	10.05	7.54	5.02
	25	Oregon	9.35	7.48	5.61	3.74
		Wallowa County	6.31	5.05	3.79	2.52
		Wallowa-Whitman NF	6.28	5.02	3.77	2.51
	10	Oregon	3.74	2.99	2.24	1.50
		Wallowa County	2.52	2.02	1.51	1.01
		Wallowa-Whitman NF	2.51	2.01	1.51	1.00
Deer	50	Oregon	7.55	6.04	4.53	3.02
		Wallowa County	7.66	6.13	4.60	3.06
		Wallowa-Whitman NF	11.23	8.98	6.74	4.49
	25	Oregon	3.77	3.02	2.26	1.51
		Wallowa County	3.83	3.06	2.30	1.53
		Wallowa-Whitman NF	5.62	4.50	3.37	2.25
	10	Oregon	1.51	1.21	.91	.60
		Wallowa County	1.53	1.22	.92	.61
		Wallowa-Whitman NF	2.25	1.80	1.35	.90

equivalencies between livestock and big game. Overestimates of competitiveness would be less tolerable.

Private landowners who provide seasonal ranges for big game residing partly on public land would benefit from hunter fees. Payments to counties could reduce taxes, increase services, or both. Contributions to the State could pay for big game management on private lands. And habitat improvements on public lands, such as enhanced forage production and water development, would benefit livestock. There is another potential boon: improved ability to lease private lands for hunting. Hunting access on public land would no longer be free and the onus of charging for hunting will have been absorbed by the FS and BLM. The payoff? The game is no longer win-lose. It could become a win-win game where more players can maintain or improve their overall position.

Social and Cultural Acceptability

Clawson (1975) suggested that forest policy issues are analyzed by considering: (1) physical and biological feasibility and consequences, (2) economic efficiency, (3) economic welfare as equity, (4) operational and administrative practicality, and (5) social or cultural acceptability. I find no insurmountable barriers to fee-hunting in the first four, leaving fee-hunting to be accepted or rejected solely on social and cultural considerations. Hunters and state fish and game departments are apt to be the arbiters. Acceptance will not be immediate and will require a concentrated educational effort to explain and explore the ramifications.

Economically there is a loser: the hunters who pay. Some say "this will make hunting a rich man's sport." This is effective rhetoric but considerably less telling when the fee is considered as a percent of the cost of hunting. The real issue is survival of big game hunting on public land at present levels. The poorest hunter is one without opportunity—including a place to hunt and a quarry to pursue.

Hunters, with other taxpayers, pay for public land management and, currently, expenditures exceed receipts. In one sense hunting may be considered partially paid for because other commodities are similarly subsidized by taxpayers at large. It may be reasonable, therefore, that hunters pay fees set just high enough to insure comparability with other commodities.

Leopold (1949:177) stated that hunting had three cultural values: "split-rail" values or experiences reminiscent of distinctive origins and evolution; recognition of the "soil-plant-animal-man food chain;" and "sportsmanship." He concluded that:

> Wildlife managers are trying to raise game in the wild by manipulating its environment, and thus to convert hunting from exploitation to cropping . . . how will it affect cultural values? . . . the split-rail flavor and free-for-all exploitation are historically associated . . . Perhaps the stubborn resistance of the 'one-gallus' sportsman to be converted to the cropping idea is an expression of his split-rail inheritance. Probably cropping is resisted because it is incompatible with one component of the split-rail tradition: free hunting.

The argument lingers: the essence fades. Stand by a FS road in elk country just before hunting season and watch the parade of trucks (many with 4-wheel drive), recreational vehicles, campers, trailer houses, and horse trucks or trailers. Visit the camps. Marvel at the equipment. Leopold's one-gallus hunter has changed. Yet the vivid and appealing imagery remains—free men, free country, free hunting! Of course, the "free lunch" was never, at least in recent times, free (Jackson 1980). It just cost less and the taxpayers and landowners paid the bill without knowing it or, at least, without loud complaint.

If hunters want to hunt in present or greater numbers, they should pay, at least, direct and opportunity costs of producing big game. Supply is thought to be governed by price as guided by Adam Smith's (1776) invisible hand of supply and demand. Demand for free hunting is increasing. But whatever effectiveness it has had in insuring huntable surpluses of big game is apt to diminish as planning intensifies and opportunity costs increase. Demand expressed in revenue to land holders would tend to have opposite effects.

Elk hunters increased dramatically from 1930 to 1980 (Potter 1982). This was also true for hunters of mule deer until the decline in both deer and hunters in 1965–1978. But hunter numbers remained high enough to contribute to decreases in success rates (Connolly 1981). Hunter success seems inversely related to hunters per animal pursued. Further, hunter numbers stabilize when success drops to 5–10 percent (USDA FS 1975). Though limiting hunters is politically and economically difficult, some states have done that. Others are scrambling to avoid the inevitable—limiting hunter numbers. Projections (USDA FS 1975) of a 66-percent increase in demand for big game hunting by 2020 indicates that further restrictions lie ahead even if present big game numbers are maintained. Increasing demand for hunting from 1930 to 1983 was met by increased big game numbers, improved access, manipulation of open seasons, bag limit reductions, and declining success rates. Such options are being exhausted. The mechanism that distributes most scarce goods in our society—charging a fee—is essentially untried on public lands. If it is desirable to constrain hunter numbers on public land, fees would have that effect, at least temporarily.

Increases of $3–7 in the cost of hunting licenses have caused temporary declines in elk licenses sold. Lesser increases had little influence (Potter 1982). There is little experience to help predict what would happen to hunter numbers on public lands if the fees described herein were instituted. In Texas, where much higher fees than $3–7 are charged for hunting on private lands, demand for hunting exceeds supply and is probably growing (Teer et al. 1983). The "law" of demand (Samuelson 1973; when a good's price increases, and other things are held constant, less will be demanded) indicates that, in the short-run, fewer people would hunt and declines would increase with price. Opportunity to hunt would depend on ability or willingness to pay these additional costs or both. Over the long run, hunters would likely rebound with the increased demand anticipated.

What are those interested in big game hunting on public lands to do? They can strive to maintain "free" hunting and current or increased numbers of big game. This seems likely to continually lose effectiveness. Or hunters can pay for producing big game at levels that support hunting. This may be the most effective way to sustain big game hunting on public lands. If the hunter pays, does the hunter lose? There would be a loss in "split-rail" values, but other cultural values would survive. If this fiscal contribution enhances the survival of big game hunting on public lands, the hunter is a clear winner—perhaps the biggest of all.

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Balance of Nature: Fiction and Reality

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Introduction

I am an environmentally concerned citizen who truly loves wildlife and has a religious respect and awe for the environment. My mission in this paper is to play the devil's advocate, for I think we all deserve to be chastised for preaching rather than teaching the role of the balance of nature and the ecology of wildlife, i.e., vertebrates, in man-modified environments. It appears that wildlife biologists have become so entrapped in this emotional arena that too often the reality of the balance of nature has been changed into emotional fictitious claims that hurt rather than help the environment.

Any intelligent discussion of wildlife or environmental problems requires a clear understanding of what is meant by the term "balance of nature." But I wonder if John Q. Public—in fact, also most biologists—is not confused as to what the balance of nature in disturbed ecosystems means ecologically and environmentally. Man has conquered nature and modified the environment, usually to satisfy his immediate wishes, although often later regretted by others.

The balance of nature is the complex interplay of birth to death of all organisms. It is the web of relationships among the population densities of the diverse species of organisms that make up an ecological community. It is ecosystem homeostatis, the intrinsic regulation, adjustments, or feedback mechanisms that creates new equilibriums (balances) in disturbed environments, leading to a climax or an approximate steady-state between inputs and outflows of nutrients. From a practical point of view, the balance of nature should be called "balancing" of nature, for it is the dynamic struggle for existence, i.e., the survival of the fittest in the cruel world of nature where it is the natural right of the largest and strongest to feed on or displace the smallest or weakest.

Since we are part of this balance, what is mankind's role? Should we be willing to share our agricultural crops with wild animals, insects, and weeds, thus requiring more land be devoted to food production? Should we allow wildlife free access to our lawns, gardens and shrubbery and permit rats in our garages and bats in our attics?

Since we must modify the environment to survive, why do we so frequently charge that environmental changes made by others have critically upset the balance of nature? Why is it that people often apply the balance of nature concept for others but not themselves? Grizzly bears, now extinct in the Sacramento Valley, California, were once common, but I have never met anyone who wishes he had these carnivores roaming about his home and garden.

Too often we have distorted the reality of the balance of nature into fictitious, strident rhetoric, rather than objectively teaching the balance of nature. We have created such an emotional aura about wildlife, especially mammals and birds, we find it almost impossible to say or write anything about these animals which does not agree with our preconceptions.

An examination of the scientific literature bears out the fact that whenever a study about wildlife falls within this emotional arena, the author is careful to defend his emotional viewpoint, and his "disapproved" reality trade-offs, even though obvious, are ignored. When people claim that man has destroyed any particular ecosystem, they rarely point out that such changes may at the same time have favored other species.

There are three major reasons for the balance of nature hypocrisy: (1) an educational system that preaches when referring to the balance of nature in modified environments; (2) too many environmental organizations that instigate an "anti" hysteria to raise money (Howard 1980b); and, (3) a new breed of environmental lawyers who take advantage of the susceptibility of environmental issues for litigation purposes. Such lawyers have even displaced biologists as the leaders of many environmental organizations.

The public has been so indoctrinated with fictitious balance of nature dogma (Howard 1983a), affecting everything from animal rights and humane issues to hunting and fishing and animal pest-control operations, that the reality of the balance of nature and the potential opportunities for environmental compatibility too often have been skipped. We overlook that nature's perturbation of the environment often is not what man, nor wildlife species, for that matter, would consider desirable.

The supporters of a fictitious model about the balance of nature have established a common belief that any natural solution to a perturbed ecosystem is always the best and any human interference is harmful. This "man must not meddle with nature" philosophy should be dispelled because "leaving it to nature" after man has altered the environment seldom provides a wise solution to ecological or biological problems. It comes as a surprise to many to learn that, as far as the perception of most people is concerned, new and better man-made ecologically and economically sound ecosystems are feasible (MacMahon 1983).

The symbiotic interplay between man and nature has generated many more diversified and interesting ecosystems than occur in some monotonous natural wildernesses. The beauty of home gardens and city parks is due to exotic plants, not native species, which people call weeds. If natural animals and habitats are best, we must abandon our pets, livestock, landscaping, and agriculture.

Miller (1982) succinctly put his finger on the basic reasons why wildlife biologists are usually not very objective in their analyses of emotional balance of nature issues that involve vertebrate wildlife species. Problem-solving behavior is influenced by deep-seated personality factors, including one's own emotional views. Therefore, environmental problem-solving cannot be viewed simply as an intellectual-technical activity. It requires the education of the whole person. Miller found that the level of integrative thinking achieved by professional biologists may be limited by their moral values.

To test yourself as to whether you preach or teach the balance of nature, see how you would cope in front of a public group on many of the issues I raise. Even though living organisms provide a unique source of genetic material, could you leave ethical issues aside and objectively analyze whether or not it would really make much difference to the survival of the human race if a hundred, even a thousand, species of wild vertebrates were exterminated this year? I doubt it, because most people are emotionally conditioned to consider only arguments opposing the loss of species. It would be very difficult for most of us to enumerate reasons why the loss of a species would make little difference to human welfare or survival. Could you discuss how the eradication of some species might also help create new gene pools? In other words, can you objectively discuss the impact of species removal or ecosystem dynamics even though I hope that you, like me, really do not want to lose any fauna, flora, or even ecosystems.

The correctness of one's viewpoint, or of a political decision, about a wildlife issue depends upon how such a view is defended. (I like to grade wildlife ecology students not on what is right or wrong, but on how well they can defend their views.) The value most people place on wildlife is determined by the manner in which that animal or species population affects them. If one is not affected directly, any alteration of the balance of nature is then usually considered unfortunate or even tragic regardless of how others may be affected.

The manipulation of public desires by creating fictitious balance of nature dreams usually does not help the environment. Such action shakes public confidence, makes the environment the scapegoat, and threatens the future of wildlife by creating controversy between sportsmen and birdwatchers, hunters and antihunters, and urbanites and agriculturalists.

Whether or not you want to agree with Case (1974) that man is a natural component of the balance of nature, the obvious problem is that man as a species has been too successful. There are many examples in the world where the human race has tragically upset the balance of nature. Why? One answer is that all environmental problems of today are the result of advances in education, science, and technology. However, the principal cause is the high degree of death control achieved during the medical and public health revolution of the past century. Last year, for example, the human population increased just in one year about 50–75 million times as much as the during the first several million years of existence of *Homo sapiens*. And the anti-abortion public still fails to realize that every birth that does not have a chance of surviving a normal life will utilize resources before dying. Thus, with each premature death, the resources consumed by that child are, therefore, not available to another person. The same is true with wildlife.

The human race has adopted the philosophy that not only is it obscene and illegal for a human to die, but we are interfering with the balance of nature by considering it unnatural for wildlife to die. Such animal right-to-life philosophy helps to upset the balance of nature, causing untold suffering amongst wild animals by trying to delay death and to prevent them from dying naturally.

The human population explosion has created many pollution, energy, resource, and food supply problems, and the potential carrying capacity of the earth for both humans and wildlife is declining daily at an accelerated rate due to soil erosion alone. Even though soil erosion is one of the most serious crimes of civilization throughout the world, don't Americans try to preserve all of nature's most eroded areas as national parks and monuments, with no attempt or desire to dam their tributaries to stem any further erosion? We do this because we think we can still afford to lose all of this soil, and comfort ourselves by calling this natural, the consequence of the balance of nature, in contrast to soil erosion caused by agriculture, which, of course, is deplorable.

In moralizing about the balance of nature, we must decide on what our goals are. Do we like diversity? Can we then define diversity as the "richness" in number of species within a community? Do we always prefer community stability, i.e., constancy and persistence, over man-stimulated environmental fluctuations? Most wildlife species are quite resilient and have the ability to resist and recover from man-caused disturbances. Sportsmen are almost always too conservative when they worry about overharvesting, for example, deer.

Balance of Nature

Nature is harsh and cruel. Every organism lives off other organisms and, in turn, is eventually eaten. Wild animals, unlike pets and domestic livestock, must be constantly vigilant to prevent being injured or killed. Wildlife rarely die a nice death in nature, and nature has no life-support devices or homes for the elderly.

All wild animals whether pests or not, play an ecological role in the balance of nature. What often is not realized, however, is that many of these functions are not essential for the welfare of humans, or for that matter, most other wildlife species. Of course, predators are benefitted by the presence of a prey species. Wildlife species are not like links in a chain where the loss of just one species has deleterious effects on all other species in the community. The environment may be more complicated than man's machines, but it is not as delicate. It has to be rugged and tough to have evolved.

When man upsets the balance of nature by modifying the physical makeup of the environment, he changes the suitability of the habitat for species, and the habitat is the key as to how well wildlife species prosper. However, habitats cannot be eliminated, only altered. If a forest is clearcut and then badly overgrazed with goats so that desertification occurs, many species may be eliminated from the area. However, desert-adapted organisms will certainly prosper.

The plant and animal populations that have evolved together (coexistence, cohabit) in nature are not delicately balanced. Competitive interaction between species of wildlife is not as common as with intraspecific competition, except from an evolutionary point of view. Remove certain kinds of plants and, of course, the wildlife that have evolved a dependence upon them will suffer. Likewise, plants needing animal pollinators could also be affected if the pollinating species disappeared. But natural communities containing wildlife would not exist if the species were not highly stable and quite resistant to most external forces. Look how successful commensal rodents, starlings and coyotes have been. Examples of species that seem to lack the genetic plasticity needed to adapt to environmental changes are the extinct passenger pigeon and near-extinct California condor and black-footed ferret.

For the most part, except with predators, there is surprisingly little interdependence amongst different species of mammals and other wildlife that live in natural situations. Fluctuations in the density of one species of vertebrate usually have little or no measureable effect on the densities of other species of wildlife present. For example, the effect that the removal of the dominant herbivores (deer) from North America would have on other vertebrate species would be negligible except for predators, such as wolves, mountain lions and perhaps coyotes (Howard 1980a). Eventually, without deer grazing and browsing, the resulting changes in the vegetation would modify the habitat and then probably affect other kinds of wildlife.

In spite of unfortunate extinctions during the past few centuries, today many more kinds of animals inhabit all the continents of the world than before, except for the two Poles. This increased richness in species is due to man's creating new habitats and intentionally or accidentally introducing many kinds of fish, birds, mammals, other wildlife, pets and livestock. Some of these additional species, such as the house mouse, rat, and starling may not be desirable to some, but that also applies to native species that people call pests.

Managing Wildlife

If the objective is to improve the welfare of individual animals or populations, we should manage wildlife and not leave it to the whims of nature. We should control wildlife when it is desirable to protect other species, resources, or for public health reasons, or when someone currently views them as a pest. "Pest" is a good term for a problem animal because it is a subjective term that permits another person to have a different opinion (Timm 1982). There are no clear-cut right or wrong environmental answers as to how best to manage wildlife issues because the correctness of any decision depends on one's perspectives.

Wildlife management is considered the science of managing wildlife and their habitat for the benefit of the entire biota. This is okay with most people as long as they don't have to make many personal sacrifices to achieve it. Do we adequately stress how all animals are predisposed to overproduce and overpopulate? Sure, we do point out how excess animals are destined to die prematurely, but do we stress the absolute necessity of there being many deaths in order to keep any population healthy? Also, do we adequately elucidate the ways man can promote fairly high, yet beneficial death rates?

If you really love wildlife and have genuine empathy for wild animals, you should consider the long-range effect of any temporary kindness you may offer to any individual or population of wildlife. To prevent "natural" death from occurring may cause an even greater suffering later on to a species or an individual which may no longer be accepted in nature as a consequence of your temporary compassion. Wildlife respond like humans, where the doubling of its population in the last 50 years has caused untold poverty and starvation. It may be comforting to help wildlife in need, but frequently such behavior is really a selfish act on our part.

Overprotection of wildlife species can work against the very goals being striven for, as all species of wildlife are predisposed to overpopulate. Examples are the overprotection of deer in the Florida Everglades and on Angel Island in San Francisco Bay and the overprotection of tigers in India's national parks at the expense of the lives of hundreds of villagers (Howard 1982). If natural factors, including predation, do not adequately restrict the density of wildlife populations, then man must become an effective predator so such animal communities can function more harmoniously (Howard 1983b). If livestock operators managed domestic animals as poorly as agencies are often forced to manage many game species, e.g., many deer herds, they would be arrested for being inhumane. The welfare of sporting wildlife can be achieved better by regulated hunting and fishing than by natural processes in environments that have been disturbed by man. There is an important ecological role for the hunter, trapper, and animal control personnel to improve the balance of nature and for humane reasons.

Since preventing the loss or destruction of habitats is the most important way of helping wildlife, people often think that any further modification is heresy. However, the introduction of exotic plants, or even animals, often creates new but favorable substitute habitats for desirable wildlife species. For instance, home landscaping in the Sacramento Valley has greatly enriched the variety of native birds that nest or spend the winter there, or stop briefly during migration. Look how buildings and bridges provide nesting sites for swallows, with artificial irrigated feeding areas nearby.

Wilderness means different things to different people. The backpacker objects to horses; the saddlesitter dislikes the four-wheeler; the cross-country skier dislikes the snowmobiler;

the autoist objects to the hazard of cyclists; and mothers object to hunters in adjacent forests. People have many views on how to obtain supreme enjoyment from nature. But, please, let's stop making fictitious statements about the balance of nature to defend our preferences because they may cause increased environmental costs. The only place where environmental problems do not exist is in a truly natural area where, by definition, there are no environmental problems since everything is natural.

In wilderness areas and national parks, the objective is to preserve as nearly as possible the original environmental conditions. Few will quarrel about such action unless they think too many potentially usable resources are being locked up. But when people, out of necessity, disturb the environment, they should establish new ecological goals and devise well-planned management and control schemes to achieve the populations of plants and animals which will produce a new "artificial" balance that is desirable and harmonious. We tend to overlook that nature's perturbations of the environment often are not what either man or wildlife species would consider desirable.

Habitat is the key to any species as far as the balance of nature is concerned, but when are we justified in protecting or enhancing the condition of any particular preferred species or group of species, e.g., waterfowl, deer, quail, etc.? Most people agree if the issue is the preservation of a natural habitat, for undisturbed areas have become scarce. But usually when we talk about habitat management, we are referring to disturbed environments. This means whatever habitat changes we make unquestionably affect some other species deleteriously, so a value judgement is required.

Most farmers like the outdoors and are fond of wildlife, as long as they do not destroy profits. During my 37 years with the University, I have had many requests from agriculturalists as to how they might provide woodlots and ditch-bank vegetation for wildlife without producing economic pest problems. In many instances this would be feasible if environmental organizations would alter their money-raising, anti-poison stance and allow the landowners to create the needed wildlife habitat and also agree to have county control agents monitor these sites each spring. Should the agent find that too large of a population of potential vertebrate pests has survived the winter, thus posing a threat to a summer crop, the environmentalists should state publicly that they then condone that the agent put out sufficient poison bait to reduce the threatening pest populations. Such action would require very little poison. However, now the public insists that growers not poison until a serious pest problem has developed. This forces growers to apply hundreds of times as much poison bait as they would have needed if they had done prophylactic control in the spring. Integrated pest management of vertebrates is very different than with insects.

Many people have become paranoid about the extirpation of local animal populations, as if such local eradication would have devastating consequences on the balance of nature. This is unfortunate, because in intense agriculture and urban situations the complete local elimination of a pest species is often the most desirable goal from a balance of nature standpoint. It is both ridiculous and environmentally disrupting to let, for example, specific species of field rodents to build up to serious economic densities before they are controlled, because then it is necessary to use much larger amounts of rodenticides, and it leaves the predator populations that have built up with little prey. This artificial cycling of predator and prey populations is both very inhumane and environmentally unsound. In these situations pest species should be locally eradicated, because control operations would then primarily involve just nontoxic monitoring; baiting would be required only a very limited basis.

Emotional and Legal Conflicts

There are several reasons why wildlife managers have so much difficulty obtaining the public support they deserve. One is that some of the public they deal with (sportsmen) are self-acclaimed experts but, more importantly, wildlife managers cannot raise money easily just by doing their daily job. It is much easier for other environmental groups to glean money by developing highly emotional "anti" platforms. Wildlifers have to think positively—not negatively; consequently their objective arguments lose out. They also have to be honest.

Some humane societies and environmental groups sue state and federal wildlife organizations for permitting wildlife to be harvested. It seems to me that they are confused; they should be suing these government organizations for not being liberal enough in bag limits. Animals that overpopulate their environment live, for the most part, a very pitiful existence and often die prematurely. The self-limiting processes that have evolved in nature to enable a species to check its density in absence of adequate predation or, e.g., hunting, are really very cruel and inhumane. Managing wildlife for consumptive uses such as fishing and hunting in disturbed environments is much kinder than restricting their use to nonconsumptive ways such as birdwatching and photography. If the "balancing" of nature were understood better by the public, both consumptive and nonconsumptive uses of wildlife might be optimized.

The public needs an empathy for realistic nature, not just an idealistic affinity for environmental conditions without people. As stated by Kellert (1982), the "common ground will be the fundamental search for an ethic of the land and its living components that embraces both scientific and humane considerations." Is it ethical for man to look the other way and not offer humane assistance, when it would be easy to do so, just because the brutality or suffering occurring is natural? Where do we draw the line? For example, when weather conditions cause deer to starve, as happened in Utah in January 1984, should we feed them or let them die? When should we mercifully apply euthanasia to suffering animals? I believe man has a moral obligation to prevent natural brutality when he can, but only as long as the long-range consequences are considered. What hurts is that feeding starving deer, or even large masses of starving people, generally creates worse problems later on.

Concerning humane treatment of wild animals, it is time for the fisheries and wildlife professions to make changes of attitudes and management practices concerning humaneness to help diminish some of the uproar directed against the wildlife profession (Schmidt and Bruner 1981). But it all depends on how you defend your viewpoint. Hutchins et al. (1982) point out that by adhering to a philosophy that emphasizes a reverence for life, one may ultimately be unfaithful to his own ideas if conditions necessary for survival are ignored. For example, they conclude that to control exotic animals in order to preserve natural ecosystems or to protect endangered animals and plants is not incompatible with the humane ethic.

Perhaps the greatest distortion of the balance of nature stems from anti-death groups that fail to recognize how easy it is to love a species to death, or at least to cause it to have a miserable existence as a result of overprotection. It is a mystery to me how animal right-to-life and humaneness philosophies can condone coyotes disemboweling sheep and raptors brutally killing prey, yet be so opposed to sport hunting, a very effective and much more humane population management tool than natural predation or overprotection. Modern sport hunting or fishing has never led to the extinction of a wildlife species. Game species have literally never had it so good, since their habitats are protected and their population densities managed.

It is amazing how many people oppose the utilization of animal skins, furs, and meat. No "game animal" in this country is endangered as a consequence of being so categorized. It is natural to recycle nature's wares. Skins and furs, that are not from endangered species, are a renewable resource, whereas I don't think we have near the moral right to make our clothing from the finite supply of fossil fuel available, which we are using at an alarming rate.

How successful is an environmental impact statement (EIS) in protecting the balance of nature? Does an EIS force the holistic approach? To a degree "unwanted" discussion of trade-offs usually appears, but for the most part the consultant or other EIS compiler does his best to please his client, who is paying him for as favorable an EIS as can be contrived, and one that lawyers can successfully use in litigation proceedings.

Too many environmentalists attack environmental issues with a religious frenzy of strident rhetoric; they don't want to negotiate with a neutral mediator because their minds are made up and they would lose face to do so. The attitude that "I'm right, you're wrong, and I'll fight you to prove it" are counterproductive to solving environmental conflicts.

A good example illustrating how confused many people are about the balance of nature is illustrated by the large number who want locally unwanted or surplus animal "pests" to be live-trapped and transported for release elsewhere. It would be both more humane and biologically sound to turn such animals over to a humane society to be disposed of properly. The only justification for such releases is when a species is reintroduced into suitable habitat where its densities are well below the carrying capacity. Otherwise the habitat will already be occupied by the species and any new immigrant will find the aggression it is greeted with most traumatic. In fact, most such transported animals soon die.

We are all hypocrites because even the most dedicated environmentalists have become so antiseptic in their urban lifestyles that they consider most wildlife in cities pests, and instead of trying to help native species, they foster exotic imported pets (Howard 1974). How can urbanites so glibly think ranchers are wrong when they object to coyotes disemboweling their sheep and other livestock, when those in suburbia become nervous wrecks over just one pocket gopher or mole in their lawns or a rattlesnake on their patio? In general, rural people are much more willing to share part of their livelihood with wildlife than are urbanites.

The fraternity of decision makers concerning balance of nature aspects of our wildlife heritage is composed of a relatively small number of leaders, for the most part genuine, although some are hardly ethical. Decision making, however, is politics, and seldom are the decisions based on the best value judgement possible. The public seldom has a vote; we merely contribute (for lawyers' fees) to those environmental organizations which have convinced us with their propaganda that they know what should be done so as not to further upset the balance of nature and to save the environment.

One reason most environmental groups do not favor mediating disputes is that they can't raise funds by compromising. After you have aroused a following concerning an issue, will the supporters think you are letting them down if you mediate the issue? Furthermore, who is the spokesman for each environmental group? Who makes the decisions, as members of environmental organizations do not get to vote. All members can do is quit paying dues if they get misrepresented. It is not easy to vote leaders out of office in environmental organizations so you might as well start a new organization—and how they have mushroomed.

My reference to environmental groups is not all exclusive. For example, many, such as The Nature Conservancy, Wildlife Management Institute and National Wildlife Federation, do not promote extremist environmentalism from an altruistic point of view. Extremism has produced mutual distrust, and too many environmentalists believe you cannot compromise and still keep your principles, so they prefer lobbying and litigation over dialogue. Environmentalists are needed, and they have exposed many environmental insults by big business and governments. But they are not needed as obstructionists who polarize issues to the point of paralysis. The environmental organizations have learned to lobby congressmen and agency officials and then sue if they don't get their way. Lawyers go out to win, not compromise. Court decisions rarely address the real issues, since it is difficult to develop environmental solutions in court. With lawyers leading many of the environmental adversary groups, it is no wonder these organizations prefer a lawsuit to negotiation or mediation. Also, this approach serves well for raising funds from constituents.

Chief Justice Warren E. Burger (1983) questions whether lawyers today are fulfilling their "historical and traditional obligation of being healers of human conflicts." He points out how law schools have traditionally steeped the students in the adversary tradition rather than in other skills of resolving conflicts. Lawyers are natural competitors, and once litigation begins, they strive mightily, using every tactic available. When I debate with a lawyer, I explain to the audience that I am a scientist so must be objective, but please recognize that my opponent is a lawyer, thus I assume you know what his constraints are.

Conclusion

To protect endangered species, manage wildlife and control problem animals in ecosystems man has altered, and to do so in the most environmentally compatible manner possible, it is essential that we thoroughly understand the role of the "balance of nature" in such disturbed environments. Too often many in academia and the general public oversimplify such issues and advocate "let nature take its course," as if nature knows best. We would not have peat, coal, oil, shale, and guano deposits if nature had not failed in the recycling process (Dubos 1973).

Contrary to what many claim, there is a high degree of innate stability and resilience in naturally evolved animal-plant-soil communities. The so-called balance of nature in such ecosystems, if relatively undisturbed by man, is not delicately balanced. Animal-plant populations have coevolved to be quite stable. For example, if all of the deer in North America were removed, there would be little effect on other wildlife, except where predators of deer still exist, until changes occur in the vegetation due to lack of grazing and browsing by deer. In wildlife communities, competitive interactions between individuals of the same species are far more pronounced than between individuals of different species that have evolved a coexistence in a common community.

Habitats are not eliminated, only altered, and "nothing succeeds like biological succession" (MacMahon 1983) following the modification of an environment. Make a desert where a forest now stands and desert-adapted species will thrive. How many people are aware that in spite of the extinction of some wildlife species during historical times, there now are many more different kinds of wildlife present on all the nonpolar continents of the world than existed at the beginning of historical time?

Overprotection of wildlife species, even in national parks, which are really only biological islands, can work against the very goals being striven for, as all species of wildlife are predisposed to overpopulate and then become self-limiting by inhumane means we usually consider undesirable. Wildlife need to be "managed" when the objective is to improve the welfare of an individual or population of a species rather than leave the fate of the animals to the whims of nature. And wildlife must be "controlled" when the objective is to protect other species or resources, for public health reasons, or because someone currently views them as a pest, whether or not they are actually doing damage. It may be a surprise to learn that vertebrate pest problems are much easier to both identify and control with monoculture than with diversified agriculture.

Nature is harsh and cruel. Wildlife do not die nicely in nature, for nature has no life-support devices or homes for the elderly. There is an important role for the hunter, trapper, and animal control agent to play in preserving a healthy balance amongst wildlife in man-altered environments. Problem animals can be removed far more humanely by those means than would be their natural fate. If livestock operators managed domestic animals as badly as we often are forced to manage underharvested game, such as many deer herds, they would be arrested for being inhumane.

The "man must not meddle with nature" philosophy needs to be dispelled because to "leave it to nature" after man has altered the environment is seldom a wise solution ecologically or humanely. Few people realize that agricultural crops could not survive if all native mammals were treated like endangered species; in fact, most home landscaping and city parks would also be destroyed just by mammals alone.

Environmental organizations are needed as watchdogs of governments and businesses, but they are a hindrance when they polarize issues to the point of paralysis. Lawyers now lead many of these organizations, and most schools train lawyers in the adversary tradition rather than how to resolve conflicts by arbitration and negotiation.

In summary, once man has modified an environment, he has a moral obligation to actively both manage and control the wildlife species present. I recognize that individuals have different moral codes, but instead of promoting a biologically unsound "protectionist" ethic, if we have genuine compassion for wildlife, we must adopt a realistic "wildlife management and control" ethic, and start teaching the real role of the balance of nature in disturbed ecosystems.

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Meeting Migratory Bird Management Needs By Integrated Disease Control

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Introduction

Aspects of the conservation community concerned with maintenance of migratory bird populations face a common problem—a diminishing habitat base for population maintenance. Regional differences exist as does problem severity for different species; however, habitat loss and degradation will continue into the foreseeable future. Effects of site-specific habitat losses extend to species' needs throughout their entire life cycle and cannot be viewed in isolation. Breeding habitat is of limited value if birds do not survive to return to that habitat because of mortality resulting from deficiencies in migration and wintering portions of the habitat base. The opposite is also true; migration and wintering habitat is not fully utilized when production is poor or large scale population losses occur prior to, or during, early stages of migration.

Wildlife is a product of the land and one of the greatest challenges being faced by wildlife managers is to maintain more wildlife on less habitat. The degree of success achieved, to a large extent, will be dependent upon the manager's ability to deal with another product of the land—disease.

Disease problems of migratory birds are often associated with habitat quantity and quality, adding another dimension to more traditional perspectives of migratory bird habitat requirements (Friend 1981a). Some disease agents are as mobile as the migratory birds they infect. Therefore, disease outbreaks are often not appropriately evaluated as site-specific events. A disease outbreak occurring at one location may have impact at other, more distant locations. These two factors, habitat conditions and bird movement, are important reasons for addressing disease problems of migratory birds as an integrated component of migratory bird management and serve as the basic focus of this paper. In addition, recommendations are provided for development of more effective disease control through integrated efforts within the conservation community.

Problems

Current migratory bird disease control programs are rudimentary at best and minimally effective in meeting national needs because of their relatively recent origin, small size, and problems associated with shortages in personnel and operational funds as well as limited availability of facilities for conducting infectious disease work. Similar problems have been reported for domestic animal disease programs (Wilson 1983).

Professional-level specialists employed on a full-time basis to investigate and combat wildlife disease problems within the North American conservation community number less than 100 individuals. The number devoting their attention to disease problems in migratory birds is even fewer. This situation is compounded by limited availability of facilities and equipment for conducting disease research associated with highly pathogenic infectious agents. In addition, program planning for combatting migratory bird disease problems is ineffective because of demands for available programs and personnel to use their limited resources for fire fighting and crises response. Inadequate data, poor communications, and institutional infrastructure (turf) considerations compound the problem of disease prevention and control.

Other problems could also be cited. However, solutions, not problem identification, are the substance of improved disease control programs. Problem identification should only serve to focus attention on issues to be addressed, not be an end in itself or serve as acceptable reasons for not addressing issues identified.

Disease Considerations

Perspectives towards the weather and disease problems in migratory birds tend to be similar—we talk a lot about it, we may even have a great deal of interest in it, but we do not feel much can be done to change anything. However, reliable weather forecasts allow us to protect ourselves and our property from the ravages of violent weather conditions. Achievement of similar predictive capabilities for disease outbreaks is the essence of disease prevention and control. This predictive capability should be an important goal in the conservation of migratory birds. Achievement of this goal will require increased awareness, responsiveness, and collaboration throughout the conservation community.

Current familiarity with disease concepts involving migratory birds tends to be comparable to violent weather conditions. Concern and awareness are high when the problem occurs in our area. During other periods, passive and even unconcerned attitudes prevail. Concern for disease problems must be elevated to a continuous basis for meaningful progress to be made. Disease outbreaks are not isolated events that just happen. They cannot be treated as such if maintenance of more birds with less habitat is going to be achieved in discharging stewardship of our migratory bird resources. Disease considerations will need to be given more attention in migratory bird managment.

Unlike the west to east movement of weather, north-south movement patterns are more typical of movement of infectious disease in migratory birds, as shown by apparent pathways associated with avian cholera in waterfowl (Friend 1981b). A classic example of this movement and resulting interspecies losses occurred during 1979–80. An outbreak of avian cholera in snow geese (*Anser c. caerulescens*) on Hudson Bay breeding grounds during the summer of 1979 was followed by a series of additional avian cholera outbreaks in the Mississippi and Central Flyways. These outbreaks involved a wide variety of waterfowl species and occurred in a time sequence consistent with the southward movement of waterfowl to wintering areas on the Texas Gulf Coast and their northward return to spring migration staging areas during 1980 (Brand 1984).

Disease outbreaks among migratory birds occur during all seasons of the year. Site-specific losses in excess of 10,000 birds are common and losses of 25,000 to 50,000 or more occur too frequently to be ignored. During 1983–84, disease outbreaks killed more than 28,000 migratory birds at Tulare Lake National Wildlife Refuge (NWR), California; the toll at Stillwater NWR, Nevada exceeded 47,000; and at Bear River NWR, Utah more than 16,000 birds died (National Wildlife Health Laboratory [NWHL] files). Many other examples could be cited. These losses are not insignificant and compound losses of breeding habitat.

Waterfowl and other migratory birds are subjected to a continual series of disease agents during their life cycle. Avian botulism is a primary disease during late summer, avian cholera is more prominent during late fall through spring, and lead poisoning has its greatest impact during late winter and spring.

Overt mortality associated with die-offs remains the only area of concern regarding disease problems in migratory birds. Diseases such as avian influenza that often have their primary impact on productivity receive virtually no attention within the conservation community. In addition, disease continues to be viewed as a simple cause and effect relationship between a disease agent and a host. Some progress is being made in appreciating the role of environmental quality, but the study of potential interactions involving chemical and microbial agents continues to be ignored.

The complexity and magnitude of the tasks associated with enhancing capabilities for combatting diseases of migratory birds should not serve as a deterrent. The conservation community is capable of meeting this challenge without forsaking other major objectives and needs. However, this challenge cannot be met by business as usual. Disease in migratory birds cannot be dealt with as a natural event, a biological accident, or from similar noninterfering or reactive perspectives. Disease is an environmental barometer reflecting conditions migratory birds are encountering. Disease problems of migratory birds are part of the biology and management of the species involved and must be addressed as such.

Migratory bird management efforts will continue to be addressed on a diminishing-habitat basis requiring more intensive habitat and population management. In the domestic animal industry increased animal management has resulted in new problems and new diseases (Brander 1979, Strauch 1978, Halpin 1975). North American waterfowl have also become subject to new disease problems during relatively recent times (Friend and Pearson 1974, Friend 1981a, b).

Agriculture has been able to successively combat emerging disease problems. Similarly, major success in combatting human health problems associated with changes in the human environment has also occurred. The time is overdue for development of more productive wildlife disease control programs if wildlife managers are to be able to meet future needs for maintenance of migratory bird populations.

Program Development

A healthy future for migratory birds requires: (1) better capacity than currently exists for combatting disease problems, (2) a major shift in philosophy towards disease from a reactive to an active approach, and (3) greater emphasis on reducing losses from disease before the first breeding cycle. Any realistic solution for significantly increasing capabilities for combatting disease problems must be accommodated without major increases in funds and personnel for the foreseeable future. This solution requires better use of available resources and clearly identifies the importance of a basic foundation of collaborative efforts.

"Planning has been defined as the process of deciding how the future should be better than the present, what changes are necessary to make those improvements, and how the changes should be implemented" (Bispham et al. 1971, cited by Fernades et al. 1983:631). Major improvements in disease data bases, communication of these data, and more in-depth evaluation of disease problems and concepts are changes needed to facilitate development of increased capabilities for combatting disease in migratory birds. The flyway council system provides a possible mechanism for implementation of these changes.

Disease Management—A Flyway Concept

"Waterfowl challenge the manager because they are here today and gone tomorrow. Since they roam the length and breadth of the North American continent, they require a high level of cooperative management, both internationally and intranationally. Such a resource is best handled through a council" (Mississippi Flyway Council 1970:1). Disease control in migratory birds is also best handled through a council for these same reasons.

Adaptation of the flyway council system to address disease control in migratory birds makes use of an existing system developed specifically for waterfowl management purposes. More importantly, this forum is where the interface between disease concerns can best be integrated with other aspects of migratory bird management. Also, the communication process already established within the flyway council system provides suitable pathways for the orderly flow of important disease information to administrators and technicians alike.

Some modifications in the existing system will be required to accommodate disease management needs satisfactorily. A standing committee on disease control should be established within each flyway council. In addition, technical committees dealing with specific diseases or problem areas should be established within flyways as need arises. These committees should interact with their respective flyway councils in the same manner as other flyway technical committees. A need also exists for coordination between flyways. This coordination might be accomplished best through an executive council composed of the chairperson of each flyway council disease committee.

A coordinated disease control effort of the type identified above is in early stages of development within the Central Flyway, but outside the flyway council system. This embryonic program might be most beneficial if it became part of the Central Flyway Council and serve as a catalyst for development of similar collaborative disease control programs.

The Interagency Playa Lake Disease Council was developed from November and December 1983 meetings of concerned biologists assembled at Lubbock, Texas to develop a strategy for addressing disease problems of migratory birds wintering on playa lakes of the Southern High Plains. This ad hoc council consists of a five person executive committee composed of individuals from Texas Tech University (chairman), U.S. Fish and Wildlife Service (FWS), Texas Parks and Wildlife, and the Central Flyway Representative. The purpose described for this council is:

> To function as an interagency body for disease research and management in the playa lake region and associated wildlife resource areas, specifically to assess management proposals and recommend priorities, to offer technical assistance and to provide information transfer to the public and scientific communities (Bolen 1981).

To achieve these goals, six technical committees were established: Migratory Bird Population Dynamics, Disease Investigation, Communications and Public Education, Environmental Quality, Disease Management, and Research. The Research Committee is composed of the chairperson from each of the other five committees. Technical committee composition is limited to scientists and managers in the subject area of concern. Cross fertilization of concepts is achieved through the Research Committee. Committee recommendations are acted upon by the administrative and coordinating body, the executive council.

All of the technical committees are focused on combatting disease problems of the playa lake area. The entire disease triangle, i.e., host, agent, and environment, is being addressed. Relationships between component parts of the triangle are investigated to identify weak links in disease cycles that can be broken to control specific disease problems. Expertise and interactions of technicians from a variety of scientific disciplines is required and timely communication of information gained is considered as important as any other aspect of this effort.

This fledgling approach represents a potential blueprint for others to use and modify. The Council is not a funding body. It is a forum for interagency planning, priority establishment, and research effort coordination for disease investigations in the playa lake region. The members share their technical expertise to address a common goal of minimizing migratory bird losses from disease. Research conducted by Council members or their agencies is expected to contribute to this goal by methodically focusing these efforts on specific questions in an overall strategy for disease control in the playa lake region.

Data Collection and Information Transfer

Disease programs must be based on sound scientific information (Clarke 1983, Atwell 1983, Hanson and Hanson 1983). The need for a continually improving data base is the fundamental building block for any significant improvement in disease control capabilities in migratory birds. Without sound, hard data, "evaluations and optimizations can only be inspired guesses" (Hugh-Jones 1983:651). Major information needs for migratory birds include development of specialized disease profiles, better information regarding the distribution of disease agents, better disease prevalence data, and general disease data banks.

Data Banks. Methodical collection and reporting of data relative to wildlife disease problems can be accomplished throughout the conservation community by disease specialists and nonspecialists alike. In its simplist form, this reporting consists of identification of dates of problem occurrence, specific location, estimated losses by species, and suspected cause of the problem. At the other extreme, a detailed report supported by appropriate field investigations and laboratory assays addresses a more comprehensive set of specific questions. Regardless of the level of intensity or scientific rigor associated with data gathering, standardization of records and establishment of data repositories are useful activities.

Establishment of composite data banks is an essential aspect of migratory bird disease data collection. Initially, undue attention need not be focused on how representative or precise data are. We always have a need to work with soft data that are incomplete, biased, and frequently without controls, yet these data are still valuable. "These data bases, weak as they seem, are of great value in indicating areas of concern, can save time in the design of detailed and appropriate studies and surveys and the initiation of control procedures" (Hugh-Jones 1983:652). Investigation of apparent areas of concern will quickly disclose any lack of validity in hypotheses generated from these data, thereby providing additional information.

For example, the NWHL eagle data base contains information on causes of mortality of nearly 1,300 bald (*Haliaeetus leucocephalus*) and 700 golden (*Aquila chrysaetos canadensis*) eagles during the period of 1963–1982 (Sileo et al. 1984). Causes of death for these eagles were determined by pathologists with various degrees of technical training. The quality of specimens received was highly variable, as were the laboratory assays used to assist in determination of cause of death. The purpose for examination was also an important variable and included law enforcement activities and, environmental contaminant studies. In addition, eagle processing occurred at more than one laboratory. The NWHL did not come into existence until 1975 or become active in processing large numbers of eagles until 1976.

Eagle management implications are readily evident from these findings regardless of data fragility and any biases present regarding relative causes of mortality in eagle populations. Specifically, major causes of mortality, the time of year these occur, and the geographic locations of occurrence provide a basis for problem identification and management actions to reduce losses in those geographic areas. Further evaluation of these data provides a basis for hypothesis generation which provides direction for research needs and establishment of research priorities. These data also have long term value for evaluating trends in eagle mortality and effects of management efforts to address specific causes of mortality.

The value of data assessments is directly related to quality of data entered into the system and personal knowledge of individuals developing the assessments. Both are variables that change over time. Developing truly reliable data requires properly designed studies conducted with rigor and discipline (Hugh-Jones 1983). This goal should be constantly sought, but is unlikely to be fully achieved and should not be an impediment to the use of composite data banks.

Disease Profiles. An understanding of ecological relationships between environmental conditions, including habitat quality, and disease problems is a critical migratory bird management need. Specific diseases such as avian botulism, lead poisoning, and avian cholera have ecological requirements that affect probability for their occurrence and magnitude of losses likely to occur. Methodical development of habitat and ecological profiles associated with the occurrence of diseases provides unique data bases for risk assessment and management purposes. Integration of these relationships with Habitat Evaluation Procedures (HEP), wetland classification systems, and environmental monitoring programs has direct application for habitat acquisition evaluations and for further development of migratory bird species, population, and flyway management plans. These data also have direct application in evaluation of current issues such as use of irrigation drainwater for marsh management (Miller 1983) and use of wetlands for wastewater disposal (U.S. Environmental Protection Agency and U.S. Fish and Wildlife Service 1984).

Distribution and Prevalence Data. The adage, "an ounce of prevention is worth a pound of cure," is especially relevant and reflects the type of active posture needed for combatting diseases of migratory birds. Disease prevention is far less costly than disease control. Therefore, a critical question that needs to be addressed when disease occurs is whether the disease is a new or established problem. The answer has direct application for selection of response actions.

Baseline data on distribution and prevalence of diseases and parasites of migratory birds are often inadequate for reaching informed judgements regarding disease risks. Areas of specific concern include activities that could result in introduction of: (1) new disease agents, (2) disease vectors, (3) animal hosts that serve as disease reservoirs or amplifying hosts for disease cycles, and (4) species highly susceptible to diseases already present in migratory birds. Examples of application of these data include environmental assessments of development projects in Alaska, including agriculture; endangered species consultations; evaluation of migratory bird translocation programs (including endangered species); and release of captive-reared migratory birds (including endangered species).

Recent examples of response to domestic animal diseases include quarantine and population eradication procedures currently being used by the U.S. Department of Agriculture in the avian influenza outbreak in Pennsylvania, against an exotic strain of Newcastle Disease virus in California (Walker et al. 1973) and other locations, and to eradicate African swine fever in the Caribbean (Chain and Rodriguez 1983, McCauley 1983). All of these attest to the importance of having sound baseline data to support disease prevention and control activities. Absence of sound data bases for migratory birds has resulted in controversy regarding control efforts involving duck plague (duck virus enteritis), inclusion body disease of cranes, and lead poisoning. Status of duck plague in wild North American waterfowl and inclusion body disease in cranes remains unresolved. Prevalence of lead poisoning continues to be debated. These examples focus attention on the need for good data bases for old as well as new disease problems.

Information Transfer. Interpretation of soft data is more an art than a science. The value of interpretations made depends on experience and knowledge of the situation and reporting structure (Hugh-Jones 1983). Therefore, caution must be exercised, and the art of interpretation might most reliably be considered a communication function assumed by wildlife disease specialists as various data sets become available. Data need to be methodically deposited, compiled, analyzed, and communicated to contributors and other users. Three distinct levels of communication are involved: (1) contact-notification procedures, (2) periodic information exchange, and (3) timely problem analysis statements.

Contact-notification procedures should be organized formally to provide direct communications between individuals faced with the problem, those involved with maintenance of the appropriate data bank, and those needing to be aware of the problem. This should expedite, not interfere with local, regional, or agency processes for dealing with disease problems.

A process similar to that being used at the NWHL can accommodate rapid communications without onsite involvement. Telephone contacts from refuge managers and others are recorded in a methodical manner to assure specific information is received. These data become part of a composite data base. Appropriate individuals are then notified of the event if a die-off or significant information is involved.

Two contacts should be made routinely within a flyway disease program, one to the flyway representative and the other to specific disease technical committees within that flyway. The flyway representative should have responsibility for contacts with state agencies and others requiring general notification of the event. Technical committee notifications provide opportunity for information gathering relative to committee activities involving specific diseases or problem areas.

Data obtained under contact-notification procedures need to be compiled on a regular basis and distributed throughout the conservation community. Quarterly reports and an annual summary of the year's data and significant events should be prepared. Appropriate contributions from outside the data bank should be included, but report content should be limited to information relative to identification and control of disease problems in migratory birds. This process fills the need for periodic information exchange and would likely expand to a monthly report as the program develops. Because of nationwide involvement in disease problems of migratory birds and its mission within the FWS, the NWHL might be an appropriate initial repository for receiving, compiling, and distributing periodic reports and evaluations of disease problems.

The other level of disease reporting required involves in-depth evaluation of specific issues. These issues might best be addressed by appropriate technical committees and groups within the flyway organization and result in recommendations for flyway council consideration. Issues that might be considered include vaccine use for control of disease, health certification standards for release of captive-reared migratory birds, and status assessment of specific diseases in migratory bird populations. Ability to obtain technical evaluations from nonagency groups will benefit control efforts involving migratory birds because many issues may have controversial aspects associated with them.

Summary

The need to combat diseases of migratory birds more effectively will intensify because of need to counteract effects of continual habitat losses. Degradation of habitat will increase potential for disease transmission and the emergence of new disease problems. Migratory bird mobility provides a ready mechanism for spread of disease to locations greatly removed from the site of initial outbreaks.

Disease control and management on a flyway basis is needed to combat disease problems of migratory birds more effectively. Modifications in the flyway council system are suggested for implementation of an integrated approach to disease control. Flyway management of disease problems is not a new concept and has been used for addressing lead poisoning in waterfowl (Greenwalt 1976). However, integration of disease concepts in the management of migratory birds on a flyway basis has not been attempted to the extent identified in this paper. Information and communication needs to achieve the goal of minimizing losses of migratory birds to disease are also identified.

The limited resources available for disease investigations dictate that sound planning efforts serve as the foundation for program development, priority assessment, and coordination of efforts. Effective disease control in migratory birds is achievable. However, disease control will not happen without adjustments in current perspectives and approaches to disease problems.

> A prime requisite of long range planning for animal disease control or eradication is an attitude of mind that sustains an unflagging optimism toward the ultimate accomplishment of desired results, coupled with an equally persistent skepticism toward dogmatic formulae promising either certain success or certain failure.
>
> A long range plan cannot remain inviolate. It must undergo constant critical review and modification as necessary to: accommodate newly acquired scientific or practical information; meet changing economic conditions; account for differences in available resources; and adapt to developments in the attitudes of the public toward the existence of the disease of concern and the procedures for control or eradication (Clarkson 1973:13).

I hope that the "attitude of mind" called for in the above quotation is present to a sufficient degree within the conservation community. If so, effective control of disease in migratory birds can become reality. Like the weather—we need not just talk about it, we have the capability to do something about it. The choice is clearly ours.

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Field Evaluation of Two Models Developed Following the Habitat Evaluation Procedures

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Introduction

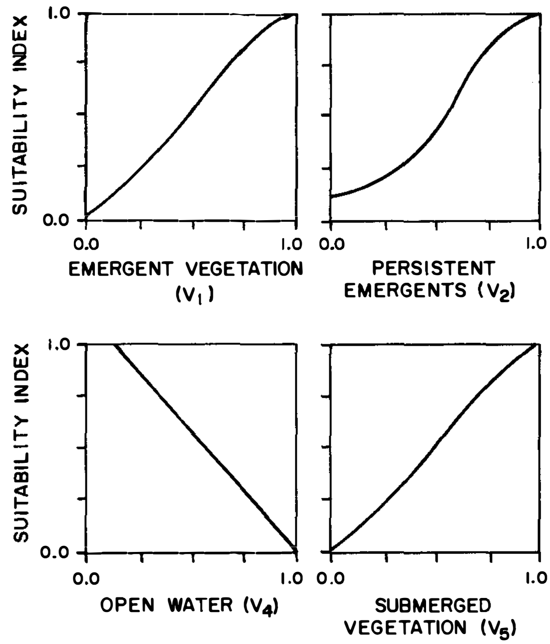
The U.S. Fish and Wildlife Service has recently developed a system for evaluating habitat suitability for individual species (Flood et al. 1977, Division of Ecological Services 1980). The models developed using the Habitat Evaluation Procedures (HEP) approach are constructed by estimating how key habitat variables affect population densities. These relationships are described in "suitability index" graphs. The habitat suitability index (HSI) rating for a site is a number between 0.0 and 1.0 determined by combining suitability indices.

HSI models have been published or are being developed for more than 80 species. Various agency regulations mandate or encourage their use in environmental assessment, development of management plans, and in inventories and habitat evaluations. Yet despite this wide use, few field evaluations of the models have been published. They often are developed solely on the basis of literature searches and reviews by species experts, and several authors (e.g., Farmer et al. 1982, Lancia et al. 1982, Thomas 1982, Cole 1983) have expressed concern over their reliability. This project was undertaken to determine how accurately two of the models estimate population levels. It should be noted that the purpose of the HSI models is to estimate habitat quality rather than population density per se. This point might be critical with species whose densities were limited on other areas (e.g., wintering grounds) or with species which have a significant delay in tracking their environment (since then the habitat might be excellent but happen not to have high densities due to the time lag). With muskrats, however, neither of these qualifications applies, and it therefore is of interest to know whether the HSI ratings were strongly correlated with population levels.

The Models

The two models both evaluate muskrat habitat. One model applies to coastal populations (Figure 1); the other applies to inland populations (Figure 2). The coastal model (Hoffman 1983) estimates habitat suitability using three vegetation and two water regime variables.

This paper was cooperatively supported by the U.S. Fish and Wildlife Service, the Ohio Division of Wildlife, The Ohio State University, and the Wildlife Management Institute.



EQUATION FOR HSI

$$\frac{2(V_1V_2V_3)^{1/3}+(V_4V_5)^{1/2}}{3}$$

Figure 1. Summary of the Habitat Evaluation Procedures model for coastal muskrats. See text for explanation of terms.

The vegetation measurements are coverage by emergent vegetation, proportion of the emergent vegetation which is persistent (does not die back annually), and proportion of the persistent emergent vegetation composed of Olney bulrush (*Scirpus alneyi*) and cattail (*Typha* sp.). The water regime variables are proportion of the site covered by open water and proportion of the open water area having submerged vegetation.

The inland model (Allen 1982) also estimates habitat suitability using three vegetation and two water regime measurements. The first two vegetation measurements are coverage by stands of emergent species and coverage by stands of persistent emergent species. "Stand" was not defined in the model, but Allen (pers. comm.) provided the following definition: a patch of vegetation which covers at least 30 percent of the surface of the water. In moving from the center of a dense stand toward open water, the stand border is crossed at the point where vegetation covers 30 percent of the water surface; the area beyond that point is classified as open water even if it has some sparse vegetation. The third vegetation measurement is the proportion of persistent emergent vegetation composed of cattail. Note that this measure is 1.0 in a pure cattail stand even if the stand covers only 40 percent of the surface. The water measurements relate to annual water level fluctuations. One is a categorical variable taking the value 1.0 if the water is permanent and 0.15 if the water is semi-permanent. The second measurement is the annual water level fluctuation in meters.

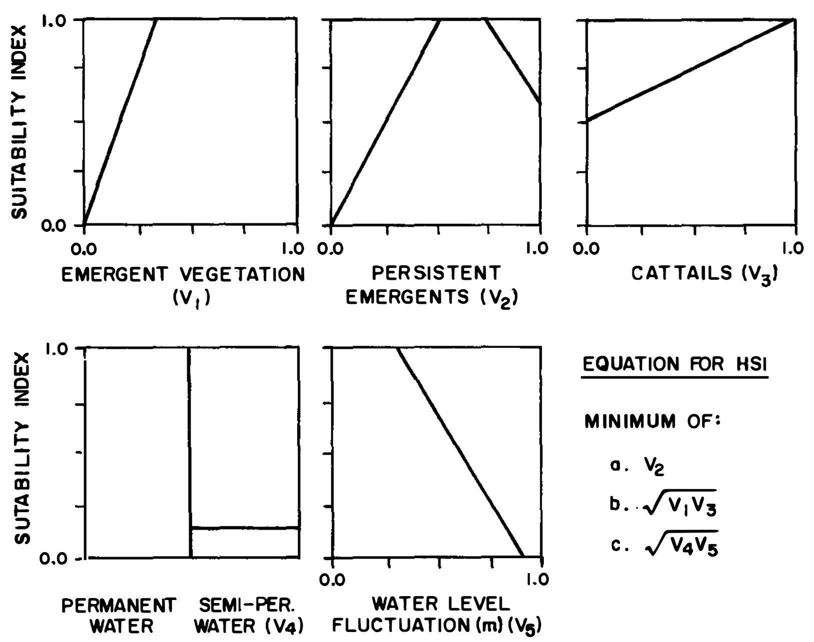


Figure 2. Summary of the Habitat Evaluation Procedures model for inland muskrats. See text for explanation of terms.

Study Areas and Methods

The coastal model was tested during December 1982 on 15 sites in Louisiana varying in size from 80 to 280 ha (Figure 3). The dominant plants were Olney bulrush and *Scirpus patens*. The inland model was tested during January 1983 on 24 sites along the southwestern shore of Lake Erie. The sites varied in size from 2.4 to 38.4 ha and were located on Ottawa National Wildlife Refuge, Magee Marsh Wildlife Management Area, and Winous Point Shooting Club (Figure 4). The dominant plant species included cattail, bur-reed (*Sparganium americanum*), and other species of less importance to muskrats.

The habitat measurements were obtained by strip or line intercept sampling. In the coastal study, one observer in a helicopter recorded measurements while flying at approximately 15 km/hr and 5 m height. The helicopter hovered every 100 meters so that more precise measurements could be obtained. The measurements made while moving and stationary did not differ significantly and were therefore combined in the analysis. Two days were spent training the observer, both on the ground and from the air, to insure that the visual estimates would be sufficiently accurate for the experiment. Muskrat houses within a semicircle of 100 m radius were counted by a second observer at each location where the helicopter hovered. The inland model measures were obtained by observers walking randomly oriented line transects. Estimates of non-persistent emergent vegetation (needed to obtain total emergent vegetation) were obtained from the refuge managers.

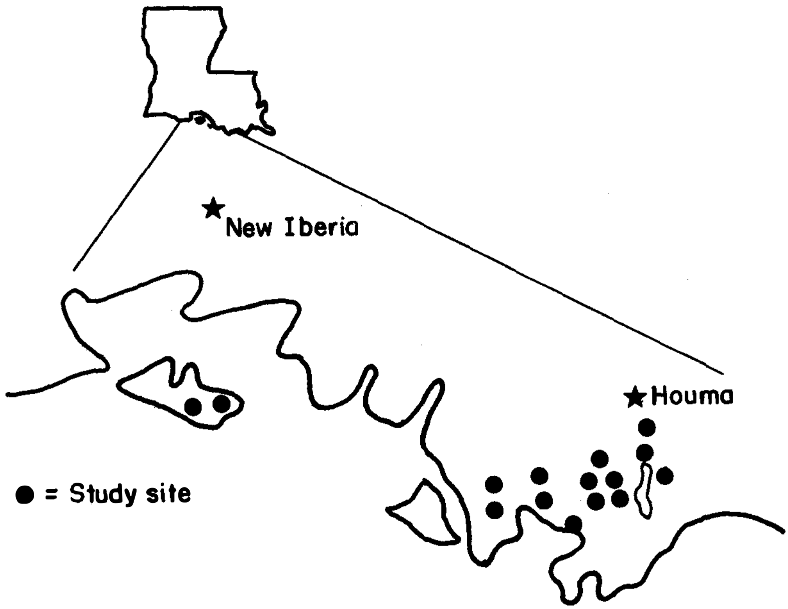


Figure 3. Locations of sites used in evaluating the HEP coastal muskrat model.

These survey methods are comparable to, or more accurate than, ones which would be used by field workers employing the habitat models we were evaluating.

Independent estimates of relative muskrat density were used to assign all sites to one of the following density categories: low, medium, and high. In the coastal study, sites with comparable trapping effort were selected, and assignments were made based on the mean number of pelts taken per ha during the three years immediately preceding the study. In the inland study, observers counted all active muskrat houses on each site during the surveys and assignments were made on the basis of number of houses/ha. In each evaluation, one-third of the sites were assigned to each of the three categories. Note that no effort was made to assign precise ranks on the basis of the trapping records or den counts. We assumed only that they were sufficiently accurate to identify low, medium, and high density sites.

The models were evaluated by determining how many of their ratings agreed with the independent estimates. Two evaluations were made. In the first, the range of possible HSI values, 0.0–1.0, was divided into three equal intervals, 0.0–0.33, 0.34–0.66, 0.67–1.0, corresponding to low, medium, and high density. In the second evaluation, the sites were ranked by their HSI values, the lowest third were classified as low density sites, the middle third were classified as medium sites, and the highest third were classified as high density sites. The rationale for these methods was that a biologist asked to rate a few sites would probably use equal-sized intervals between 0.0 and 1.0. If he had a large sample of sites, he might make assignments based on ranks. The model's performance may be evaluated by noting that if the ratings were chosen at random, approximately one-third of them would be correct. This method of evaluation is easy to understand and

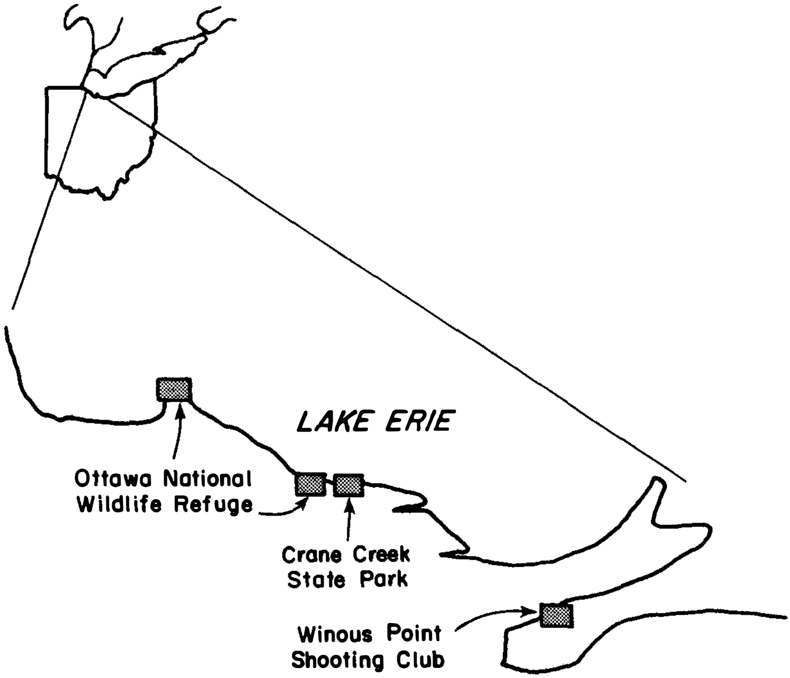


Figure 4. Locations of sites used in evaluating the HEP inland muskrat model.

its results are simple to interpret. Neither more complex evaluation methods nor methods based on the correlations between HSI estimates and the independent estimates of density produced results differing significantly from those reported below.

Results

Among the coastal sites, coverage by emergent vegetation varied from 50–100 percent, all of the emergent vegetation was persistent and Olney bulrush composed 0.0–70 percent of the emergent vegetation. Open water covered 0.0–50 percent of the sites and submerged vegetation covered 80–100 percent of the open water area. The number of pelts/ha varied from 0.0 to 15.0 (Table 1).

Among the inland sites, coverage by stands of emergent vegetation varied from 41–100 percent, coverage by stands of persistent emergent vegetation varied from 35–100 percent, and from 0.0–100 percent of the persistent emergent stands were composed of cattails. Twelve of the sites had permanent water, 12 had semi-permanent water. Annual water level fluctuation varied from 0.31–0.77 meters. The number of houses/ha varied from 0.6–20.9 (Table 2). Few sites of any importance to muskrats in either study region have values of any of the variables exceeding the ranges exhibited by our sites (Linscombe, pers. data; Bednarik, Herzberger, Meeks, pers. comm.).

In the coastal evaluation, 3 or 5 of the 15 sites were classified correctly depending on which method of assigning ratings was used (Table 3). Few relationships between the

Table 1. Characteristics of sites used in evaluation of coastal HEP muskrat model. See text for explanation of terms.

				% coverage emergent sp.			% coverage	
					Persistent sp.			
Site #	Size (ha)	Muskrat hses/ha	Muskrat pelts/ha	Total	Total	O. bulrush	Open water	Sub'd veget.
1	80	12.8	15.0	100	100	18	0	—
2	120	37.1	11.9	50	100	28	50	80
3	90	29.0	10.7	65	100	37	35	100
4	225	52.3	4.8	75	100	35	25	100
5	240	23.4	4.2	65	100	7	35	80
6	130	14.2	4.0	70	100	41	30	100
7	130	9.0	3.6	60	100	5	40	80
8	280	7.2	2.3	100	100	30	0	—
9	80	8.8	2.1	100	100	13	0	—
10	100	2.0	1.1	90	100	15	10	100
11	260	17.3	0.4	65	100	14	35	100
12	180	6.8	0.4	90	100	5	10	100
13	130	0.0	0.4	100	100	0	0	—
14	100	0.0	0.0	100	100	40	0	—
15	260	0.7	0.0	100	100	70	0	—

Table 2. Characteristics of sites used in evaluation of inland HEP muskrat model. See text for explanation of terms.

Site #	Size (ha)	Muskrat hses/ha	% coverage emergent sp. Total	Persistent sp. Total	Persistent sp. Cattail	Water regime	Annual water fluc. (m)
1	8.0	20.9	100	85	45	Perm	0.43
2	3.2	20.6	92	77	78	Perm	0.43
3	11.2	18.8	79	64	3	Perm	0.43
4	2.5	15.6	100	95	0	Perm	0.31
5	12.4	13.6	87	72	25	Perm	0.43
6	15.2	10.9	100	91	70	Perm	0.43
7	4.8	10.2	100	95	100	Perm	0.31
8	24.0	10.1	96	81	42	Perm	0.43
9	4.0	9.2	100	86	50	Semi	0.77
10	2.8	8.6	100	100	0	Semi	0.52
11	6.0	5.5	91	76	97	Semi	0.77
12	2.4	5.4	100	98	7	Semi	0.62
13	20.0	5.2	100	89	9	Semi	0.62
14	14.0	5.1	64	79	21	Semi	0.77
15	24.0	4.7	100	92	23	Semi	0.62
16	3.2	4.4	85	75	0	Perm	0.31
17	38.4	4.2	88	78	44	Perm	0.43
18	34.0	3.7	45	35	60	Perm	0.31
19	3.6	3.6	96	86	82	Semi	0.37
20	8.4	2.0	75	65	18	Semi	0.62
21	21.2	1.9	48	38	39	Perm	0.43
22	7.2	1.8	74	64	0	Semi	0.62
23	6.0	0.7	88	78	46	Semi	0.62
24	3.2	0.6	68	58	1	Semi	0.31

HSI values and the estimated densities could be detected. The site with the highest HSI value had one of the two lowest estimated densities. In the inland evaluation, 9 or 11 of the sites were correctly classified depending on which rating method was used (Table 4). There appeared to be a tendency to rank high density sites correctly but medium and low density sites incorrectly, though this pattern could have been produced by chance alone. Overall, the models did not perform significantly better than models which selected ratings at random.

Discussion

Why did the models perform so poorly? One possible explanation is that the wrong variables were included. However, muskrat experts throughout the country reviewed the models, and they generally agreed that the factors most important in determining muskrat densities were included. Furthermore, addition of new variables did little to improve the model's performance. For example, we tried adding the amount of bur-reed and the ratio of perimeter to area to the inland model. Bur-reed is an important food source of muskrats along Lake Erie, and its abundance varied greatly among the sites. We used it alone and in combination with the abundance of cattail. We incorporated the ratio of perimeter to area because we noticed during the field work that most of the houses were within several meters of the edge of stands. Nonetheless, we were unable to improve the model's performance substantially by adding either of these variables. Thus, if the critical variables were omitted, it is not going to be easy to identify and incorporate them.

We believe the main reason the models failed to perform well is that the interactions among variables are too complex to be modelled without extensive field trials (The models

Table 3. Performance of the HEP coastal muskrat model in evaluating 15 sites for which independent estimates of muskrat density were available.

Site no.	# pelts per ha.	Rating	HSI value	Rating[a] I	Rating[a] II
1	15.0	H	.72	H	M
2	11.9	H	.78	H	H
3	10.7	H	.75	H	M
4	4.8	H	.58	M	L
5	4.2	H	.51	M	L
6	4.0	M	.76	H	H
7	3.6	M	.50	M	L
8	2.3	M	.81	H	H
9	2.1	M	.68	H	M
10	1.1	M	.61	M	L
11	0.4	L	.64	M	L
12	0.4	L	.64	M	M
13	0.4	L	.85	H	H
14	0.0	L	.69	M	M
15	0.0	L	.98	H	H
No. correct ratings				5	3

[a] I: HSI of 0.00–0.33=low (L) density; 0.34–0.66=medium (M) density; 0.67–1.0=high (H) density. II: lowest five HSI values =low, middle five=medium, highest five=high density.

Table 4. Performance of the HEP inland muskrat model in evaluating 24 sites for which independent estimates of muskrat density were available.

Site no.	Number of houses/ha.	Rating	HSI value	Rating[a]	
				I	II
1	20.9	H	0.75	H	H
2	20.6	H	0.83	H	H
3	18.8	H	0.72	H	H
4	15.6	H	0.65	M	M
5	13.6	H	0.79	H	H
6	10.9	H	0.69	H	M
7	10.2	H	0.65	M	M
8	10.1	H	0.79	H	H
9	9.2	H	0.19	L	L
10	8.6	M	0.31	L	M
11	5.5	M	0.19	L	L
12	5.4	M	0.27	L	M
13	5.2	M	0.27	L	L
14	5.1	M	0.19	L	L
15	4.7	M	0.27	L	L
16	4.4	M	0.71	H	M
17	4.2	M	0.82	H	H
18	3.7	L	0.87	H	H
19	3.6	L	0.37	M	M
20	2.0	L	0.27	L	L
21	1.9	L	0.84	H	H
22	1.8	L	0.27	L	L
23	0.7	L	0.27	L	L
24	0.6	L	0.39	H	M
No. correct ratings				9	11

[a] I: HSI of 0.00–0.33=low (L) density; 0.34–0.66=medium (M) density; 0.67–1.0=high (H) density. II: lowest eight HSI values =low, middle eight=medium, highest eight=high density.

were developed without conducting field work.) There are two aspects of this point. First, there is an implicit *ceteris paribus* assumption involved in drawing the habitat variable graphs (Figures 1 and 2). There is only one graph for each variable, not one graph for each relevent combination of other variables. For example, open water is generally regarded as a negative factor in the coastal model on the reasonable assumption that the more open water there is, the less food and cover there will be. But in the Louisiana sites many of the patches of open water are due to former eatouts. The sites are probably poorer than they would be if the open water were covered by beneficial plants. But these sites may have been partly eaten out because other, subtle factors made them high quality sites. If this is true, then there should be two open water graphs: one for natural openings and one for openings caused by eatouts. Many interactions such as this one are possible, but investigation of them would require extensive field work. Furthermore, in many cases, including the eatout example, it probably would not be possible for biologists rating the site to obtain enough information to determine which graph should be used.

The second sense in which interactions among variables is important is that as the number of variables in an equation increases, their influence on each other rapidly becomes difficult to predict. Variables taking consistently high or low values, or variables having high positive or negative correlations, are just a few of the situations with impacts that are hard to predict. Computer simulations may be helpful in studying how the models respond to different input values. But with models having five or more variables, such simulations may only show that the models behave erratically. This seems indicated by the results in our study.

Several steps might be taken to improve the reliability of the models. Field work during model development seems essential, and it must be conducted in widely separated areas because many species show considerable variation in habitat requirements in different parts of their range. The structure of the HSI equation also merits consideration. Current equations contain one variable representing each habitat variable thought to be important to the species. The equation is thus a simplified description of the process believed to determine abundance. There generally is insufficient information to delete members of highly correlated pairs of variables or variables which interact strongly but unpredictably with other variables. If the models are developed through field work, it may be possible to consolidate the equations, producing simpler models justified empirically on the basis that they work rather than on the basis that they mimic the natural processes and therefore, in theory, ought to work. The issue of whether or not HSI models should include a component for each important habitat variable deserves detailed study.

It is also possible that the current practice of not using direct abundance estimates should be re-examined. If habitat measures alone were sufficient to indicate population levels, then perhaps direct estimates could be ignored on the basis that sometimes they are difficult or impossible to obtain. But this study suggests that reliable habitat models may be difficult to develop. When abundance estimates are available it seems only prudent to use them. As an example, consider how the counts of muskrat houses made during the coastal evaluation might be used. Assigning the 5 sites with the highest house density to the high category, the next 5 to the medium category, and the lowest 5 to the low category produces 12 correct assignments—a substantial improvement over the 5 correct assignments made by the HSI model. In many cases, it seems likely that abundance estimates could be obtained with little extra effort while collecting the habitat measurements.

In summary, both HSI models performed poorly during this evaluation. The results appear to be due to basic problems in the process of model development, especially not conducting field work and not studying interactions between the variables in sufficient detail. The poor performance is disturbing in view of the fact that several dozen other HSI models have been completed but few evaluations of them have been published.

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Migratory Birds: Status and Needs

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Introduction

The mallard (*Anas platyrhynchos*) is the most widely distributed and abundant duck in field and bag within both Canada and the U.S. During recent years the overall population of mallards has been decreasing, much to the concern of sportsmen, biologists, and administrators alike. In this paper, we report status and trends of mallard populations and harvests and discuss those issues likely to influence mallard numbers, distribution, and management in the years ahead.

Population Status

Breeding

Each year since 1947 extensive surveys have been conducted in principal waterfowl nesting habitats to estimate numbers of ducks present and to assess habitat conditions. The resulting data represent a major contribution to the information upon which mallard management is based. Presently, over 1.3 million square miles (3.37 million km^2) are systematically sampled in Canada and the U.S. by the Canadian Wildlife Service (CWS) and the Fish and Wildlife Service (FWS) (see Martin et al. 1979 for a detailed description of methods). In addition, six states and one province provide significant contributions to information about the North American mallard population by conducting annual surveys. Collectively, these surveys are estimated to measure about 80–90 percent of the continental mallard population.

During 1961–83, the estimated size of the mallard breeding population in the spring from these surveyed areas has ranged from 5.9 million (1965) to 10.4 million (1970) and averaged 7.9 million (Figure 1). For the past 4 years the breeding population index has averaged 7.1 million mallards which is down 10 percent from the long-term average and down 18 percent from the desired population level. (A management objective of 8.7 million mallards within the surveyed areas was established in 1974 as a consensus of FWS, CWS, and the four Flyway Councils. It was derived from the 1955–74 average index of 8,728,000 mallards and continues through the 5-year study involving stabilized regulations.) Generally, breeding population indices were lower in the early 1960s and in the 1980s than they were throughout the late 1960s and 1970s. For purposes of this discussion, we have identified four large geographic areas of major importance to mallards: (1) the prairies and parklands of the southern Prairie Provinces; (2) the tundra, forested, and northern river delta habitats of Alaska and northwestern Canada; (3) the central prairie areas of the north-central U.S. (the Dakotas and eastern Montana); and (4) "other" important breeding areas including Ontario, Minnesota, Wisconsin, Nebraska, Wyoming, Colorado, and California.

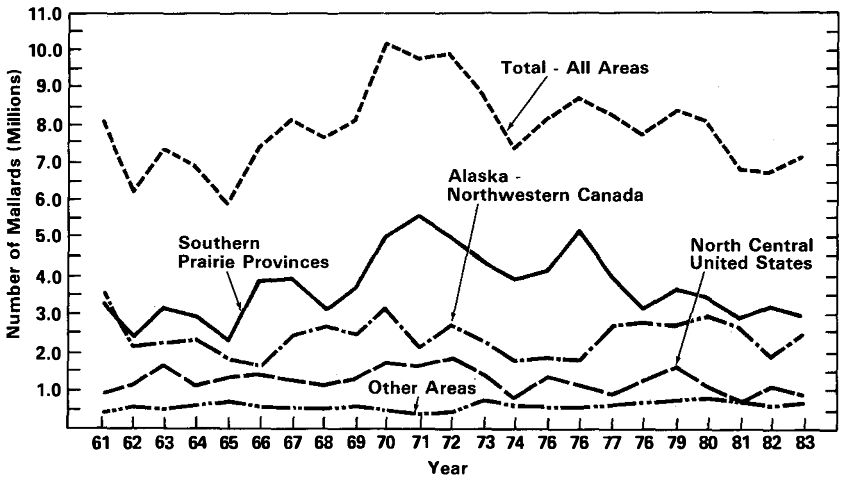

Figure 1. Spring mallard populations in principal breeding areas, 1961–83.

Mallard numbers have varied most widely in the glaciated prairie regions of the Prairie Provinces and the north-central U.S. This situation occurs as a result of the greater annual variability in weather and habitat conditions in these areas than in other geographic areas. Significant positive correlations ($p<.05$) exist between the estimated populations in the southern Prairie Provinces and those in the north-central U.S. This implies a tendency toward similar habitat conditions throughout prairie areas of both Canada and the U.S. in any year. There is also a significant negative ($p<.05$) correlation between mallard numbers in the north-central U.S. and those in "other" areas which result in higher populations in "other" areas during years of poor habitat in the north-central U.S. The general decline in mallard breeding populations that has occurred in the Prairie Provinces since 1971 is of most immediate international concern to those involved in waterfowl management.

Mallard breeding habitat, as indicated by surveys of ponds in the southern Prairie Provinces, has varied substantially during the past 23 years (Figure 2). Data in the U.S. comparable to those for Canada are available only after 1974 (Figure 3). Drought conditions were apparent during at least 8 years: 1961–63, 1968, 1973, 1977, and 1980–81. These years were characterized by indices of fewer than 3 million ponds in prairie Canada and fewer than 0.8 million ponds in the north-central U.S. Normally, pond indices in July follow the same patterns as those in May. Notable exceptions occurred during the 1962 and 1973 nesting seasons in which the direction of change from the previous year in July pond indices was opposite the direction of change in May pond indices as a result of summer rainfall. The late summer rains in 1973 substantially aided the recovery from

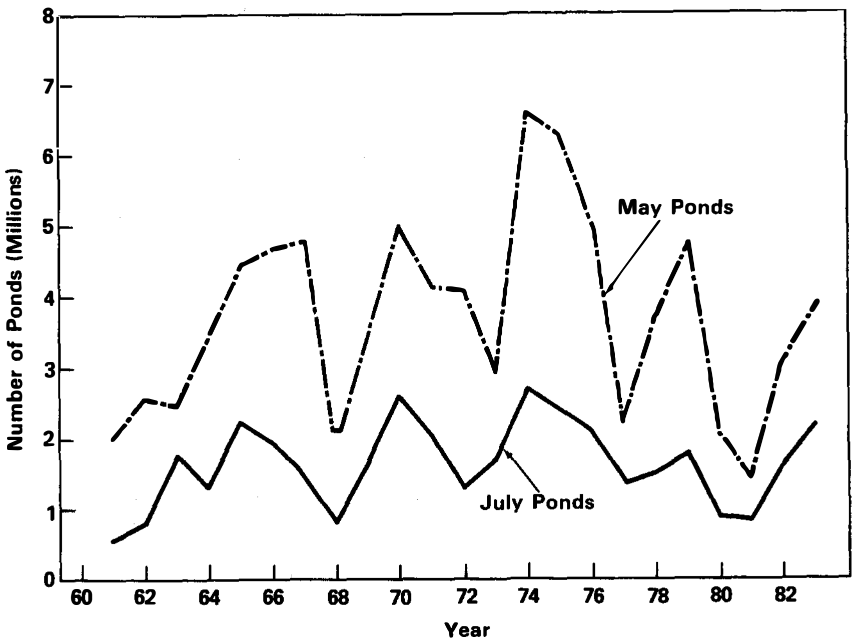

Figure 2. Number of water areas in the southern portions of Alberta, Saskatchewan, and Manitoba, 1961–83.

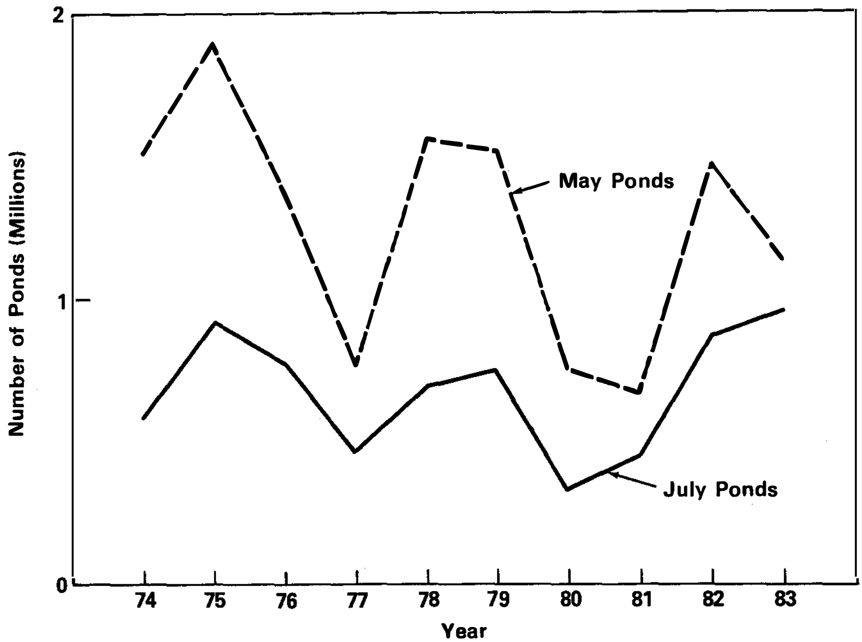

Figure 3. Number of water areas in eastern Montana, North Dakota and South Dakota, 1974–83.

drought conditions that was reflected in the improved conditions that existed in the spring of 1974.

Habitat conditions during the spring and summer play important roles in both the distribution of breeding mallards among various important nesting areas and, obviously, recruitment. Significant negative correlations ($p < .1$) exist between the number of May and July ponds in the southern portions of Alberta, Saskatchewan, and Manitoba and the number of breeding mallards in Alaska and northwestern Canada. Significant positive correlations ($p < .1$) are evident between the number of mallards and May ponds in the north-central U.S.

Production and Fall Flight

Mallard fall flights are a function of the size of the spring breeding population, nesting season survival, and recruitment. Breeding populations are estimated each spring, and after-the-fact estimates of production rates (immatures/adult in the fall population) can be derived by using both banding and harvest data. Unfortunately, only single annual estimates pertaining to the whole population can be made since production rates cannot be determined for specific geographic areas. Annual estimates of breeding season survival are not available for past years, but we have used values that seem reasonable based on published reports (e.g., Johnson and Sargeant 1977:2).

Mallard fall-flights indices varied from 10.5 million (1981) to 17.4 million (1969) (Figure 4). Generally, indices were highest (14.7–17.4 million) during 1969–76. Between 1961 and 1968, the indices were less than 14 million in all years except 1966 and 1967.

Since 1976, the indices exceeded 14 million mallards only in 1979 and trend downward since the high of 1969.

Production rates exert a substantial influence on the fall flight in a given year and are dependent on the quality and quantity of wetland habitat available, the weather, extent of predation, etc. The average production rate for mallards was 1.0 imm./adult during 1961–82. Rates of either 0.7 or 0.8 imm./adult occurred in 6 of the 22 years—1961, 1964, 1968, 1977, 1980, and 1981–all of which are coincident with poor habitat conditions as reflected by pond counts in prairie Canada (Figure 2). Conversely, production rates above 1.2 imm./adult occurred in 3 years—1965, 1969, and 1974—in which generally good nesting conditions prevailed. Recruitment in a particular year also affects the size of the breeding population the next year. For example, in the year following each of the 6 years of low production, the breeding population was smaller in five instances; whereas, in the year following each of the 3 years of high production, the breeding population increased. These relationships between wetlands and duck production are expected to change because of the increasing impacts of agriculture upon nesting ducks.

Wintering

While not providing as reliable an index to duck numbers as the Breeding Population Survey, the Midwinter Waterfowl Survey nonetheless provides the only information about overall distributions and trends among waterfowl wintering in the U.S. These surveys are not made in Canada, although coastal provinces, in particular, winter appreciable numbers of waterfowl. Mallards are of minor importance among the many ducks wintering in Mexico.

During 1955–83, winter population indices for the entire U.S. averaged 7.3 million mallards and ranged from 5.2 million (1983) to 10.6 million (1958) (Figure 5). During this period, the Mississippi Flyway contributed an average of 44 percent to the total U.S. index, followed by the Central (28 percent), Pacific (25 percent), and Atlantic (3 percent)

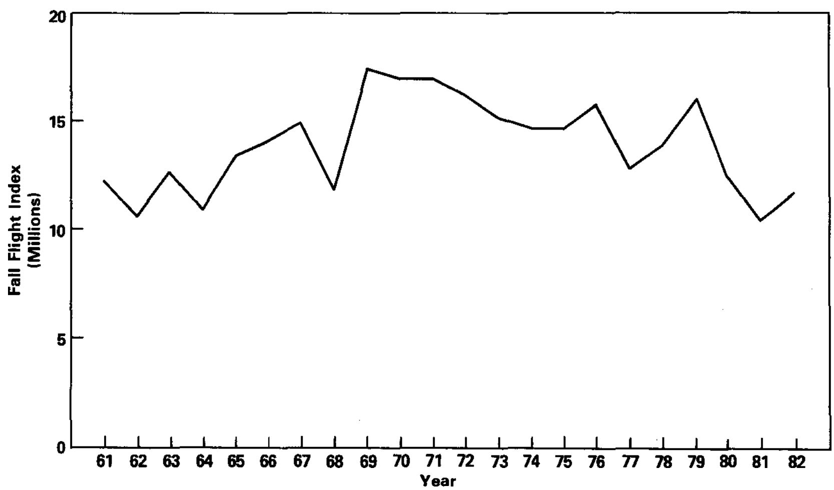

Figure 4. Mallard fall flight index, 1961–82.

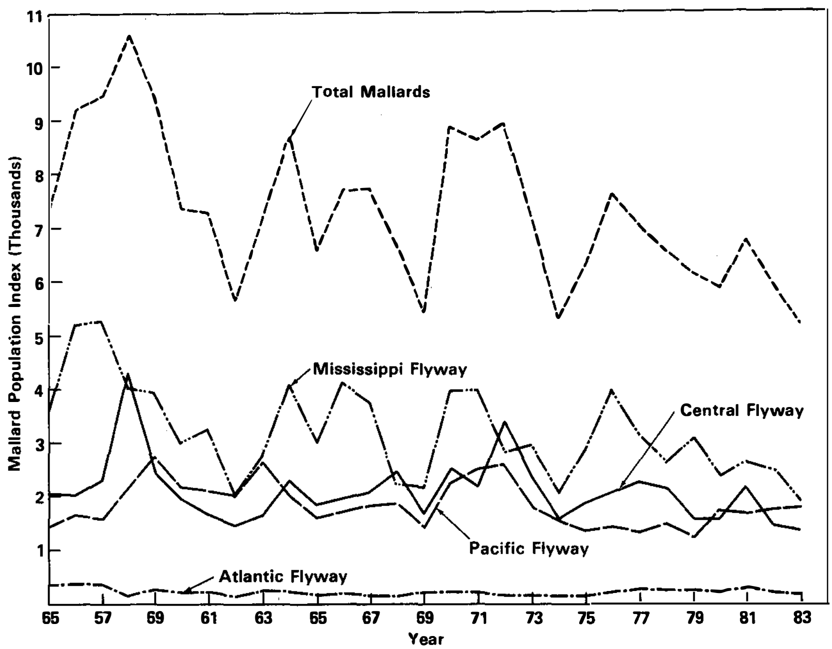

Figure 5. Midwinter mallard index by flyway, 1955–83.

Flyways. Downward trends in winter indices during the 29 years occur in all four flyways but are significant only in the Mississippi Flyway ($p<.01$) and for the total U.S. ($p<.001$), with average declines of 1.8 percent and 1.3 percent per year, respectively.

Harvests

Harvest surveys in the U.S. began in 1952 using mail questionnaires as a source of information on the size and species composition of the harvest. In 1961, the program was expanded to include a nationwide parts-collection sample as a more direct means of determining the age and sex as well as species compositions of the kill. Canadian harvest surveys, including both mail-questionnaire and parts-collection surveys, began in 1967 after the acquisition of a suitable sampling frame in 1966. Additional information concerning these surveys is presented in Martin and Carney (1977) and Boyd and Finney (1978).

United States

Mallard harvests in the U.S. since 1961 have ranged from 1.4 million (1962) to 5.3 million (1970) (Figure 6). Generally, mallard harvests have increased since the low levels of the early 1960s and have approached the high harvests observed during most of the 1950s (Martin and Carney 1977). This change is most apparent in the Mississippi Flyway because of the large proportion of the total mallard kill associated with the region. Each of the other three flyways, however, has generally returned to the high levels of earlier years. With a 50 percent increase in the average total U.S. harvest from 1961–70 to 1971–82, the percentage increase was greatest in the Atlantic Flyway (94 percent), followed from east to west by smaller increases in the Mississippi (71 percent), Central (61 percent), and Pacific (11 percent) Flyways.

During the 1961–82 period, the Mississippi Flyway has accounted for over 43 percent of the total mallard kill (Table 1), followed by the Pacific Flyway (30 percent), Central (19 percent), and Atlantic (8 percent) Flyways. Compared to data presented by Martin and Carney (1977) for the early, high-harvest years prior to 1961, the distribution of the mallard bag declined in the two inland flyways but increased in the Atlantic and Pacific Flyways.

Since 1961, the percentage of mallards in the total duck bag in the U.S. has remained essentially unchanged and averaged about one-third of the total duck harvest in the Mississippi, Central and Pacific Flyways (Table 1).The percentage of mallards in the total bag changed substantially only in the Atlantic Flyway, becoming an increasingly larger fraction of the total bag and reaching the highest level (25 percent) during the 1982–83 season.

With a trend towards longer and later seasons and larger limits on ducks in the Mississippi Flyway, increases in harvests, hunter success, and hunter participation have been greater in the lower region than the upper region. Between the 1960s and the 1970s mallard harvests increased 113 percent in the lower region but only 51 percent in the upper region, resulting in a harvest distribution favoring the south.

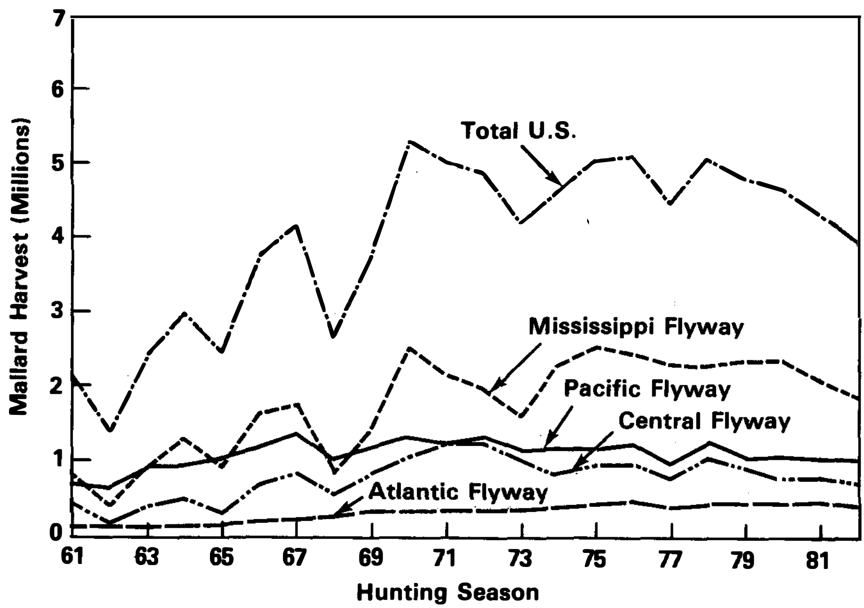

Figure 6. U.S. mallard harvest by flyway, 1961–82.

Table 1. Summary of annual percentage of mallards in total duck bag and distribution of mallard harvest, by flyway in the U.S., 1961–82.

Hunting season	Pacific Flyway		Central Flyway		Mississippi Flyway		Atlantic Flyway		U.S.[a]
	Percent total bag	Percent mallard bag	Percent total bag	Percent mallard bag	Percent total bag	Percent mallard bag	Percent total bag	Percent mallard bag	Percent total bag
1961–62	35.0	34.3	51.9	19.4	49.7	41.2	14.6	5.1	39.5
1962–63	33.4	46.5	44.6	13.6	38.9	31.4	15.9	8.4	32.9
1963–64	33.4	38.9	40.8	17.0	37.1	38.3	15.5	5.8	33.5
1964–65	38.1	32.4	39.4	17.5	37.4	44.5	16.5	5.5	35.5
1965–66	35.4	42.0	27.4	13.6	25.5	37.7	16.1	6.7	28.0
1966–67	33.4	31.3	32.9	18.7	33.7	44.0	15.8	6.0	31.4
1967–68	31.9	33.3	36.6	19.6	36.4	41.5	17.4	5.6	32.9
1968–69	33.5	38.0	45.1	20.9	35.0	31.3	19.2	9.9	33.3
1969–70	28.9	31.3	31.3	21.7	31.9	38.2	18.5	8.9	29.0
1970–71	30.3	25.2	35.7	20.1	39.3	47.8	18.2	6.8	33.5
1971–72	31.8	25.3	44.1	24.6	40.3	43.3	20.0	6.9	36.1
1972–73	34.0	26.9	42.4	25.7	39.1	40.0	22.2	7.5	36.3
1973–74	35.8	27.5	41.2	24.0	36.9	40.4	22.2	8.2	35.6
1974–75	32.5	25.3	36.5	17.5	43.3	48.7	22.7	8.5	36.3
1975–76	28.9	23.1	31.9	18.6	38.2	50.1	22.4	8.3	32.7
1976–77	29.6	24.1	34.8	19.1	39.9	47.3	23.2	9.5	33.8
1977–78	32.1	22.2	32.4	17.7	38.2	51.1	21.1	8.9	33.3
1978–79	31.9	25.1	35.7	21.0	35.7	44.9	23.1	8.9	33.1
1979–80	31.7	22.3	34.2	19.3	36.8	49.1	24.1	9.3	33.5
1980–81	33.9	23.2	37.4	16.9	39.9	50.4	22.8	9.5	35.5
1981–82	39.0	24.2	28.4	18.1	37.7	47.5	23.3	10.2	35.8
1982–83	36.3	27.0	30.8	17.4	35.5	45.4	24.5	10.2	33.3

[a] Total U.S. estimates exclude Alaska.

Canada

Annual retrieved harvests of mallards in Canada have ranged from 1.0 million (1968) to 2.0 million (1970) and averaged 1.6 million during 1968–82 (Figure 7). There was a general increase in mallard harvest until 1976, followed by a general decline.

From 1968 to 1982, Prairie Provinces have accounted for 71 percent of the total Canadian mallard kill, eastern provinces for 21 percent and 8 percent in British Columbia and the Territories (Table 2).There has been a shift to a smaller percentage of mallards being harvested in the prairies. Prior to 1977, the prairies accounted for 73 percent of the Canadian mallard harvest compared to about 65 percent since 1977; whereas eastern Canada has taken 19 percent and 26 percent during these periods, respectively. Evidence suggests that mallard populations are increasing in Ontario and Quebec and throughout the Atlantic Flyway (Rogers et al. 1984).

Mallards averaged 45 percent of the total Canadian duck bag during 1968–82 (Table 2). The mallard is the important bird for prairie Canada as it accounted for 69 percent of the total duck harvest. Mallards make up 21 percent of the eastern duck harvest and 49 percent of the harvest in British Columbia and the Territories. The importance of mallards in the duck harvest has increased from 17 percent prior to 1977 to 21 percent afterwards in eastern Canada and from 47 percent to 55 percent in western Canada but has remained relatively stable at about 68 percent in the Prairie Provinces.

The percentage of the total North American mallard harvest occurring in the three Prairie Provinces has trended downwards from the high of 22 percent in both 1969 and

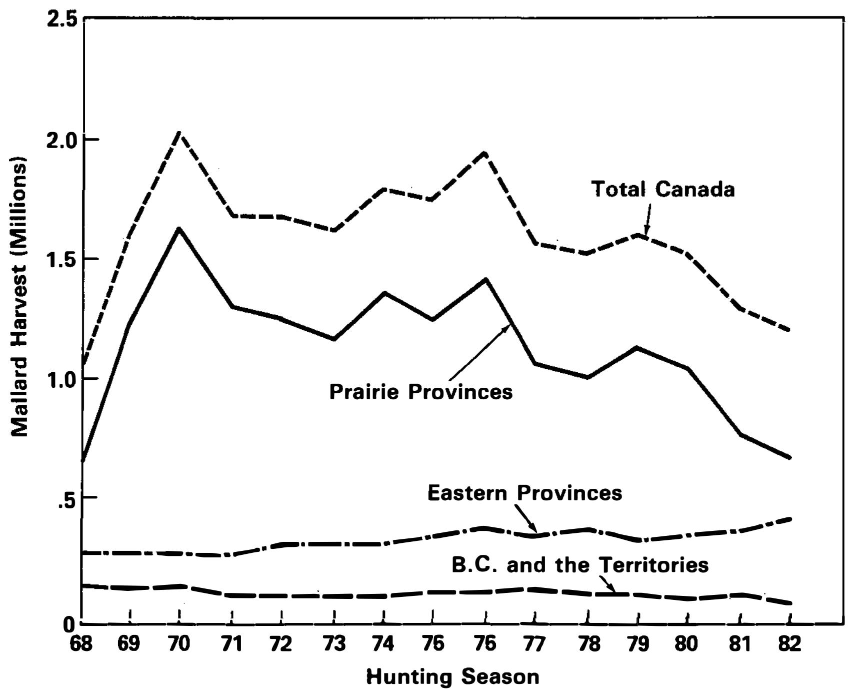

Figure 7. Canadian mallard harvest by area, 1968–82.

Table 2. Summary of annual percentage of mallards in total duck bag and distribution of mallard harvest, by regions in Canada, 1968–82.

Hunting season	Eastern Provinces		Prairie Provinces		British Columbia and the Territories		Total Canada
	Percent total bag	Percent mallard bag	Percent total bag	Percent mallard bag	Percent total bag	Percent mallard bag	Percent total bag
1968–69	21.1	26.8	58.7	59.8	38.0	13.5	37.9
1969–70	16.9	16.7	67.1	75.1	48.8	8.2	43.9
1970–71	16.6	12.7	69.3	80.6	47.1	6.6	48.3
1971–72	17.9	16.0	69.3	77.3	48.9	6.8	46.6
1972–73	21.2	18.9	70.4	74.3	43.4	6.8	47.6
1973–74	21.4	20.6	75.3	72.8	41.5	6.6	47.9
1974–75	19.8	18.5	69.2	75.4	51.6	6.0	46.7
1975–76	20.8	20.5	64.3	72.1	51.3	7.4	44.5
1976–77	20.8	20.2	69.7	73.0	49.6	6.7	46.3
1977–78	18.6	22.6	69.1	68.5	49.7	9.0	41.9
1978–79	21.4	25.4	68.7	66.4	53.9	8.2	43.3
1979–80	21.2	20.9	70.1	71.6	55.8	7.5	46.8
1980–81	21.8	24.6	71.3	68.2	54.6	7.2	45.1
1981–82	22.8	29.5	72.6	61.3	60.7	9.1	43.7
1982–83	25.9	35.5	65.0	56.7	56.8	7.8	42.0

1970 to the low of 14 percent in both 1981 and 1982. The percentage of the continental mallard kill occurring in all of Canada has remained relatively stable at about 26 percent (C.V.=7.5 percent) during 1968–82, with percentage increases in western Canada and particularly eastern Canada offsetting the decreases in the Prairie Provinces.

Relationships Between Harvests and Populations

The effects of hunting regulations and special seasons on hunter activity and success and the total mallard harvest have been discussed thoroughly by Martin and Carney (1977). Such regulatory actions as the special mallard restrictions in the Central and Mississippi Flyways during the 1962–63 hunting season and the establishment of the High Plains season in the Central Flyway as a late-season opportunity for mallards are reflected in varyng degrees in the 1961–82 harvest data (Figure 6, Table 1). However, waterfowl population management has been based historically on the regulation of the harvest. Consequently, any attempts to interpret variations in harvest in relation to regulatory changes are confounded by hunting regulations that have been adjusted annually to correspond with the anticipated size of the fall flight of ducks. In response to this problem, season lengths and bag limits have not been changed in the U.S. and prairie Canada since 1979 (since 1975 for the Pacific Flyway and for the High Plains portion of the Central Flyway). In the absence of annual variation in these two key regulatory measures, mallard kill and hunter activity have both declined substantially in both countries. At the same time, fall flights have been markedly reduced since 1979 (Figure 4), suggesting that harvests during this period may have corresponded more to hunter activity and mallard availability than to particular components of harvest regulations at the levels that existed.

Preliminary analyses suggest that harvest in prairie Canada is highly correlated with breeding population size ($p<.001$) (Brace and Caswell 1983). Mallard harvest has been density dependent in prairie Canada. Mallard harvest rate (harvest/fall flight) for prairie Canada has remained basically constant even throughout the drought. Total mallard harvest in the Prairie Provinces dropped to 690,000 in 1982, being 40 percent below the 1968–81 average. Migratory Game Bird Hunting Permit sales declined by 4 percent during this period (Metras 1984).

Mallard harvests in the U.S. also declined from 4.8 million in 1979 to 3.9 million in 1982. Duck stamp sales declined by 10 percent during these years. The relationship between harvest and population size is less clear possibly because of the effect of higher hunter densities or of more sedentary wintering populations of mallards. Mallard harvests in the U.S. as a whole appear to be density independent. Unlike the situation in prairie Canada, mallard harvest rates in the U.S. have increased during the past decade, and this increase continued through the drought. Although total mallard harvest dropped, U.S. hunters took a higher percentage of mallards out of a reduced fall flight. It is interesting that indices of the U.S. harvest rate during all years since 1974 (except 1979) has exceeded those of 1964 and 1970; years which Anderson and Burnham (1976) suggested as perhaps exceeding the "threshold point" at which hunting mortality and nonhunting mortality cease to operate in a compensating fashion.

Issues and Needs

Prairie Canada

The size of the mallard population in the southern portions of Alberta, Saskatchewan, and Manitoba has declined significantly throughout the last decade (Figure 1). In 1976, 58 percent of the surveyed mallard breeding population occurred in the Canadian prairies, but by 1983 only 41 percent occurred there. In absolute values, prairie mallards have declined from an average of 4.4 million during the 1970s to 3.1 million during the first 4 years of the 1980s. Furthermore, the situation is not static. The present downward trend will likely persist and, if unaltered, future projections indicate further declines. This decline is believed to be accentuated by overharvest, especially in the U.S., during years of low recruitment.

Mallard production in the southern prairies plummeted during an extensive drought that persisted in the 1980s. During this period, total duck brood production indices on the Canadian prairies declined by 40 percent, from 265,000 in 1979 to 112,000 in 1983. Unadjusted mallard age ratios in the prairie Canada harvest dropped from a 1974–79 average of 2.4 imm./adult to a 1980–83 average of 1.4 imm./adult.

The negative impacts of agricultural land-use practices on mallard breeding habitat were accentuated during the drought. The arid conditions permitted cover removal, filling, and cultivation of drought-stricken wetlands. A CWS survey of prairie wetlands indicated that the percentage of basins altered by agriculture increased from 20 percent in 1980 to 28 percent in 1983. The percentage of wetland margins altered during the same period increased from 49 percent to 61 percent.

Recruitment

Although only well documented in a few areas, reduced rates of recruitment among mallards and other ducks are believed by some biologists to pervade the prairie and parkland "duck factory" and to occur in other localities important to mallard production.

Cowardin et al. (1983) reported that of hen mallards studied in central North Dakota during 1977–80: (1) only 8 percent of the nests initiated were successful, (2) only 15 percent of the hens would successfully hatch a clutch, and (3) a minimum of 20 percent of the nesting hens would be killed. Mammalian predators were implicated as being the most important factor in these losses. They concluded that for this region of North Dakota, when considering prevailing survival rates and the poor recruitment, the mallard population was declining and was being maintained only through pioneering of birds from other regions. They offered a glimmer of hope for prairie-nesting mallards by demonstrating that nest success was about 20 percent higher on managed than on unmanaged tracts and that highest duck production consistently occurred in areas where habitat was good and predation was greatly reduced whether naturally or purposefully.

Notwithstanding recent improvements in interpreting nesting data (e.g., Miller and Johnson 1978), evidence from early studies in North Dakota suggests that recruitment rates among ducks were better then than now. Estimates from several early nesting studies suggested that about 63 percent of duck nests found in the 1930s were successful as compared to only 29 percent in the 1950s (Miller 1971). Nesting success on the Lower Souris National Wildlife Refuge decreased from 70–80 percent in 1937–38 to 20–30 percent in 1947–51 (Hammond and Forward 1956).

Collectively, the diverse evidence suggests that at least a portion of the mallard population is being confronted by a long-term decrease in recruitment rates rather than short-term changes. This suggestion is reasonable if consideration is given to the drastic and continuing changes in land use over much of the mallard's primary breeding range. Recent incursions into mallard habitats in Montana illustrate the accelerated nature of the problem. Approximately 750,000 acres (303,750 ha) of Montana grasslands were converted to croplands between 1977 and 1982 (Walcheck 1983); and in June 1983, U.S. Senator Max Baucus (1983) reported that nearly 2 million acres (810,000 ha) of Montana were "plowed down", with another 21 million acres (8.5 million ha) of open pastureland being vulnerable. Sugden and Beyersbergen (1984) conclude that present land-use practices in east-central Saskatchewan, particularly extensive tillage of uplands, will favor low recruitment rates. Nests, especially of early-nesting mallards, have little chance of success in annually tilled croplands. Furthermore, the remaining untilled lands are further degraded by increased grazing pressure and concentrations of predators.

Mid-Continent Waterfowl Management Unit

In the Mid-Continent Waterfowl Management Unit (MCWMU), which includes southeastern Saskatchewan, southern Manitoba, the eastern Dakotas, Minnesota, and Wisconsin, severe losses of wetlands and suitable upland nesting cover have occurred, and mallard productivity has declined. Public and private habitat preservation efforts have saved many wetlands that otherwise would have been lost. However, because most ducks are produced on private lands, any long-term effort to achieve an overall improvement in mallard production rates must include programs for these private lands.

In recognition of this need, the FWS and Minnesota Department of Natural Resources, with advice from the Wildlife Management Institute, initiated a pilot study in 1978 in three west-central Minnesota counties to develop and test techniques which would be acceptable and effective in improving waterfowl production throughout the larger MCWMU. The objectives are: (1) increase the number of duck breeding pairs by 50 percent and (2) increase nest success rates from what is now less than 20 percent to 60 percent or more.

Activities through 1981 focused on gathering baseline information for measuring achievement of objectives and developing a management program for the subsequent 10 years. In addition to the ongoing FWS acquisition program, activities during 1982 and 1983 have involved: (1) development of a 10-year leasing system for restoration of private wetlands, (2) assisting local clubs and others in wetland restoration projects, (3) agreements with the Minnesota Department of Transportation to improve nesting cover on rights-of-way, (4) demonstration of alternate grazing systems, (5) no-till farming to improve nesting cover on private lands, and (6) predator removal and exclusion on two areas totaling about 100 square miles (259 km^2). These activities will be continued and expanded in future years, and a multi-year evaluation of their effectiveness is just now underway.

Lower Mississippi River Valley

At least half of the Mississippi Flyway's 3.2 million mallards counted in winter surveys are in the Lower Mississippi River Valley, or the Delta as it is commonly known. The value of the Delta to mallards is actually higher than suggested by these early January surveys because many birds using forested habitats go uncounted, and others may be forced into the area by severe weather in more northern areas after the survey has been completed.

The 25-million-acre (10.1 million ha) Delta was almost entirely forested at the time settlement began, but most of this has been cleared, including the forested wetlands. Of the estimated 11.8 million acres (4.8 million ha) of forested wetlands present in 1937, only 5.2 million acres (2.1 million ha) (44%) remained in 1979, and projections indicate that only 3.9 million acres (1.6 million ha) will remain by 1995 (MacDonald et al. 1979).

The impact of this drastic change on wintering mallards is difficult to assess. During 1960–83, no trend is evident in the mallard indices for the Delta, although changes did take place. Evidence is emerging that the condition of winter wetlands may influence subsequent recruitment (Heitmeyer and Fredrickson 1981). Additional research now under way will provide further information about the dynamics of mallard populations during the wintering period and the role of the forested wetlands. Meanwhile, efforts are being made to preserve the Delta wetlands through habitat acquisition programs and opposition to channelization and other projects that will further reduce and/or degrade the remaining habitat.

Columbia Basin

The Columbia Basin gained national prominence in 1964, when amid restrictive seasons elsewhere, liberal seasons and limits were allowed so that hunters could take advantage of mallard increases that accompanied the conversion of desert into croplands along the Columbia and Snake Rivers. The liberal regulations persist, but with less difference from surrounding areas; and the Basin still accounts for 60 percent of the Pacific Flyway's 1.8-million-average (1955–83) index of wintering mallards. However, there has been a recent change in distribution of ducks within the Basin itself.

Denney (1983), in chronicling the change, noted that during 1970–79 about 23 percent of the Basin's mallards in January were in the southern part, i.e., northeastern Oregon and a bordering strip of Washington along the Columbia River boundary; but the indices increased to 53 percent in 1981, 77 percent in 1982, and 62 percent in 1983. These increases were either because of a shift in distribution which was at the expense of hunters in other portions of eastern Washington and in southwestern Idaho or because of different survival rates among unrecognized subpopulations. Numbers of mallards closely followed the increased acreages of corn in the southern area (both new acres being brought into production and other acreages being switched from wheat, potatoes, and alfalfa). The increase also coincided with Carty Reservoir being used as a cooling pond for a new coal-fired, electricity-generating plant. This 1,500-acre (607.5 ha) impoundment, which held more than 410,000 ducks in January 1982, is closed to hunting and can provide ice-free water during the coldest periods.

During the 1983–84 season, Washington, Oregon and the FWS attempted to redistribute mallards by providing more sanctuaries and lessening the hunting pressure in the northern part while doing the opposite in the southern part. However, Mother Nature, through extremely cold temperatures in December, and Portland General Electric, by shutting down the power plant, gave the redistribution plan the biggest boost but with unexpected results. Not only did mallards disperse from the southern area, but most of them departed from the Basin. January counts in 1984 tallied only 31 percent of the Flyway's 1.6 million mallard index in the Basin, which was about half of normal and the lowest percentage in at least the previous 34 years. The Midwinter Waterfowl Survey data suggest that the mallards went to California where the mallard index was three-fold greater than during the previous winter and was exceeded in only three winters since 1949.

Mallards and Black Ducks

There is considerable evidence supporting both a westward expansion of the black duck's (*Anas rubripes*) range into that of the mallard and, conversely but later, an eastward expansion of the mallard's range into that of the black duck. While there are no long-term, extensive surveys of breeding ducks in the eastern area, occasional surveys in the Hudson Bay lowlands (Palmer 1976) and extensive surveys of breeding waterfowl (Darrell G. Dennis, pers. comm.) and hunting club records (Blandin 1982) from Ontario all point to increasing ratios of mallards to black ducks in most eastern states and provinces. An extreme example is in Delaware where in Christmas Bird Counts during 1900–39 there were virtually no mallards recorded, but by the 1960s those surveys found ratios of 1.4 mallards per black duck (Johnsgard 1967). As previously noted, the number of mallards harvested in the Atlantic Flyway during 1971–82 nearly doubled from 1961–70, and their percentage composition of the duck harvest increased from 17 percent to 22 percent during the same period. The relative importance of black ducks was little changed, as the percentage composition of the kill increased to 21 percent during 1971–82 from the 15 percent of the earlier period.

Both habitat changes favoring mallards and the large-scale releases of hand-reared mallards are postulated as reasons for the increasing numbers of mallards breeding and wintering in the Altantic Flyway. It is not known whether mallards compete with black ducks. However, mallards, especially hens, are likely to benefit from the current restrictive measures directed at reversing declining numbers of black ducks.

Stabilized Regulations

The stabilized regulations program, developed in response to the continuing controversy surrounding harvest regulations and their ability to control waterfowl populations, has completed the fourth year of a 5-year program (see Brace et al. 1981). This concept, involving the stabilization of season lengths and bag limits, was initiated in Canada by the CWS and the Provinces of Alberta, Saskatchewan, and Manitoba in 1979. In 1980, the FWS began a similar program in the U.S. with the backing of the four Flyway Councils and various organizations. Since then, a joint, international effort has been implemented to hold regulations constant at the 1979–80 level in order to provide a sound evaluation of the effects of hunting regulations on duck harvest and populations. At the same time, researchers and managers realized the opportunity to investigate on a large scale those factors associated with the regulation of duck populations, such as hunting and nonhunting mortality and recruitment. This evaluation, focused on mallards, contains five major objectives:

1. determine the effects on duck populations resulting from stabilization of hunting regulations at current season length and bag limits;
2. determine what factors influence the size and rate of harvest of mallards when season length and bag limit are held constant;
3. evaluate the relationship between hunting and nonhunting mortality of mallards under current hunting regulations;
4. determine if recruitment rates of mallards are adequate to achieve current population objectives, given current survival rates; and
5. at the conclusion of the study, evaluate those factors that appear to be most important in the dynamics of mallard populations and determine what management approaches will help ensure adequate numbers in the future.

Field studies, encompassing both ongoing and new programs, are currently in progress and in total address the objectives listed above. They include:

1. *Estimates of breeding population and production.*—Operational surveys continue

to monitor breeding populations and production. In addition, new methods, such as the use of empirical Bayes procedures and auxiliary information are currently being evaluated for improving estimates.

2. *Measures of harvest and hunter activity.*—Besides ongoing harvest and hunter activity surveys in Canada and the U.S., a hunter observation program was initiated in prairie Canada in 1979 to provide more detailed information on the annual duck kill.

3. *Factors affecting hunter activity and success.*—Population data currently obtained during periodic fall surveys on state and federal areas in the Central and Mississippi Flyways, together with information on weather and habitat, are being collected to examine questions related to the availability of ducks and hunter activity and success.

4. *Determination of annual and seasonal survival rates.*—Since 1981, intensive banding studies have been conducted during the spring and summer in prairie Canada and Minnesota and during fall and winter in the Mississippi Delta. Multinomial band-recovery models are available to determine seasonal and interval survival rates of mallards by sex and age class. Also, for the past 2 years, radio-telemetry has been used to follow marked hens in the Mississippi River Delta to determine what levels of nonhunting mortality operate on a primary wintering area. Finally, body condition of banded mallards is being related to survival probabilities for different periods of interest, using recently developed modeling procedures.

5. *Breeding habitat inventories.*—High-resolution, color-infrared photography has been collected for selected plots in prairie Canada, the Dakotas, and Montana since 1982. This imagery will improve current wetland habitat surveys in these areas by providing a more quantitative assessment of the changes in the number and persistence of ponds among years and within a breeding season. Also, in 1980, Canadian biologists began a program to determine the impact of agricultural practices on wetlands. Both activities enhance the assessment of wetland areas to waterfowl production.

6. *Recruitment rates and factors affecting them.*—Beginning in 1981, duck numbers and broods have been surveyed along selected roadside transects in Canada to develop a capability to forecast waterfowl production based upon changing social components in the breeding duck populations. In addition, a widespread assessment of duck nesting success and the impact of predation on waterfowl production has been carried out in prairie Canada and in part of north-central U.S. since 1982.

Overall, these field studies consolidate the energies of many conservation agencies in the U.S. and Canada and represent a large-scale, cooperative effort among waterfowl biologists. These field studies will continue through 1985 and, although the results to date are preliminary, we believe the outcome will establish a more firm basis for mallard management in particular and waterfowl management in general.

The Future

The functional relationships among hunting mortality, non-hunting mortality, recruitment, and population status are still not clearly understood. However, the questions asked about these relationships are now better framed so that meaningful answers may become more likely. The evaluation of stabilized regulations will greatly improve our chances of obtaining those answers. We believe that it is unlikely that a single cause is responsible for the decline in mallards. It is also unlikely that any single-factor treatment, such as restricting hunting, as in the case of black ducks, or piecemeal habitat retention programs, or wintering ground enhancement programs, or even a return to more favorable environmental conditions in the prairies will reverse the present trend. Recovery to former levels may not occur unless harvest rates and production rates are treated synchronously. Sustaining this resource requires initiating a comprehensive, multifaceted continental approach that addresses international needs, future goals, rational harvest strategies, and innovative habitat retention projects. Steps toward developing and implementing such a cooperative program are now being taken by the responsible governments in Canada and the U.S. and will be prsented in the North American Waterfowl Management Plan.

Few will dispute that the level of the mallard population in North America is unacceptable. However, we as managers know that the trend can be reversed but recognize that for some actions, such as widespread and large-scale changes in land-use practices, considerable public support must be mustered. In those areas where predators are implicated as significantly hindering recruitment, the controversial issue of predator management must be addressed and not ignored. Improvements are within our grasp if we reach a bit farther.

The future for both mallards and for those of us who hunt them looks brighter.

Acknowledgements

This paper, as are most that pertain to any widely distributed species of waterfowl, was developed from information collected during nearly three decades and through cooperative population and harvest surveys and banding programs of State, Provincial, and Federal wildlife management agencies, universities, and other organizations. While the thousands of participants in these programs cannot be identified, we recognize and appreciate their contribution to this paper and to the importance of their efforts to waterfowl management in general. We thank John P. Rogers and James H. Patterson for their critical reviews of this manuscript.

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Winter Habitat Preference of White-Fronted Geese in Louisiana

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Introduction

White-fronted geese (*Anser albifrons gambelli*), which nest in Alaska and the arctic region of Canada, depart in late summer for staging areas in Saskatchewan and North Dakota (Bellrose 1976). From the staging areas, they migrate southward to wintering grounds located mostly on the Gulf Coasts of Louisiana, Texas, and Mexico. They begin arriving on the wintering grounds in late September, but most birds do not arrive until mid-October.

The number of white-fronts wintering in Louisiana in recent years has exceeded 50,000 birds, and approximately 90 percent of the geese winter on the coastal prairie of southwestern Louisiana (Leslie 1983). The coastal prairie consists mainly of agricultural lands, and geese do considerable movement about the region. Owen (1972a) reported that movement by white-fronted geese on wintering grounds in England was caused mainly by disturbance and changing habitat conditions.

The northward, spring migration from Louisiana is a gradual process; some white-fronts leave in early February (Bellrose 1976), but others remain until mid-April (Lowery 1974). White-fronted geese are in Louisiana more than 7 months; consequently, the availability of suitable habitat has a great influence on the winter condition of the birds, their ability to make the northward migration, and perhaps their breeding success when they reach the nesting grounds. Although Louisiana is a major wintering area, little information is available on winter habitat of white-fronted geese in the state. Therefore, this investigation was conducted to determine the habitat types used by the geese and the relative availability of each type and to evaluate habitat preference and the factors affecting habitat use.

Methods

Since most white-fronted geese in Louisiana winter on the coastal prairie, a study area was established that included the coastal prairie and a segment of coastal marsh south of the coastal prairie. The study area contained 1,262.5 square miles (3,270 km^2) and consisted of flat, open terrain with forests located only along streams. Major agricultural uses of the area were rice and soybean farming and pasture.

The availability of habitat types in the study area was determined by aerial surveys of transects established by Chabreck (1970). The transects were equally spaced, oriented north-south, bounded on the north by Interstate Highway 10 and on the south by the Gulf Intracoastal Waterway. The transects began at 93°40′W longitude and were placed at 7.5 minute intervals eastward to 92°17′30″W longitude. Major concentration areas of wintering whitefronts were more intensively surveyed by adding an intermediate transect midway between each major transect, beginning with transect line 6 and continuing eastward.

The study area contained 19 transects totaling 363.9 miles (585.6 km) in length and covered an area from the Sabine River eastward to the Vermilion River.

Each flight was taken in a Cessna 210 airplane; the direction, altitude (330–460 feet [100–140 m]), and airspeed (100–110 knots) flown on each transect were kept as constant as possible during each survey. During each survey, an observer identified habitat types and used a stopwatch and a hand-held tape recorder to measure and record the number of seconds flown over each type. Total seconds over each habitat type were determined, and percent occurrence of each type was then computed for each sample date.

Habitat types were classified into 14 categories: harvested soybeans, unharvested soybeans, harvested rice (wet), harvested rice (dry), unharvested rice, cultivated field, fallow field, native pasture, winter pasture, marsh, open water, timber, residential, and other (sorghum, spoil deposits, shrub, etc.). A rice field was classified as wet if pools of water were present in the field. Winter pasture was identified as cultivated land containing a green cover crop.

A second observer recorded the locations of white-fronted goose flocks and approximate number of geese on each transect. The location of flocks was marked on a map so the geese could be observed and counted during later ground surveys. Because farming practices can rapidly change habitat types, ground surveys were conducted as closely as possible to aerial survey dates. Ground surveys were conducted by driving highways, unimproved roads, and field roads throughout the study area. When a flock of geese was located, its members were counted with the aid of 7×35 binoculars or a 30X spotting scope, and the habitat type being utilized was noted. The total number of goose flocks and the percentage of all goose flocks in each habitat type were determined for each survey period.

Seasonal habitat use was evaluated with a Chi-square goodness- of-fit test. The following null hypothesis was tested: goose flocks utilize each habitat type in proportion to its availability. Observed habitat use (number of flocks) and expected habitat use were compared for each survey. To calculate Chi-square values for testing seasonal habitat use, a subset of habitat types was derived from the 8 habitats used by goose flocks. This subset was reduced to 6 habitat types, and percent occurrence of each type in each season was recalculated.

Marsh and native pasture were eliminated from the original habitat-use data and, therefore, were not statistically tested. Native pasture was removed because of its low percent occurrence (average less than 3 percent), and marsh was eliminated because of the difficulty in observing goose flocks in marsh and the nature of use. Harvested, wet rice during late season 1981–82 was eliminated from the goodness-of-fit test because its observed value was 0.

The statistical technique proposed by Neu et al. (1974) was used to place condidence limits about the proportion of habitat use observed in each habitat type. Some habitats may be preferred, while others are avoided or used in proportion to availability. Some inferences concerning habitat preference or avoidance may be made from individual $(0-E)^2/E$ values in the goodness-of-fit test. However, by placing confidence intervals about the proportion of habitat use (Neu et al. 1974) and the proportion of habitat available (Leslie 1983) in each type, we were able to classify habitats with greater precision as preferred (P), avoided (A), or used in proportion to availability (neutral (N)).

Results and Discussion

Habitat Availability

Agricultural land comprised an average of 76.6 percent of the area surveyed, while non-agricultural land comprised 23.4 percent. Percent occurrence of active agricultural types changed considerably from one sample date to the next, but the percent occurrence of non-agricultural types remained fairly stable. Composition of the non-agricultural category was marsh (12.0 percent), timbered areas (6.6 percent), open water (3.0 percent), residential (1.5 percent), and other (0.1 percent).

The major agricultural crops in the study area were soybeans, rice, and winter pasture. Other agricultural lands were fallow fields, native pasture, and cultivated fields. During the October surveys, soybeans comprised 19.7 percent of the transects and rice fields comprised 23.7 percent of the transects, but both types declined rapidly thereafter as the fields were cultivated or placed in winter pasture. The moisture regime of rice fields was largely determined by rainfall, and more wet, harvested rice fields were noticed after above-average rainfall in mid and late 1982–83.

Winter pasture increased in late winter as fields planted in ryegrass or winter wheat used as winter cover crops began to green-up. The amount of late-season winter pasture almost tripled over early and mid-season figures in 1981–82, and was over 3.5 times more abundant in late season 1983 than in the two earlier surveys of that year. The percent of cultivated fields increased as the season progressed.

Habitat Use

Goose flocks utilized only 8 of the 14 habitat types classified in the aerial surveys. Less than 2 percent of all flocks counted were found in native pasture, less than 4 percent occurred in marsh, and less than 4 percent occurred in fallow fields. Geese tended to avoid native pasture and fallow fields, possibly because these habitat types often contained tall vegetation that obstructed their view. Marshes were located mostly on Lacassine National Wildlife Refuge and were used as resting sites between morning and afternoon flights to feeding areas, as roosting sites at night, and as escape cover when flocks were disturbed.

Winter pasture contained less than 8 percent of the goose flocks counted in both years and seemed to be utilized only when producing fresh, sprouting grasses and forbs.

Harvested rice fields were a major feeding habitat for whitefronts. Harvested rice fields contained 47.3 percent of goose flocks counted in early season and 30.3 percent of flocks counted in mid-seasons. Late season use of harvested rice fields dropped to 16.9 percent of flocks counted.

More flocks were found in wet, harvested rice fields than in dry, harvested rice fields during both years. Ninety of the goose flocks observed during early season and mid-season both years were in wet, harvested rice fields; however, only eight flocks during the same period were in dry, harvested rice fields.

Cultivated fields contained 6.0 percent of goose flocks counted in early season 1981–82 and 6.7 percent in early season 1982–83. Utilization of cultivated fields increased in the middle season of both years, and peaked in the late season. Cultivated fields contained more late-season flocks than any other habitat type during any period.

The largest flocks of geese counted were feeding in vast, harvested soybean fields. The use of soybean fields was greatest in early seasons, and 30.1 percent of goose flocks were located there. By mid-season, utilization of harvested soybean fields dropped to 16.5 percent. Much of the supply of waste soybeans from mechanized harvest was probably consumed during the early season, forcing geese to feed elsewhere as the season progressed.

Habitat Preference

Observed habitat use and expected habitat use were compared in each survey period. The Chi-square value calculated for each survey period exceeded the tabular Chi-square value, thus indicating that seasonal habitat use was significantly different ($P<0.005$) than would be expected due to chance alone.

Preference ratings (Table 1) were computed by relating white-fronted goose habitat use to habitat availability. The ratings disclosed that wet, harvested rice fields, soybean fields, and cultivated fields were the preferred habitats of white-fronted geese in Louisiana. In a similar study in Texas, Hobaugh (1982) reported the same findings but did not separate wet from dry rice fields.

Wet, harvested rice fields were classified as preferred habitat more often than any other habitat type. This habitat was preferred during four of the six seasons surveyed, and included all seasons of 1981–82 and the early season of 1982–83. During mid and late season 1982–83, goose flocks utilized wet, harvested rice in proportion to its availability. Even though no wet, harvested rice fields were found on aerial surveys in late season 1981–82 (indicating very little of this habitat available in the study area), several fields of this habitat type were observed during ground surveys and contained six goose flocks. Owen (1972a) reported that wet fields with standing water were thought to attract white-fronted geese. He also noted that geese usually need water to drink and preen; and if they are required to fly to other areas for water, they waste valuable feeding time and energy in flying (Owen 1972b). These flocks were concentrated in two fields and located on the same day.

Glazener (1946) examined whitefronts wintering along the Texas Gulf Coast and reported that rice supplied more food than any other cultivated crop. He postulated that rice grains remained available to geese all winter, and the errosive action of rainfall uncovered buried rice grains that were previously unavailable. However, Hobaugh (1982) sampled rice fields in Texas at monthly intervals following the harvest and reported that all waste rice was gone by mid-January.

Geese which consume more nutritious foods (such as rice) might have a survival advantage (Owen 1972b). More nutritious foods would yield the same amount of energy during less feeding time, leaving more time for survival behavior.

Dry, harvested rice fields were not rated as a preferred habitat type during any survey period. Apparently, whitefronts prefer rice as a food source, buy may also prefer feeding in fields where the rice gleanings are water-soaked. Also, rice gleanings in dry, harvested rice fields are readily available to other birds and small rodents and much may be consumed before whitefronts reach the wintering grounds. Additional research should be conducted to determine the reasons for the difference noted.

Harvested soybean fields were a preferred habitat during the early season 1981–82. This type comprised only 4.3 percent of available habitat yet contained 34.0 percent of

Table 1. Percent occurrence, number of white-fronted goose flocks present, and preference rating[a] of habitat types used by geese in southwestern Louisiana during different periods of the 1981–82 and 1982–83 wintering seasons.

Habitat type	Wintering period								
	Early			Middle			Late		
	Habitat (%)	Flocks (*N*)	Rating	Habitat (%)	Flocks (*N*)	Rating	Habitat (%)	Flocks (*N*)	Rating
				1981–82 Wintering season					
Cut rice, dry	30.5	1	A	14.7	2	A	19.2	5	N
Cultivated	24.7	3	A	29.9	13	N	35.8	45	P
Fallow	20.2	1	A	13.5	4	N	15.0	1	A
Cut rice, wet	10.1	20	P	6.0	26	P	0	6	P[b]
Cut soybeans	8.0	17	P	30.6	13	N	16.7	9	N
Winter pasture	6.5	7	N	5.3	7	N	13.3	6	N
Total	100.0	49		100.0	65		100.0	72	
				1982–83 Wintering season					
Cut rice, dry	27.6	5	A	1.4	0	—[c]	2.4	0	—[c]
Cultivated	10.8	4	N	25.5	34	P	24.2	44	P
Fallow	22.6	4	A	8.3	2	N	18.9	1	A
Cut rice, wet	11.6	26	P	26.2	18	N	15.7	19	N
Cut soybeans	25.0	17	N	33.2	12	A	25.7	33	N
Winter pasture	2.4	2	N	5.4	8	N	13.1	6	N
Total	100.0	58		100.0	74		100.0	103	

[a] Preference rating: P=Preferred, A=Avoided, N=Neutral
[b] Not calculated, but tested and found to be Preferred
[c] No preference rating calculated

the goose flocks counted. Soybean fields were used in proportion to availability during all other seasons, except mid-season 1982–83 when they were generally avoided.

Harvested soybean fields provided a valuable source of protein and a secure feeding site. However, heavy use early in the wintering season probably caused rapid depletion of the supply of waste soybeans. By mid-season most waste soybeans were probably consumed, and use during late season probably resulted from geese feeding on sprouting native vegetation. We examined fields in February and found no remaining waste soybeans. Hobaugh (1982) sampled soybean fields in Texas and reported that no soybeans remained after mid-January, a finding similar to that of waste rice. He also reported green vegetation began to appear in soybean and rice fields after mid-January and increased in abundance through mid-March.

Cultivated fields were the major habitat used in the late season of both years. Cultivated fields were avoided in early season 1981–82 when other habitats were more desirable and did not become attractive either year until later in the season. In late winter, cultivated fields contained sprouts of native grasses and forbs that attracted the geese. Hobaugh (1982) noted that green vegetation appeared in plowed fields during mid- December, but substantial growth did not occur until mid-January, and growth peaked by mid-February.

McLandress and Raveling (1981) reported that giant Canada geese (*Branta canadensis maxima*) entered a period of hyperphagia in March before northward migration in April. New-growth grasses provided the high levels of protein needed by the geese for migration, nesting, egg-laying, and territorial defense. Owen (1972b, 1975) reported that whitefronts preferred fields where grass was younger and more nutritious, and that overall use of fertilized areas was 42 percent higher than unfertilized control areas. A newly cultivated field in southwestern Louisiana in early spring contains succulent forbs and grasses and although not fertilized at the time, probably contains abundant nutrients recycled by cultivation. Both factors probably influenced the increased goose utilization noted.

Winter pasture was not rated as a preferred habitat type during any season, and, although use appeared to increase during the winter, it remained within the confidence limits of habitat availability. After harvesting soybeans and rice in late summer and early fall, many farmers cultivate, fertilize, and plant fields with winter cover crops of ryegrass and winter wheat. Some fertilized cover crops are sprouting when whitefronts arrive on the wintering grounds. This protein-rich food source is readily available and utilized by the geese. Other farmers, however, do not plant winter pasture until later in the wintering season. By late winter and early spring, early-planted cover crops have grown taller and are less succulent. Such plants may be less palatable and less attractive to feeding geese and are abandoned. At the same time, cover crops planted later may be reaching a stage attractive to whitefronts. The total amount of winter pasture gradually increased during the wintering season, but the amount in early growth stage changed little. Consequently, use by white-fronted geese generally remained unchanged and reflected their preference for recently sprouted winter pasture.

Linscombe (1972) noted that whitefronts appeared not to use winter pasture in January and February. However, Lynch (1956) noted that fall plowing and light flooding of winter pasture resulted in increased goose use.

Fallow fields were avoided during early and late seasons of both years; but during mid-season, they were used in proportion to availability. Stands of taller vegetation are usually present and make many fallow fields unattractive to wintering geese. Like fallow fields, native pasture also contains stands of taller vegetation which apparently make this habitat unattractive to geese. In addition, palatability of plants in fallow fields and native pasture may have affected use of these habitats by geese. Owen (1972a) noted that whitefronts possibly preferred the better quality agricultural varieties to the usually more fibrous wild grasses.

Summary and Conclusions

Habitat availability in southwestern Louisiana was aerially inventoried during three periods of the wintering seasons of 1981–82 and 1982–83. Habitat use by white-fronted goose flocks was examined by ground surveys during each of the survey periods and compared to habitat availability. Soybeans, rice, and winter pasture were the major agricultural crops in the study area.

Of the 14 habitat types classified in the aerial surveys, goose flocks utilized only 8. Habitat availability and habitat use by goose flocks changed from one survey period to another, but the yearly pattern of habitat use remained fairly constant in both wintering seasons. Habitat use in each survey period was significantly different ($P<0.005$) from habitat availability.

During the six survey periods, wet, harvested rice fields were preferred during four periods; cultivated fields during three periods; and harvested soybean fields during one survey period. Winter pasture was used in proportion to availability each period. Dry, harvested rice fields and fallow fields were generally avoided. Seasonal food availability, the palatability of available plants, and the dominant cover type seemed to determine white-fronted goose use of habitats. Goose flocks preferred to feed in habitats producing nutritious forage (waste grains and new plant growth) and containing no obstructions of visibility.

Habitat types present in greatest abundance were generally those most preferred by white-fronted geese. Also, habitat types provided by some form of agricultural management received greatest use, and types containing native vegetation (fallow fields, native pasture, and marsh) received least use. The wintering population of white-fronted geese in Louisiana has more than tripled over the past several decades (Leslie 1983). If goose preference for a habitat can be used as a measure of habitat quality, then improved habitat conditions as a result of agricultural practices may be an important contributing factor to the population increase.

Acknowledgements

We thank Gerald Daigle for assistance during aerial surveys, Vernon Wright for assisting in statistical analysis of data, and personnel of Lacassine National Wildlife Refuge for providing facilities. This study was conducted under the auspices of the Louisiana Cooperative Wildlife Research Unit: Louisiana State University, Louisiana Department of Wildlife and Fisheries, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating.

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The Black Duck Population and Its Management

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Introduction

The status of the black duck has been a matter of concern to waterfowl managers for many years. This species, which has long been the principal game duck in eastern Canada and the Atlantic Flyway in the United States, experienced a sharp decline in numbers in the late 1950s and early 1960s. This was a period of general decline in continental duck populations associated with adverse conditions on the breeding grounds. Although duck populations as a whole recovered in subsequent years, black ducks did not. After increasing slightly in the mid-1960s, they have continued to decline at an average rate of about 1.5 percent per year. Surveys indicate about 40 percent fewer black ducks on United States wintering areas now than in the mid-1960s.

In spite of intensive investigation, a clear understanding of the factors most responsible for the decline has not yet fully emerged. This has been, and continues to be, a subject of debate and disagreement not only among waterfowl managers but between management agencies and other interest groups. The debate has centered largely on the role of hunting mortality, which some observers believe to be the principal factor affecting black ducks. The depth of disagreement on this point came into the open in 1982 when the Humane Society of the United States intervened in Federal court in an attempt to force the U.S. Fish and Wildlife Service to prohibit black duck hunting in the United States. Although the Service opposed this measure, and successfully defended its position in court, questions about the future of black ducks in North America are by no means resolved.

Why are black ducks declining and what can be done about it? Since 1976, the U.S. Fish and Wildlife Service and the Canadian Wildlife Service have been working together, and with State and Provincial wildlife agencies, to obtain the information and understanding needed to deal with these questions. We have reviewed and evaluated earlier studies, particularly in regard to the effects of hunting mortality, and we have undertaken new investigations to further explore this and other factors. We do not yet have clear answers but we believe we are beginning to see where the answers may lie. This paper summarizes in separate but related discussions the current views of our agencies on these matters. The views of the Fish and Wildlife Service emphasize a perspective from the wintering grounds, which are primarily in the United States; the views of the Canadian Wildlife Service emphasize a perspective from the breeding grounds, which are primarily in Canada.

Black Ducks in the United States

A major source of information on black duck population trends is a general waterfowl survey conducted each year in early January on wintering areas in the United States. This is the mid-winter waterfowl survey, which is a count of the number of waterfowl observed in important winter habitats. It does not provide an estimate of the total of wintering black ducks. Nevertheless, it provides the only long run of annual information on black ducks—going back to 1955. A graph of the results of the mid-winter survey for the period 1955–1984 (Figure 1) illustrates the downward trend mentioned previously and indicates that the trend is similar in both the Atlantic and Mississippi Flyways.

It is often assumed that the changes shown in this graph apply to all black ducks in all parts of the range. The fact is that there are significant regional differences in both Flyways. A comparison of data for four regions in the Atlantic Flyway (Figure 2) shows that the greatest part of the decline is in the lower mid-Atlantic region (Delaware, Maryland, Virginia and West Virginia). There is an obvious downward trend in the south-Atlantic region (North Carolina, South Carolina, Georgia, and Florida) but this involves a relatively small part of the Flyway population. In New England, and the upper mid-Atlantic region (New York, New Jersey, and Pennsylvania), changes are relatively modest over the past 30 years. There are also pronounced regional differences in the Mississippi Flyway (Figure 3), where the greatest declines are in the central and northern parts of the Flyway. In the southern part of the Flyway, the population has fluctuated but there is no clearly defined trend.

The regional changes shown in these graphs appear to be directly associated with substantial declines in black duck breeding populations in Ontario and western Quebec. As will be discussed below, there have been major changes in land use, and possibly

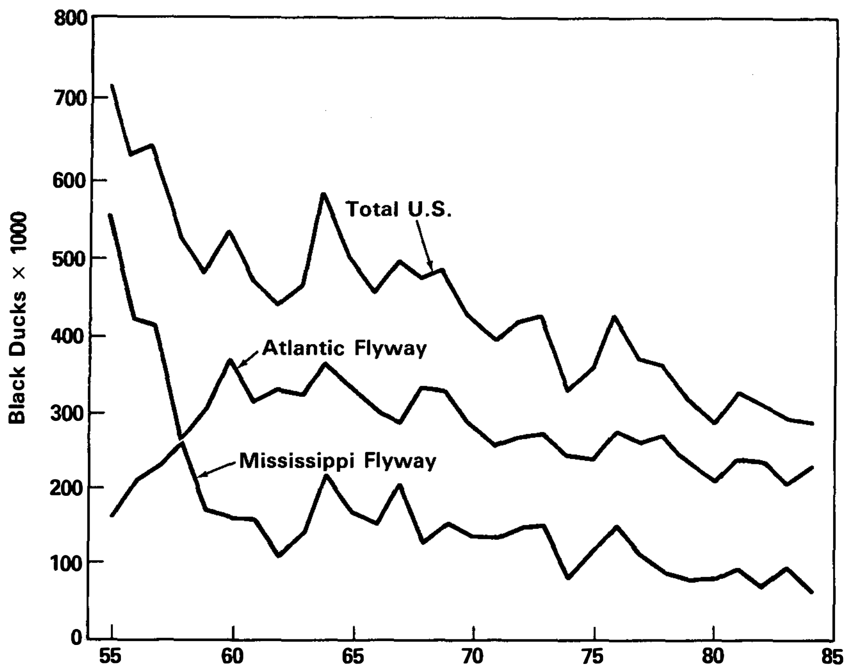

Figure 1. Black duck count—mid-winter survey, 1955–1984.

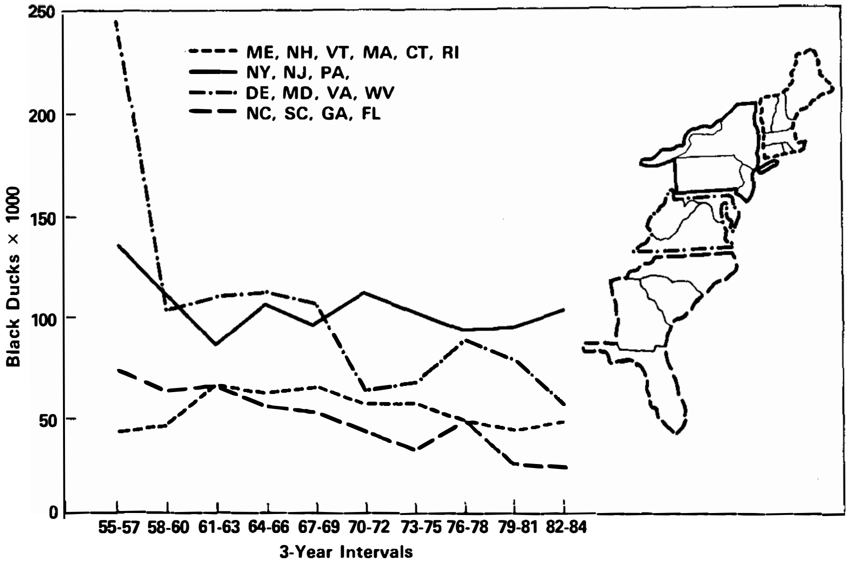

Figure 2. Black duck count—mid-winter survey, showing averages for 3-year intervals within regions of the Atlantic Flyway.

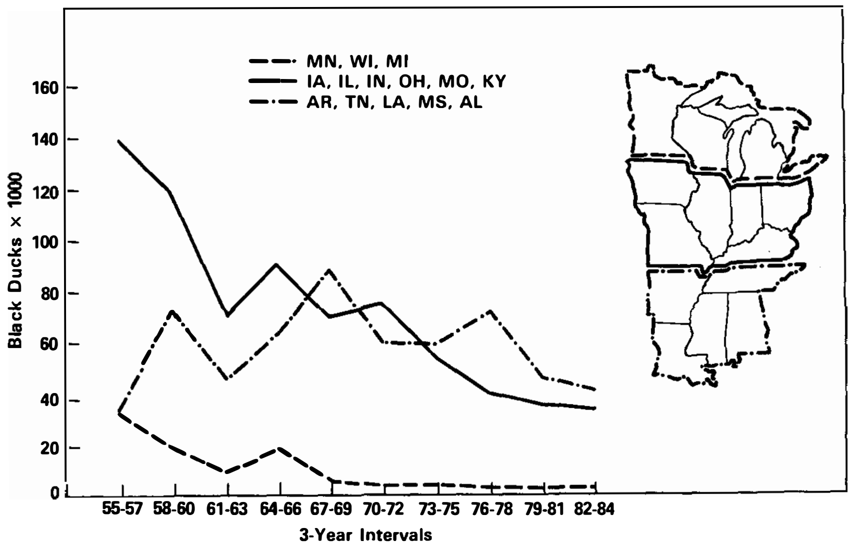

Figure 3. Black duck count—mid-winter survey, showing averages for 3-year intervals within regions of the Mississippi Flyway.

other environmental factors in some parts of these Provinces, that are unfavorable to black ducks but apparently not unfavorable to mallards.

There is no doubt that similar changes in the United States portion of the black duck range have contributed to the decline indicated by the mid-winter survey. Large portions of the northeastern part of the United States from the Great Lakes eastward into New England support fewer breeding black ducks than formerly. This is an area where much of the habitat formerly used by black ducks has been modified by large scale industrial development, urbanization, and changes in agricultural practices. Everything that is known about black ducks indicates that they are unable to adapt to such changes. In this respect, they differ from the mallard, which has shown itself to be quite capable of living and reproducing under such circumstances.

We should not be surprised, therefore, to find that while the black duck has been declining in parts of its range, the mallard has been increasing. The process appears to have been underway since the early part of this century. Paul Johnsgard, in a 1961 paper on North American mallards, summarizes information indicating that it began in the early 1900s—possibly even earlier. By 1960, it had become obvious that mallards were an increasingly important part of the waterfowl population, and the harvest, in the Atlantic Flyway. In 1969, mallards exceeded black ducks in the harvest in this Flyway for the first time, and they have made up an increasingly larger portion of the bag since then. By 1982, they outnumbered black ducks in the harvest by about 2 to 1. Figure 4 shows the magnitude of the average annual harvest of mallards as compared to black ducks for the period 1971–1980. From this it can be seen that the mallard is predominant over the black duck in every region of the Flyway except New England.

Another illustration of how mallards have moved north and east in the Atlantic Flyway in the last 20–25 years is provided in Figure 5. The percentages on the map represent

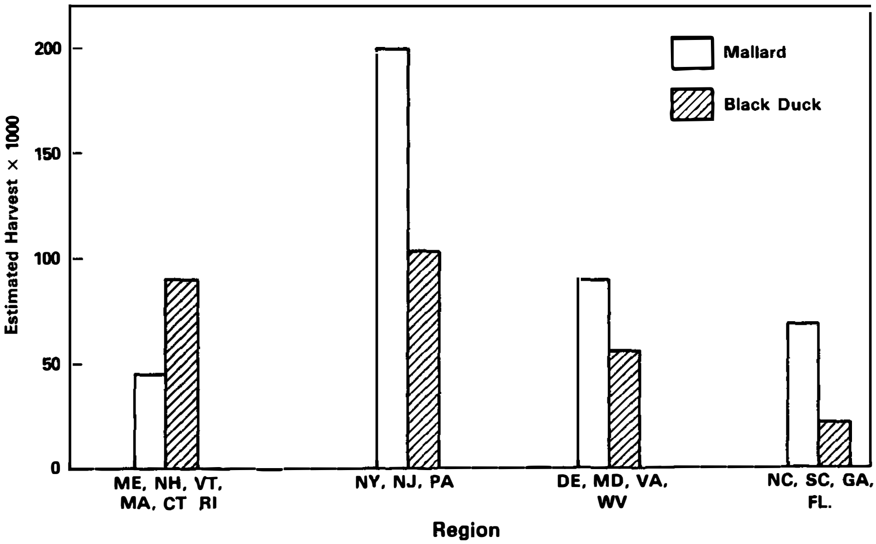

Figure 4. Mallard harvest compared to black duck harvest in four regions of the Atlantic Flyway, 1971–1980 average.

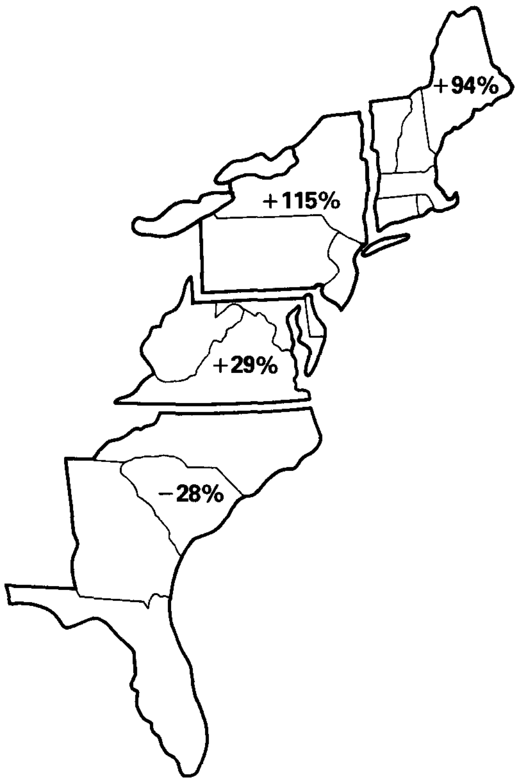

Figure 5. Percent change in mallards counted during mid-winter survey, 1960–69 average compared to 1980–84 average.

changes in the average annual count of mallards in the mid-winter survey during the period 1980–1984 as compared to the period 1960–69.

The eastward extension of mallards into the range of the black duck is a major waterfowl population event in North America. Mallards now occupy major portions of this range, and may be extending further into it with each passing year. At the same time, black ducks have decreased and their center of abundance has shifted to the east. In many of the areas where these changes have occurred, there is no apparent net population loss. It is the balance between the two species that has changed—not the total population. The situation is further complicated by hybridization between the two species. There are numerous individuals that are genetically neither pure mallard nor pure black duck. This subject will be further discussed below.

It seems clear from the information available to us now that this situation is far more complicated than was formerly thought and cannot be understood by focusing solely on one factor such as hunting mortality. In the past, mortality from hunting was believed to be the main factor involved. Many continue with that persuasion but, as a generalization, it is not supported by modern investigations.

The most recent analyses of black duck population data fail to demonstrate a simple, direct relationship between harvest levels and population status. Estimates of harvest and survival rates appear to be no different for mallards and black ducks where they occupy the same range and are exposed to the same environmental conditions and levels of hunting. On the other hand, the late Dr. Warren Blandin, who explored this more thoroughly than anyone else (Blandin 1982), concluded that hunting mortality could be affecting black ducks in some areas, by reducing the survival rate of immatures. Also, there could be other effects not detectable with the data and analytical methods he used. Thus, the possibility of a relationship between harvest levels and population status cannot be entirely discounted.

While other factors now appear to be more critical, it is essential that we continue to explore the role of hunting mortality. For this reason, additional restrictions on the harvest of black ducks were implemented in the United States in 1983 in a cooperative program with State wildlife agencies. The program will be maintained for the next 3 to 5 years. The aim is to bring black duck harvest rates below those for mallards in the same areas, and determine the response, if any, by black ducks.

Black Ducks in Canada

As indicated above, the status and management of the black duck is not a straightforward issue. Certainly on the Canadian breeding grounds, where 85 to 90 percent of North American black ducks breed, the status of populations is not uniform. In northern Quebec, Labrador and the Maritimes black duck breeding populations appear to be quite stable or in some areas actually increasing. However, along the western edge of the black duck range there have been substantial declines in breeding populations. For example, in southwestern Ontario populations have declined by approximately 80 percent since the early 1950s. In eastern Ontario, the decline has been approximately 40–50 percent in the last decade with a corresponding increase of mallards. For the two species combined, there has been little or no change in total numbers, but the ratio between blacks and mallards has changed in favor of mallards. There are some local losses of black duck breeding populations in New Brunswick as well. This regional picture is quite consistent with information from the mid-winter inventory. Black ducks from these areas winter in the Mississippi Flyway and lower mid-Atlantic Flyway where drops in the winter counts have been most predominant.

Results of black duck banding in Ontario show that approximately 50 percent of the band recoveries occur in Canada, mostly in Ontario, and 50 percent in the United States. The locations of these recoveries in the United States are the Mississippi Flyway, the mid-Atlantic region, and the south Atlantic region. Very few recoveries are reported from New England. Bandings in the Maritime Provinces show that recoveries are distributed approximately 80 percent in Canada, and 20 percent in the United States. Of that 20 percent in the United States almost all were in New England.

As previously mentioned, recent analyses of population data do not demonstrate that hunting is the single most important or major cause of the decline of the black duck. Table 1 presents mean annual survival and harvest rates of black ducks and mallards banded in Ontario and Quebec, 1968–1981. Harvest rates for adult black ducks are lower than those for adult mallards, yet survival rates are similar. For young birds harvest rates are essentially the same for blacks and mallards in Ontario, but somewhat higher for mallards in Quebec. Survival rates for young black ducks are lower in Ontario but higher

Table 1. Estimates of mean annual survival rates and harvest rates of black ducks and mallards banded in Ontario and Quebec, 1968–1981.

	Adults				Young			
	Ontario		Quebec		Ontario		Quebec	
	Black duck	Mallard	Black duck	Mallard	Black duck	Mallard	Black duck	Mallard
Annual survival rate (%)	57.9	57.8	61.9	57.2	42.2	47.8	43.4	37.9
Harvest rate (%)	14.3	15.7	12.4	16.5	24.8	24.2	25.6	33.1

in Quebec as compared to young mallards. Since harvest rates are similar, we conclude that hunting is not responsible for the lower survival rate of young black ducks in Ontario. To provide additional perspective on this point, we note that in the Maritime Provinces survival rates for adult blacks ducks are approximately 61 percent, and for young black ducks approximately 38 percent. The latter is lower than in Ontario and Quebec yet black duck populations are thriving in the Maritimes and undergoing declines in Ontario and southwestern Quebec.

There have been substantial habitat changes in parts of the black duck range in Ontario and southwestern Quebec. In extreme southwestern Ontario, where agricultural development is most intensive, changes in the relative abundance of black ducks and mallards were noted in the early 1950s. For whatever reason, the changes in that environment, including the loss of wetlands along the Great Lakes and St. Lawrence Valley, have favored the mallard and not the black duck. There is also the potential impact of acid precipitation. We know that this phenomenon is affecting the quality of many wetlands. While we do not, at this time, understand how it would detrimentally affect the black duck and not the mallard, it is a possibility that we are investigating.

A major problem in Ontario and southwestern Quebec appears to be hybridization and competition with the mallard. As mentioned earlier, the total population of blacks and mallards is stable, but blacks are being replaced by mallards. In a cooperative research undertaking with the University of Western Ontario, the Canadian Wildlife Service is investigating the phenomenon of hybridization between mallards and blacks. Preliminary results reported by Dr. David Ankney, the principal investigator, indicate that mallard genes occur in black ducks as far east as Labrador. Research results indicate that mallard genes are dominant, and certainly in terms of competition there is evidence that mallard drakes are more aggressive and out-compete black duck drakes in selecting black duck females, if no mallard females are available. It may well be that what we are seeing is the evolution of a hybrid species that can function in the present environment of eastern Canada, better than either the black duck or the mallard.

It is one thing to say the issue is complicated, but quite another to do something about it. Although hunting mortality doesn't seem to be the single factor affecting the status of black ducks, we cannot dismiss it altogether. We are aware that there may be heavy hunting pressure on some local populations of young birds. Consistent with the approach taken in the United States, Canada will implement a period of restrictive hunting regulations for black ducks in 1984. Our objective is to lower harvest rates on black ducks and determine if breeding populations respond positively. There will be a general reduction in the black duck bag limit throughout Canada, but the most severe restrictions on black duck hunting will be centered in Ontario and southwestern Quebec where the problem is greatest. So, throughout the range of the black duck in both Canada and the United States, action is being taken to reduce harvest and see if we can measure an impact on the population.

That's not to say that this is the only action we will take. Research on hybridization and competition will continue. It is extremely important to understand this phenomenon and determine what, if anything, can be done about it. Investigations of the quantity and quality of habitat available to black ducks will be continued, also. The eastern Provinces and the Canadian Wildlife Service have been cooperating for several years now in evaluating and mapping wetlands in the Maritimes, Ontario and Quebec. This work is continuing and is providing a basis for new surveys of breeding populations of black ducks and other species. This effort has benefitted from research into the problems of acid rain, and from surveys relating to the James Bay hydroelectric development. Because of these activities we have been able to get a better understanding of the habitat requirements and habitat selection of black ducks in northern Ontario and northern Quebec. New survey techniques and procedures for monitoring breeding populations and their habitats have been developed. The U.S. Fish and Wildlife Service and the Canadian Wildlife Service together with the Provinces are currently evaluating proposals for accelerating black duck research and population surveys throughout Eastern Canada.

In conclusion, we believe that the complexities of the black duck situation make it inappropriate to focus all our efforts on a single factor such as hunting. The management, monitoring, and research activities of the U.S. Fish and Wildlife Service, Canadian Wildlife Service, States and Provinces are predicated on the view that many factors are affecting the abundance, breeding success and survival of black ducks. The task of our cooperative effort is to identify the relative importance of each factor at different places and times, determine what practical steps can be taken to benefit the black duck, and implement them to the extent possible. There is a commitment in the United States and Canada to accomplish this.

Acknowledgements

The authors drew heavily on the knowledge and expertise of Robert I. Smith, U.S. Fish and Wildlife Service, and Hugh Boyd, Canadian Wildlife Service, in developing this paper. We acknowledge with thanks their extensive contributions.

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Compensatory Mortality in Waterfowl Populations: A Review of the Evidence and Implications for Research and Management

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Introduction

In 1976, the publication of "Population Ecology of the Mallard: VI. The Effect of Exploitation on Survival" (Anderson and Burnham 1976) had an important effect on views about how the harvest of waterfowl populations should be managed. Anderson and Burnham (1976) pointed out that the basic premise upon which waterfowl harvest management had been based was not necessarily true and that the previous evidence marshalled in its support had been based on faulty statistical inference procedures. Anderson and Burnham (1976) specified two hypotheses about the relationship between hunting mortality and total annual survival rate (and thus about the interaction between hunting and nonhunting mortality). They then tested predictions of these competing hypotheses using historical banding, band recovery, and other population data for mallards, *Anas platyrhynchos*, in North America.

Because of the fundamental importance to waterfowl management of its results and implications, the report by Anderson and Burnham (1976) has been widely read, cited and discussed. Many discussions (of which we are aware) of this work, however, reveal varying degrees of confusion and misunderstanding about the two hypotheses and their implications for waterfowl harvest management. In addition, there have been several recent efforts to test predictions of these hypotheses. It seems that it would be useful now to discuss these hypotheses and to review the relevant evidence that has accumulated since 1976. Our objectives here are: (1) to specify the hypotheses of completely compensatory and additive hunting mortality and to provide clarification of them with respect to what we perceive as sources of confusion; (2) to list testable predictions which can be deduced from these two hypotheses; (3) to review specific tests of these predictions which have been published within the last 9 years; (4) to discuss needed research and appropriate management responses to the available evidence relating to these two hypotheses.

The Hypotheses

Anderson and Burnham (1976) specified two hypotheses which represented extremes with respect to possible relationships between hunting mortality and annual survival rate: the totally additive mortality hypothesis and the completely compensatory mortality hypothesis. The "true" relationship for any population may lie at some intermediate point between these two extreme hypotheses. These hypotheses are valuable as conceptual reference points from which predictions can be deduced and tested. Both hypotheses can be expressed in several equivalent ways (e.g., Anderson and Burnham 1976:5–12). Here, we will express them in terms of the relationship between an annual hunting mortality rate and a corresponding total annual survival rate.

A natural, and appropriate, approach is to study the effect of hunting on annual survival and nonhunting mortality rates, with the anniversary date for the year being the start of the hunting season. Then, let $S(0, 1)$ be the probability that a bird alive on the anniversary date in year i survives all mortality sources (hunting and nonhunting) until the anniversary date in year $i+1$. For a hunting season of proportional length $L(0<L<1)$, let $S(0, L)$ denote the probability that a bird survives the entire hunting season. Similarly, let $S(L, 1)$ denote the conditional probability that a bird alive at the end of the hunting season survives until the annual anniversary date (the beginning of the next year's hunting season). Regardless of the relationship between hunting mortality and annual survival we can write the annual survival probability, $S=S(0, 1)$, as the product of the probabilities corresponding to the two segments of the year:

$$S(0, 1)=S(0, L)\, S(L, 1) \qquad (1)$$

In our graphical representations of the two hypotheses we plot the annual survival rate $S(0, 1)$ against a corresponding annual hunting mortality rate. Specifically, we define K as the probability that an individual alive at the beginning of the hunting season will die as a result of hunting during the interval $(0, L)$. The corresponding annual nonhunting mortality rate (also interpretable as a probability) is defined as V. Both K and V are actual rates, and total annual mortality is $M=V+K=1-S$ (this is not to be confused with Ricker's (1958:25) equation; see Anderson and Burnham 1981:1053 and Anderson and Burnham 1976:46–54). Hunting mortality occurs only in the time interval $(0, L)$. By contrast, nonhunting mortality occurs during the entire year. Note that if there were no nonhunting mortality during $(0, L)$ then we would have $K=1-S(0, L)$ and $V=(1-K)(1-S(L, 1))$. Given this assumed temporal separation of mortalities, both these relationships are true regardless of what we assume about the effect of varying hunting mortality rates (K) upon $S(=1-K-V)$ or V.

Understanding the effect of varying hunting mortality on total survival (or what is equivalent, how V varies as K varies) is greatly complicated by two factors: (1) hunting and nonhunting mortality overlap during the hunting season and (2) birds which die from hunting are no longer "available" to die from nonhunting causes. Because of this second complication there is always some amount of decrease in nonhunting mortality as hunting kill rate increases, regardless of the effect ("additive" or "compensatory") of hunting mortality on annual survival.

Additive Mortality Hypothesis

The relationship between annual survival rate, S, and annual kill rate, K, under the additive mortality hypothesis is illustrated in Figure 1. As the intensity of hunting mortality increases, the total annual survival rate decreases in essentially a linear manner (for kill rates not too close to 1; for K very near 1, this linear model is a poor approximation). The intercept of this line, i.e. when $K=0$, is denoted here by S_o. Thus, S_o has the simple interpretation as being the annual survival rate which would apply if there were no hunting kill during the year.

Consider the simplified situation in which all hunting mortality occurs during the hunting season in (0, L), followed by all the nonhunting mortality in (L, 1). In this case $S(0, L) = 1 - K$, and under the additive hunting mortality hypothesis $S(L, 1) = S_o$, so equation 1 can be written as:

$$S(0,1) = S_o(1-K) = S_o - S_oK \qquad (2)$$

Although equation 2 only holds exactly when all hunting and nonhunting mortality occur in separate time periods, it is a good approximation, given additivity, under the more realistic situation where some nonhunting mortality occurs during the hunting season (0, L).

Another way of viewing this model is that the additive mortality hypothesis (Figure 1 and equation 2) implies complete independence of hunting mortality K and the nonhunting mortality rate $1-S(L, 1)$ after the hunting season. The magnitude of this post-hunting season mortality rate may be influenced by environmental conditions during a particular

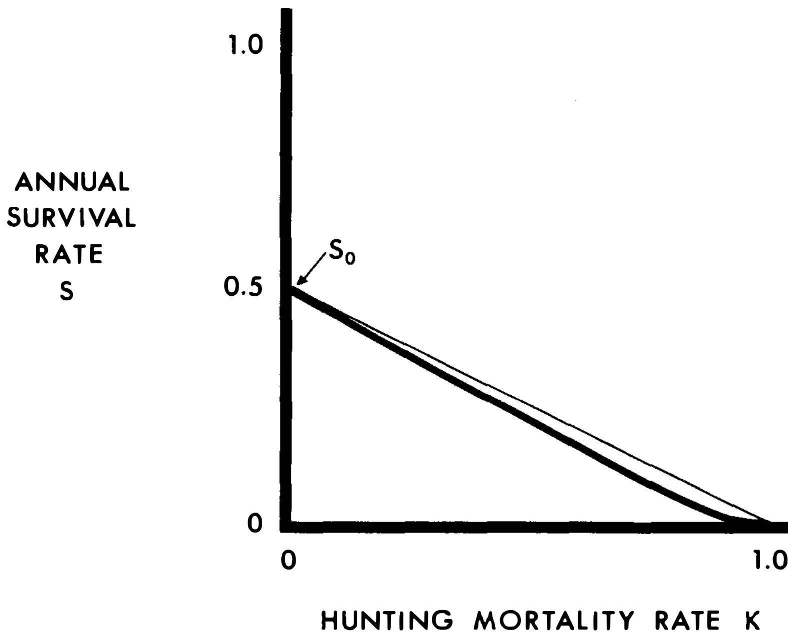

Figure 1. Annual survival rate as a function of hunting mortality rate under the additive mortality hypothesis (Figure 2b of Anderson and Burnham 1976:9).

year, but it is not affected by either the hunting mortality rate that year or the actual number of individuals exposed to this post-season nonhunting mortality. Thus, the action of nonhunting mortality is defined to be free of density-dependent mechanisms under this hypothesis.

Compensatory Mortality Hypothesis

The basic idea here is that as hunting mortality rate increases there is a compensating decrease in nonhunting mortality rate. The annual survival rate (recall, $S=1-K-V$) stays unchanged (at least for kill rates, K, that are below a threshold value). Consider the simple case where hunting and nonhunting mortality are temporally separated. Then for compensation to occur, $S(L, 1)$ must increase as the kill rate, K, increases. Because S(L, 1) cannot exceed 1, there is a limit to the degree of compensation which can occur (that is K cannot exceed a threshold). An alternative view of this process is that nonhunting mortality decreases to compensate for an increasing kill rate, and because $V \geq 0$ is required, there is a mathematical limit to the degree of compensation. This limit is in fact achieved at $K=1-S_o$, where as above, S_o is the annual survival rate when kill rate, K, is zero. In practice we would expect compensation to break down before the kill rate reaches this absolute limit of $1-S_o$. Thus, we are led to adopt the following as the compensatory mortality hypothesis.

Total annual survival rate is assumed to be completely independent of the intensity of hunting mortality for hunting mortality rates ranging between 0 and a threshold point, c (see Figure 2). Thus, variation in hunting mortality within this interval ($0<K<c$) produces no corresponding variation in annual survival rate $S(0, 1)$, i.e.,

$$S(0, 1)=S_o \text{ for } 0<K<c \tag{3}$$

At some point, of course, further increases in hunting mortality must reduce annual survival rate and, for $K>c$, $S(0, 1)$ decreases with increases in K.

The maximal possible value of c is $1-S_o$. This observation is informative; it indicates that species with high survival rates (in the absence of exploitation) have little potential for compensation. Conversely, species with low values of S_o have considerable potential for compensation.

The relationship shown in Figure 2 and equation 3 requires that nonhunting mortality decreases (compensates) as hunting mortality increases (for K below c). If we return to the situation in which all nonhunting mortality occurs in $(L, 1)$, then for $0<K<c$, $S(L, 1)=S_o/(1-K)$. This suggests that nonhunting mortality must act in a density-dependent manner such that when population size is relatively large at time L (e.g.,, this might occur after a hunting season with low K) nonhunting mortality is relatively high, and when population size at L is small (e.g., as a result of high K) then nonhunting mortality is low. Density-dependent mortality is often thought to involve competition for limited resources during some critical period, but the compensatory mortality hypothesis itself does not specify a particular mechanism.

A sharp threshold point may not be realistic. Indeed it is possible to formulate somewhat more realistic mathematical models of compensation. However,these formulations require the mathematics of competing risk theory, and they get very complex with little or no improvement in our ability to test for additivity versus compensation (Burnham unpubl.). Thus, the above formulation of the compensatory mortality hypothesis (i.e., with a distinct

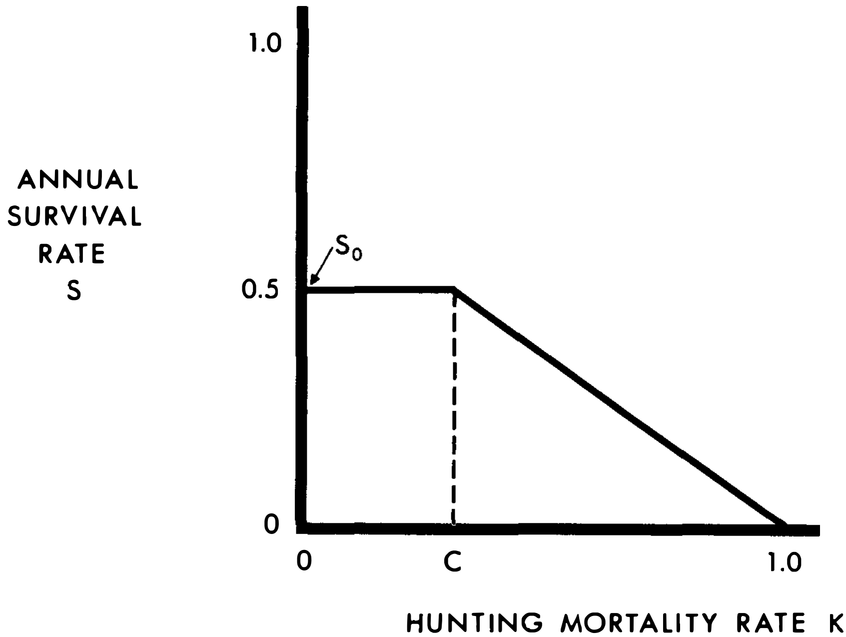

Figure 2. Annual survival rate as a function of hunting mortality rate under the compensatory mortality hypothesis (Figure 1b of Anderson and Burnham 1976:6).

threshold, c) is appropriate as a basis for testing between the two extremes of additivity and compensation.

Comparison of the Two Hypotheses

Under either hypothesis we are considering how varying K affects S and/or $V=1-S-K$. Two numerical examples will be given here. First consider the situation (case A) in which all nonhunting mortality occurs in $(L, 1)$. Let $S_o=0.7$, and take c as $1-S_o=0.3$. The values of S and V, for given K, are shown for both hypotheses in Table 1. For a second example (case B) we let $L=1/3$ and assume constant instantaneous hunting and nonhunting mortality rates. This allows nonhunting mortality to occur during the hunting season. Resulting values of S and V are again presented (case B) in Table 1.

There are three important points illustrated in Table 1: (1) nonhunting mortality rate, V, decreases as the kill rate, K, increases under both hypotheses, but the decrease in V is much more pronounced under the compensatory hypothesis; (2) under the compensatory mortality hypothesis annual survival rate, S, stays constant as K increases until kill rate exceeds some threshold point (selected as 0.3 here); under additivity, any increase in kill rate results in a decreased annual survival rate; (3) the results for case A and case B do not differ very much even though they assume (slightly) different distributions of natural mortality during the year.

Table 1. Values of K, S and V under the additive and compensatory mortality hypotheses for the 2 situations (cases A and B) described in the text.

	Additivity (Case A)		Compensation[a]		Additivity (Case B)	
K	S	V	S	V	S	V
0.000	0.700	0.300	0.700	0.300	0.700	0.300
0.050	0.665	0.285	0.700	0.250	0.663	0.287
0.100	0.630	0.270	0.700	0.200	0.626	0.274
0.150	0.595	0.255	0.700	0.150	0.589	0.261
0.200	0.560	0.240	0.700	0.100	0.552	0.248
0.300	0.490	0.210	0.700	0.000	0.478	0.222
0.400	0.420	0.180	0.600	0.000	0.405	0.195
0.500	0.350	0.150	0.500	0.000	0.331	0.169

[a] Values under complete compensation are the same for both cases, A and B.

Sources of Confusion

In discussions with waterfowl biologists and managers, and in some recent literature concerning the effect of hunting, we have noted a number of misunderstandings and sources of confusion about these two hypotheses. Two of these sources of confusion are sufficiently widespread that we believe their discussion here will be useful.

The first source of confusion involves the phenomenon that, even under the additive mortality hypothesis, some individuals that are harvested would have died anyway as a result of nonhunting mortality if there had been no hunting. This is illustrated in the examples in Table 1, and, as emphasized above, V will always decrease to some extent as kill rate increases. This is true even under additivity; wherein this decrease does not represent any form of compensation.

Consider the situation in which all nonhunting mortality occurs after the hunting season in (L, 1), and assume that the additive mortality hypothesis is true. If we begin the hunting season with N birds, then we expect N K to die as a result of hunting during the season. Only the surviving $N(1-K)$ birds will be exposed to nonhunting mortality during (L, 1). Of these we expect $(1-S_o)$ to die of nonhunting mortality, representing $N(1-K)\,(1-S_o)$ total birds. Hence $V=(1-K)(1-S_o)$ is clearly affected by K. If there was no hunting mortality (i.e., if $K=0$), then all N birds would be exposed to nonhunting mortality, of which $N(1-S_o)$ would be expected to die. The difference between these two numbers $[N(1-S_o)-N(1-K)\,(1-S_o)=N(1-S_o)K]$ is the expected number of birds killed by hunting that would have died of nonhunting mortality had they not died first due to hunting. This situation is illustrated by case A, Table 1. The important point is that this phenomenon (V decreases some as K increases) exists under the additive mortality hypothesis and does not represent compensatory mortality (also see Anderson and Burnham 1976:47).

The second source of misunderstanding stems from a failure to consider separately the birth and death processes; in particular density-dependent reproduction has been confused with the compensatory mortality hypothesis. As noted by Anderson and Burnham (1976:5), the birth and death process are biologically and mechanistically distinct. Therefore, despite the tendency in some mathematical models of exploited populations to combine reproductive and mortality rates into a single parameter reflecting a populations's rate of change in size, we strongly assert that it is important to maintain a distinction between these two processes (see related discussion in Conley and Nichols 1978:29). In any case, the compensatory and additive mortality hypotheses deal only with mortality and make no statement about reproductive rates or responses of recruitment rates to exploitation. We note that some evidence of density-dependent reproductive rates is available for mallards (Pospahala et al. 1974, Pospahala pers. comm.) and that this process may be important to the population's response to exploitation. Nevertheless, the hypotheses considered here, and by Anderson and Burnham (1976), concern only mortality (the death process) and have nothing to do with density-dependent reproduction.

Testable Predictions

Given these two competing hypotheses, we would like to deduce testable predictions from them which can be used to decide which one corresponds more closely to "reality" in any population being investigated. We believe that the following 3 predictions should be useful in distinguishing between these hypotheses for a population of interest:

1. The compensatory mortality hypothesis predicts that there is no relationship between annual survival rates and hunting mortality rates, if $K<c$. The additive mortality hypothesis predicts a negative relationship between annual survival rates and hunting mortality rates for the entire possible range of hunting mortality ($0<K<1$).
2. Under most reasonable scenarios, the compensatory mortality hypothesis predicts a negative relationship between hunting mortality rate (K) and nonhunting mortality rate after the hunting season ($1-S(L, 1)$). The additive mortality hypothesis predicts that there is no relationship between these rates.
3. The compensatory mortality hypothesis predicts a positive relationship between nonhunting mortality rate and population size or density at some time of the year. Under most reasonable scenarios, nonhunting mortality after the hunting season (i.e., during $(L, 1)$) should be positively related to population size at the end of the hunting season (L). The additive mortality hypothesis predicts no relationship between nonhunting mortality and population size.

We believe it is worth noting that the contrasting predictions listed under (1) differ from those listed under (2) and (3) with respect to the mechanics of statistical hypothesis testing. With (1), for example, the prediction associated with the compensatory mortality hypothesis is the statistical null hypothesis (the hypothesis of no relationship). Thus, we are placed in the situation of essentially accepting the compensatory mortality hypothesis until we can amass enough evidence to reject it in favor of the additive mortality hypothesis. With (2) and (3), however, the situation is reversed, and the prediction corresponding to the additive mortality hypothesis is the statistical null hypothesis. In this case, the compensatory mortality hypothesis is not accepted until sufficient evidence is available to reject additivity. Those who favor a conservative approach to resource management may thus be more comfortable using tests associated with the predictions of (2) and (3).

Review of the Evidence

Our intention here is to review the results of studies designed to distinguish between the compensatory mortality hypothesis and the additive mortality hypothesis in waterfowl populations. Work on this subject published prior to 1976 was reviewed by Anderson and Burnham (1976). Therefore, we will be primarily concerned with work appearing after 1976. Our review will be brief. For the reviewed studies we will specify the data and estimation methodologies used, outline the specific hypotheses tested, relate these hypotheses to the above sets of competing predictions and summarize the test results in a qualitative manner. Although there are several possible ways of organizing this review, we will classify reviewed analyses based on the specific statistical hypotheses tested and the actual testing methodology used.

All of the tests to be described rely heavily on statistical inferences from bird banding and band recovery data and associated estimation models. The data consist of numbers of birds banded in each of a number of successive years and, from each of these annual banded samples, the number of bands recovered (birds shot or found dead and band number reported to the FWS Bird Banding Laboratory, BBL) during each subsequent hunting season. Data of this sort contain information on both annual survival and hunting mortality rates. Here we define S_i as the probability that a bird alive at the approximate mid-point of the banding period in year i will survive until the mid-point of the banding period in year $i+1$. This banding period mid-point is approximately August 15 for birds banded preseason and January 30 for birds banded during winter. We define three parameters associated with hunting mortality. Recovery rate, f_i, represents the probability that a banded bird alive at the approximate mid-point of the banding period in year i will be shot or found dead during the subsequent hunting season and its band reported to the BBL. Harvest rate, H_i, denotes the probability that a bird alive at the approximate mid-point of the preseason banding period in year i will be shot and retrieved by hunters during the subsequent (year i) hunting season. Kill rate, K_i, denotes the probability that a bird alive at the approximate mid-point of the preseason banding period in year i will die as a result of hunting (this includes both retrieved and unretrieved kill) during the hunting season of year i.

The survival and recovery rates defined above are estimated using the models and computing algorithms of Brownie et al. (1978; also see White 1983, Conroy and Williams in press). Estimation of harvest rate requires additional information about the probability that a retrieved bird is reported by a hunter to the BBL. This information is available from reward band studies (e.g., Henny and Burnham 1976, Conroy and Blandin in press), and estimation methods are discussed in detail by Conroy (in press). Kill rate then requires additional information on unretrieved kill obtained from the FWS Hunter Questionnaire Survey and special Hunter Performance Surveys (e.g., see Martin and Carney 1977).

Tests Between Band Recovery Models Representing Competing Hypotheses

Recovery rates exhibit substantial year-to-year variation in most studied waterfowl populations (e.g., see Anderson 1975a:7–10, Burnham and Anderson 1979:361–362). If survival rates appear to exhibit no temporal variation in the face of variable recovery rates (and thus hunting mortality rates), then this provides some evidence in favor of the compensatory mortality hypothesis and against the additive mortality hypothesis. In addition, the ability to demonstrate year-to-year variation in annual survival rates should logically precede efforts to ask whether this variation is associated with hunting mortality. Brownie et al. (1978) thus developed one band recovery model (M2) assuming constant adult survival rates and time-specific adult recovery rates, and another (M1) assuming time-specific survival and recovery rates. Similar models, HO2 and H1, respectively, were developed for use with both young and adult data (Brownie et al. 1978). If goodness-of-fit tests provide evidence that the more general models (M1 and H1) adequately fit the data, then likelihood ratio tests between these pairs of models (M2 vs. M1, and HO2 vs. H1) address the hypothesis of time-varying survival rates (see Anderson and Burnham 1976:59-60; Brownie et al. 1978). Specifically, a significant likelihood ratio test statistic provides evidence that the null hypothesis (represented by the model with constant survival rate; either M2 or HO2) should be rejected in favor of the alternative hypothesis (represented by the model permitting year-to-year variation in survival rate; either M1 or H1), and thus that survival rates do vary over time.

These likelihood ratio tests between models representing competing hypotheses have been used with data from several duck species. The tests have been applied to the extensive data for mallards banded during both the preseason (July–September; see Anderson 1975a:8–11, Anderson and Burnham 1976:20–21, Rogers et al. 1979:118–121) and the winter (January–February; see Rakestraw 1981:1033–1035, Nichols and Hines in prep.) periods. In these mallard analyses, a large number of individual data sets (each data set corresponding to a particular age-sex class and geographic banding area) showed nonsignificant test statistics. However, continental test statistics summed over individual data sets were generally significant ($P<0.05$), leading to the conclusion that survival rates of adult and young mallards generally exhibit some year to year variation, although such variation does not appear to be large. These tests permit no inferences about whether or not this variation in survival rate is associated with variation in hunting mortality rate.

These tests have also been conducted using data from black ducks (*Anas rubripes*), ring-necked ducks (*Aythya collaris*), and canvasbacks (*Aythya valisineria*). Black ducks banded preseason showed no evidence of temporal variation in survival rates (Blandin 1982:50–57), but the power of these tests was low because of small sample sizes. Data for black ducks banded during winter were far more extensive and substantial than the preseason data. Test results based on winter bandings were similar to results of the mallard analyses, yielding nonsignificant test statistics for a number of individual data sets but significant statistics overall (Blandin 1982:50–57). Conroy and Eberhardt (1983:132–134) found evidence of year-to-year variation in survival rates of ring-necked ducks in four of six winter banding data sets examined. Nichols and Haramis (1980:168–169) investigated winter bandings of canvasbacks and obtained significant ($P<0.05$) M2 vs. M1 test statistics in two of six data sets.

Results of these likelihood ratio tests (M2 vs. M1 and HO2 vs. H1) have provided evidence of at least some year-to-year variation in survival rates for all four studied species. Test results were not as convincing as might have been expected *a priori*, and it is not clear whether this reflects the relatively low power of these tests, a relatively small amount of temporal variation in actual survival rates, or both factors. In any case, the finding of temporal variation invites additional study about whether this variation is associated with variation in hunting mortality.

The likelihood ratio test results described above are relevant to the predictions listed under (1). The models (M2 and HO2) with constant survival and time-varying recovery rates correspond closely to the compensatory mortality hypothesis. However, the models (M1 and H1) with year-specific survival and recovery rates do not correspond directly to the additive mortality hypothesis. Instead, these models are more general and include the additive mortality hypothesis as a special case.

Recently Burnham and Anderson (1984) proposed a new test between band recovery models which was developed specifically for the purpose of distinguishing between the compensatory and additive mortality hypotheses, again using the predictions under (1). The compensatory mortality hypothesis is again represented by model M2, which assumes constant survival and time-varying recovery rates. Burnham and Anderson (1984) then developed a band recovery model that corresponds directly to the additive mortality hypothesis. Specifically, they modeled annual survival rates as $S_i = S_o(1 - Wf_i)$, where W is a constant relating recovery rate to kill rate ($W = K_i/f_i$) and was estimated using results from a mallard reward band study (Henny and Burnham 1976) and the Hunter Performance and Hunter Questionnaire Surveys (Martin and Carney 1977).

Burnham and Anderson (1984) used data from mallards banded preseason to evaluate the likelihood functions under each of these competing models. Comparison of the likelihood functions under each model permitted classification of the data sets with respect to the two models. Burnham and Anderson (1984) found that 57 percent of all data sets were classified under the compensatory mortality hypothesis, as were 70 percent of a select group of "best data sets." Results of a large-scale Monte Carlo simulation study indicated that these empirical results were similar to what would be expected if the compensatory mortality hypothesis had been true for all data sets. Results of this study thus supported the compensatory mortality hypothesis, although the inference was much stronger for adult male mallards than for adult females.

Survival Rate Contrasts Between Years of Extreme Regulations/Harvest Rates

If increases in hunting mortality bring about decreases in annual survival (see prediction 1 for the additive mortality hypothesis) then we would expect the highest survival rates to occur during years with the lowest hunting mortality rates. Similarly, we would expect low survival rates during years of high hunting mortality. We can estimate both survival rates and recovery rates (indices to hunting mortality rates) from band recovery data, and one might be tempted to select years of extreme high and low recovery rates and to then test the hypothesis that survival rates differ between these years. However, survival and recovery rates are estimated from the same data, and under the models of Brownie et al. (1978) there is a nonzero sampling correlation between the estimators for survival and recovery rate of a given year (see Brownie et al. 1978:177–179). The existence of such sampling correlations can produce misleading results in inference procedures such as correlation analyses and the described survival rate contrasts (see discussion in Anderson and Burnham 1976:13–16). For this reason, the analyses described below utilize indicators of hunting mortality rate extremes which are independent of the band recovery model survival rate estimators.

Anderson and Burnham (1976:22–25) selected years of extreme restrictive (1962, 1965, 1968) and liberal (1964, 1970) waterfowl hunting regulations. Comparisons of mallard harvest estimates (Martin and Carney 1977) and recovery rate estimates (Anderson 1975a, Martin et al. 1979) confirmed that these years indeed represented extremes in mallard hunting mortality. Anderson and Burnham (1976:22–25) then used mallard survival rate estimates (obtained using preseason banding data) and their estimated variances to construct test statistics (after Brownie et al. 1978:207–208) comparing average survival rates during these two sets of years. These average survival rate estimates are reproduced here as Table 2. Although there was some evidence of low mallard survival rates in 1964, the overall tests involving the two sets of years with extreme regulations did not permit rejection of the null hypothesis of no difference in survival rates. The power (probability of rejecting a false null hypothesis) of the composite test statistic for all four age-sex classes was high for reasonable differences between survival rates. Rogers et al. (1979:119–122) repeated these tests using the same years of restrictive regulations but

Table 2. Average mallard survival rates in years of restrictive (1962, 1965, 1968) and liberal (1964, 1970) hunting regulations (from Anderson and Burnham 1976:24).

Age-sex class	Reference areas	Average survival rate in restrictive years	Average survival rate in liberal years	Difference
Adult males	12	0.657	0.637	0.020
Adult females	11	0.550	0.559	−0.009
Young males	10	0.518	0.520	−0.002
Young females	9	0.526	0.537	−0.011
Combined	—	0.563	0.563	0.000

different years of liberal regulations including more recent data (1970, 1974, 1975). These tests, like those of Anderson and Burnham (1976), provided no evidence of lower survival rates during the years of restrictive regulations (Rogers et al. 1979) and thus support the compensatory mortality hypothesis.

Nichols and Hines (1983) randomly partitioned preseason mallard bandings and associated band recoveries from individual data sets into two groups in order to obtain survival and harvest rate estimates with no sampling correlation. They used data from one of the two partitioned data sets to estimate harvest rates and data from the other to estimate survival rates. Years of extreme high and low harvest rates were then selected, and survival estimates for these years were compared as in the tests using years of liberal and restrictive regulations. The resulting test statistics provided some evidence that young female mallards experienced lower survival rates in the years of high harvest rates than during years of low harvest rates. However, the data set for young females was the smallest used, and the comparisons provided no evidence of low survival rates during years of high harvest rate in the other three age-sex classes (Nichols and Hines 1983:345–346).

Blandin (1982:96–110) compared black duck survival rate estimates from both winter and preseason bandings for years of extreme liberal and restrictive hunting regulations. None of the comparisons provided evidence of lower survival rates during years of liberal regulations. However, Blandin (1982) noted that black duck hunting regulations have been less variable than those for mallards and that many of his survival estimates had large sampling variances, producing tests with low power.

Nichols and Haramis (1980:169–171) estimated survival rates for winter-banded canvasbacks in three different wintering areas and selected years of extreme hunting regulations for each area. Survival rate comparisons suggested lower survival rates in years of liberal regulations for one of the wintering areas, but not the other two. However, these results were inconclusive, as they were based on survival rate estimates from winter-banded birds. As explained later in the discussion, survival rate estimates from winter-banded birds are not as useful as those from preseason-banded birds in testing hypotheses associated with the predictions listed under (1).

Survival rate contrasts between years of differing hunting regulations and harvest rates have thus been conducted for three species of ducks. Results of analyses for two species, black ducks and canvasbacks, provide little information that could help us to choose between the competing predictions of the compensatory mortality hypothesis and additive mortality hypothesis. Results for mallards are more helpful. In two instances (the comparisons using 1964 by Anderson and Burnham 1976; the results for young females by Nichols and Hines 1983) results pointed toward the additive mortality hypothesis, but the majority of the comparisons yielded results consistent with the compensatory mortality hypothesis.

Correlation Analyses Using Annual Survival Rate Estimates and Independent Harvest Rate Indices/Estimates

Correlation analyses using estimates and/or indices of survival and hunting mortality rates have been used to address directly the predictions listed under (1) for mallards, black ducks and ring-necked ducks. Anderson and Burnham (1976:31–33) computed annual harvest rate indices as the estimated adult mallard harvest in the United States (estimated from the Hunter Questionnaire and Parts Collection Surveys; Martin and Carney 1977) divided by the estimated May population size (estimated from the May Aerial Breeding Ground Survey; see Pospahala et al. 1974 and Martin et al. 1979). Continental mallard survival rate estimates were then computed for each year as averages of the preseason survival estimates from geographic areas throughout North America. Correlation analysis with these survival rate estimates and harvest rate indices was then used to test the hypothesis of a negative relationship between survival and harvest. Anderson and Burnham (1976) found no indication from these analyses of a negative relationship between survival rates and harvest rates for either adult males or females. Rogers et al. (1979:123–125) repeated this exercise including additional years of high harvest rates in the 1970s, but again found no indication of a negative relationship for either sex. These results support the compensatory mortality hypothesis.

Nichols and Hines (1983:342–345) used the independent harvest rate and survival rate estimates from their partitioned preseason data sets to conduct Spearman rank correlation analyses corresponding to specific age-sex classes in specific geographic areas. These analyses provided weak evidence ($P=0.08$) of a negative relationship between survival and harvest rates for young female mallards, although this evidence was based on the analysis of only five data sets. Analyses for the other three age-sex classes provided no support for the hypothesis of a negative relationship.

Blandin (1982:110–111) estimated adult black duck recovery rates using preseason banding data and survival rates using winter banding data for both the Atlantic and Mississippi Flyways. He then used correlation analyses to test for a negative relationship between these parameters. The Pearson correlation coefficients were negative for all four analyses (adult males and females in the Atlantic and Mississippi Flyways), and approached significance ($P<0.10$) for adult males in the Atlantic Flyway. Conroy and Eberhardt (1983:133–136) examined the relationship between recovery rates of preseason-banded ring-necked ducks and survival rates estimated from winter-banded birds. They found evidence of a negative relationship in two of the four data sets they examined. The implications of the results of Blandin (1982:110–111) and Conroy and Eberhardt (1983:133–136) for the predictions of interest (1) are not clear because of their use of winter banding data (see later discussion and Conroy and Eberhardt 1983:135–136).

Correlation analyses investigating possible relationships between survival rates and hunting mortality rates have thus been conducted for three species. Because of their reliance on survival rate estimates from winter-banded birds, results for black ducks and ring-necked ducks are not very helpful in distinguishing between the hypotheses of interest. One of the analyses using mallard data provided weak evidence of a negative relationship between survival and harvest rates (young females in the analysis of Nichols and Hines

1983). However, none of the other analyses provided any evidence of a negative relationship between survival rates and hunting mortality rates in mallards. On the whole, the compensatory mortality hypothesis is supported by these findings.

Estimation of the Slope of the Linear Relationship Between Annual Survival and Kill Rates

The competing predictions listed under (1) can both be placed in the framework of a single equation:

$$S_i = S_o(1-bK_i) \tag{4}$$

In practice the kill rate, K_i, is estimated based on the equation $K_i=Wf_i$ (discussed previously). If the compensatory mortality hypothesis is true, then the slope parameter, b, in (4) should equal 0. If the additive mortality hypothesis is true, then b should be approximately 1 (theoretical investigations suggest it would be closer to 1.05 in this linear model, but certainly less than 1.1). If neither extreme hypothesis is true, but rather there is partial additivity, then (4) provides a very useful way of modeling such a situation. Then b assumes an intermediate value between 0 and 1, and we can think of b as representing the degree of additivity (on a scale of, basically, 0 to 1).

The linear relationship of equation (4) was presented in Anderson and Burnham (1976) in the form $S_i=S_o-b^*K_i$. Since then we have realized that equation (4) is an easier to interpret version of this relationship (because b in (4) is automatically scaled to be in 0 to 1). Also, our more recent investigations (Burnham unpubl.) have provided much stronger theoretical justification for, and understanding of, (4) as a reasonable basis for statistical inference (using band recovery data) on the degree of additivity/compensation in waterfowl.

Anderson and Burnham (1976:25–29) used a components-of-variance approach (see Anderson and Burnham 1976:62–66) to estimate b in the earlier version of (4) for preseason-banded mallards. Their combined estimate of b, for all geographic areas and age-sex classes expressed in terms of (4) was $\hat{b}=0.29$. This value was found to differ significantly ($P<0.01$) from 1, the slope expected under the additive mortality hypothesis, but not from 0, the value expected under the compensatory mortality hypothesis. Results of this analysis were thus consistent with the compensatory mortality hypothesis but not with the additive mortality hypothesis.

Anderson et al. (1982) and Burnham et al. (in press) recently developed another method for estimating b in equation (4). Basically, they incorporated the relationship expressed in equation (4) directly into a survival estimation model and, using the computing algorithm of White (1983), directly obtained maximum likelihood estimates of b. Burnham et al. (in press) used this methodology with 47 sets of preseason banding data for adult mallards. The resulting slope estimate for adult males ($\hat{b}=0.05$) differed significantly from the slope predicted under the additive mortality hypothesis ($b=1$), but was very close to the value expected under the compensatory mortality hypothesis ($b=0$). The estimate for females ($\hat{b}=0.61$) was nearly midway between the predicted values based on the two extreme hypotheses and did not differ significantly from either prediction. Thus, the results for adult males support the compensatory mortality hypothesis, while the results for adult females are inconclusive and favor neither extreme hypothesis.

Thus, two different methods have been used to estimate b in equation (4) for preseason-banded mallards. One method (Anderson and Burnham 1976:25-29) yielded estimates of *b* that indicated rejection of the additive mortality hypothesis and were consistent with the compensatory mortality hypothesis. The other method (Anderson et al. 1982, Burnham et al. in press) yielded estimates of *b* that supported the compensatory mortality hypothesis for adult males but that were inconclusive for adult females.

Correlation Analyses Using Annual Survival Rate Estimates and Estimates of Population Size

If the compensatory mortality hypothesis is true, then we would expect nonhunting mortality during some time interval of the year to vary as a function of population size or density (see predictions listed under (3)). In order to test this prediction we first require knowledge (or a good guess) about the time period(s) of the year in which density-dependent mortality is important. We then need estimates of nonhunting mortality rate corresponding to those periods of the year and of population size at the beginning of those periods. We are aware of no tests with waterfowl using such estimates.

There have been some efforts to relate annual survival rate to population size in mallards and ring-necked ducks. The difficulty with such analyses lies in the development of suitable predictions about what to expect under the compensatory mortality hypothesis. Evidence already reviewed indicates that survival rates of ducks vary to some extent from year to year, as do population sizes (see Pospahala et al. 1974, Martin et al. 1979). Evidence of a negative relationship between annual survival rate and population size may be indicative of density-dependent nonhunting mortality. However, we do not believe that absence of such a relationship provides information that can be used to distinguish between the additive and compensatory mortality hypotheses.

Anderson (1975a:27) estimated the size of the fall mallard population in North America using data from the May Aerial Breeding Ground Survey and age ratios estimated using Hunter Questionnaire Survey, Waterfowl Parts Collection Survey and band recovery data (see Martin et al. 1979 and Munro and Kimball 1982 regarding age ratio estimation). Correlation analyses were then conducted using these population size estimates together with continental survival rate estimates from preseason bandings from the 4 age-sex classes. No significant relationships were detected and the analyses provided no evidence of density-dependent mortality (Anderson 1975a:27).

Anderson (1975a:26) also computed annual ratios of May mallards to May ponds in southern Canada (both estimated in the May Aerial Breeding Ground Survey), and used correlation analysis to test for an association between this ratio (for year $i + 1$) and survival rates of southern Canada mallards (for year i). The analysis produced a negative, but nonsignificant, correlation coefficient (Anderson 1975a:26). Nichols et al. (1982) examined this same general question using survival rate and mallards-per-pond estimates from specific geographic areas in the North American prairies. Results of Spearman correlation analyses and contrasts of survival rates between years of extreme mallards-per-pond ratios provided some evidence that mallards (especially males) exhibited lower survival rates during years of high mallards-per-pond ratios (Nichols et al. 1982).

Conroy and Eberhardt (1983) tested for an association between survival rates estimated from winter bandings of ring-necked ducks and May population size estimated in the May Aerial Breeding Ground Survey. Correlation analyses indicated a significant ($P < 0.05$) negative correlation for male ring-necked ducks, but not for females.

The described analyses provided some evidence that population size (the ring-necked duck work of Conroy and Eberhardt 1983) and population size expressed relative to a limited resource (the mallard analysis of Nichols et al. 1982) are associated with variation in annual survival rates. Although these results do not argue strongly for the compensatory mortality hypothesis, they do provide evidence for the existence of the sort of mechanism (density-dependent mortality) that must underlie the compensatory mortality hypothesis.

Discussion

We reviewed a number of studies testing predictions of the compensatory and additive mortality hypotheses for ducks. Many of these studies tested the predictions (1) about the relationship between kill rate K_i, and annual survival rate, S_i. Results of these studies are summarized in Table 3.

The reviewed analyses of mallard data permit stronger inferences than those addressing other species. The combined results for males, especially adults, permit rejection of the additive mortality hypothesis and point toward a highly compensatory mortality process for the years studied. Results for female mallards are much less conclusive. However, even for females, much of the available evidence tends to favor the compensatory mortality hypothesis rather than the additive mortality hypothesis (see discussion in Burnham et al. in press).

Even conclusions emerging from the mallard analyses require some cautions, however. First, it must be remembered that the different mallard analyses do not represent independent looks at a common question (see related discussion in Burnham et al. in press). Many of the methods used in the different analyses are interrelated, at least to some degree. In

Table 3. Summary of published results from studies addressing predictions (1) of the compensatory and additive mortality hypotheses about the relationship between kill rate, K_i, and annual survival rate, S_i.[a].

Species	Published reference	Age-sex class			
		Adult		Young	
		Male	Female	Male	Female
Mallard	Anderson and Burnham (1976:22–25)	C	C	C	C
	(1976:25–30)	C	C	C	C
	(1976:31–33)	C	C	—	—
	Rogers et al. (1979:119–122)	C	C	C	C
	(1979:123–125)	C	C	—	—
	Nichols and Hines (1983:342–345)	C	C	C	?
	(1983:345–346)	C	C	C	A
	Burnham and Anderson (1984:108–110)	C	?	—	—
	Burnham et al. (in press)	C	?	—	—
Black duck	Blandin (1982:96–110)	?	?	?	?
	(1982:110–111)	?	?	—	—
Canvasback	Nichols and Haramis (1980:169–171)	?	?	—	—
Ring-necked duck	Conroy and Eberhardt (1983:133–136)	?	?	—	—

[a] "C" indicates that the results generally supported the compensatory mortality hypothesis. "A" indicates that the results generally supported the additive mortality hypothesis. "?" indicates that the results were inconclusive and provided no evidence that could be used to distinguish between these 2 hypotheses. "—" indicates that the hypotheses were not addressed by the study.

addition, most of the analyses dealt only with the predictions listed under (1). More importantly, although the more recent analyses have been able to include additional years of data, the original data analyzed by Anderson and Burnham (1976) form a large portion of the data bases of all subsequent work. This original data set contains virtually all of the available information on years with low harvest rates. Thus, the different mallard analyses are not at all independent.

A second caution regarding the mallard analyses involves their reliance on an observational (correlational), rather than an experimental approach. Correlational approaches are much less convincing than manipulative experiments and can sometimes yield spurious results. Related to this general problem is the specific problem that not all factors that could potentially affect annual survival varied independently of hunting mortality rate. For example, population size may affect nonhunting mortality, as postulated under the compensatory mortality hypothesis, but harvest regulations and hunting mortality of mallards have not varied independently of mallard population size over the last 30 years. During the 1960s, especially, hunting regulations were restricted in years of low mallard population size and liberalized in years of high population size. In the 1970s, harvest regulations were not tied as closely to population size, and this period included some years of high harvest rates. However, most of our information about low harvest rates comes from years of low mallard populations during the 1960s. Although this association between population size and hunting regulations is undesirable, it is important to note that it does not negate conclusions drawn from the studies reviewed here. The additive and compensatory mortality hypotheses concern kill rates and survival rates. Despite low fall population sizes in years of restrictive hunting regulations, harvest rates (indices to kill rates) were demonstrably lower in those years than in years with larger fall populations and liberal regulations. Such variation in harvest rate permits legitimate tests of the predictions of interest (also see Burnham and Anderson 1984:110).

The reviewed studies dealing with species other than mallards yielded largely inconclusive results which provided little help in choosing between the compensatory and additive mortality hypotheses (a possible exception was the evidence of density-dependent mortality in ring-necked ducks by Conroy and Eberhardt 1983). Two factors were largely responsible for the inconclusive nature of the results for species other than mallards: the quantity of data and the use of winter bandings. Regarding the data, we note that very large numbers of bandings and recoveries are required to obtain precise estimates of survival rate. The data for canvasbacks, black ducks and, to a lesser extent, ring-necked ducks often did not yield precise survival rate estimates, and tests using these estimates were thus not very powerful. In addition, the optimal properties of the band recovery model estimators (e.g., of Brownie et al. 1978) are dependent on large sample sizes, and estimator properties for small samples are poorly known.

The problem with using survival rate estimates based on winter bandings concerns the anniversary date of the survival estimates and the timing of compensatory mortality. Assume, for example, that density-dependent nonhunting mortality occurs after the winter banding period but before the beginning of the next hunting season (i.e., assume that it is incorporated in $S(L, 1)$ from equation (1)). In such a situation, any compensatory response to mortality during the hunting season of year i would be reflected in the annual survival estimate (based on winter bandings) for year $i+1$. However, hunting mortality during the hunting season of year $i+1$ would also be included in this annual survival estimate. This situation results in a confounding of mortality sources which makes it difficult to deduce clear predictions for testing (see related discussion in Conroy and Eberhardt 1983; Nichols and Hines in prep.).

It is apparent from reviewing these studies and analyses that there are a number of difficulties associated with testing predictions of the compensatory and additive mortality hypotheses and with understanding these tests and interpreting their results. Some of these difficulties result from the complexity of the studied process itself. For example, the extreme hypotheses represented by (2) and (3) clearly represent simplified views of the mortality process. Equation (3) depicts annual survival rate as a constant (at least for some range of hunting mortality rates) and equation (2) asserts that all variation in annual survival rate results directly from variation in hunting mortality. Certainly various environmental factors are expected to influence survival to some extent, and thus S_o in equations (2) and (3) is probably not a constant but instead varies from year to year. The existence of factors other than those being studied which influence survival, decreases the power of tests to distinguish additivity from compensation. These factors do not, however, invalidate such tests (e.g., Burnham unpubl.; Nichols and Hines 1983:340–341).

As noted, the compensatory and additive mortality hypotheses represent extremes with respect to the relationship between annual survival rate and hunting mortality rate, and it is very possible that the true relationship lies somewhere between these extremes (e.g., in equation 4, $0<b<1$). The possible existence of such an intermediate hypothesis and the inability to specify it *a priori* add to the difficulties associated with investigating the relationship of interest. Similarly, predictions of the compensatory mortality hypothesis are dependent on a clearly specified model of compensation, either in terms of specifying the threshold value, c, or in terms of a realistic model for compensation that has no threshold (such models exist but provide no unique, or simple, representation of compensation; Burnham unbpubl.). Again, our lack of knowledge about c and the resultant inability to specify it *a priori* make testing more difficult. In fact, when $K>c$ we would tend to conclude that the additive mortality hypotheses was true when the compensatory mortality hypothesis actually applied.

We believe that the effect of hunting on waterfowl deserves further study. However, we are not very hopeful that additional correlational studies will provide many new insights. The quanity of data obtained in most ongoing banding programs will not permit the kind of analyses that have been possible with mallards. The mallard data through 1979 have been thoroughly analyzed, although application of the methods of Anderson et al. (1982) and Burnham et al. (in press) to data from both young and adult mallards would be interesting. We recommend periodic "new looks" at the mallard data as more years become available, but our expectations for such work are not very high unless deliberate efforts are made to vary hunting mortality rates in an experimental manner.

There have been very few efforts to test predictions listed under (2) and (3), but some research efforts now underway may yield relevant results. Special mallard banding operations associated with the current program of stabilized hunting regulations have been designed to estimate mortality rates corresponding to particular portions of the year (roughly May–August and November–February; see Brace et al. 1981). If these efforts yield sufficiently precise estimates, and if the study years show sufficient variation in either harvest rates or population size, then inferences related to the predictions of (2) and (3) may be possible. In addition, there are FWS research efforts currently underway to estimate winter mortality rates using radio telemetry for both mallards in Arkansas (K. Reinecke, pers. comm.) and black ducks in New Jersey (Conroy, unpubl. data). Again, if there is sufficient variation in population size in the study areas over the course of these investigations, then it may be possible to draw inferences about density-dependent mortality. These studies could also provide insight into the actual mechanism (e.g., competition for limited resources) underlying density-dependent mortality, if such mortality indeed operates during the winter.

In addition to these studies directed specifically at winter mortality, considerable research attention has been focused recently on the ecology of waterfowl during the winter and migration periods (Anderson and Batt 1983). Some of this work represents a direct response to the recommendations of Anderson and Burnham (1976:42). Much of this work is just beginning and may provide useful information on mortality and resource limitation during the winter and migration periods.

Despite the potential new insights that may result from these current research efforts, we doubt that a good understanding of the effect of hunting on waterfowl populations can be obtained without large-scale field experimentation (see Anderson and Burnham 1976:41–42). Such experimentation would involve deliberate efforts to manipulate hunting mortality rate via hunting regulations in large geographic areas over a number of years in accord with an *a priori* design. Intensive banding programs for these areas could then provide the data base for investigating the effects of these different hunting mortality rates on annual survival. Although implementation of such an experiment would be difficult for political and sociological reasons, it is doubtful that conclusive evidence about the relationship between hunting mortality and annual survival can be obtained in any other manner.

The compensatory and additive mortality hypotheses lead to very different management responses (e.g., see Anderson 1975b). Our current state of knowledge about the effect of hunting on waterfowl thus leaves room for debate about appropriate waterfowl management actions. Most available evidence for mallards favors the compensatory mortality hypothesis, although this evidence is much less conclusive for females than males. Even the mallard results should be viewed with some cautions in mind, as discussed earlier. There is very little evidence about the effect of hunting on species of ducks other than mallards. Reproductive rates, survival rates and other population characteristics of some other duck species differ sufficiently from those of mallards that it would be unwise to assume that such species exhibit responses to hunting similar to those of mallards (see Patterson 1979). All of these uncertainties and cautions make it impossible to produce a set of general, concrete management recommendations. Instead we believe that our current level of understanding of waterfowl population processes suggests that species should be managed using a mixture of common sense and qualified inferences such as those reviewed here. We believe that any move towards more scientific management must be preceded by and based upon experimentation of the type briefly described.

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Geese and Hunters of Alaska's Yukon Delta: Management Problems and Political Dilemmas

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The delta of the Yukon and Kuskokwin (Y-K) Rivers was described in 1951 as America's greatest goose-brant nesting area (Spencer et al. 1951). The U.S. Fish and Wildlife Service (USFWS) began systematic surveys of waterfowl on the Y-K Delta in 1956. J.G. King described his first inventory experiences as follows: "In the earlier years the air was so full of flying geese that as one cruised across at 100 feet there was fear of a strike. . . The whole scene was overwhelming" (King and Conant 1983).

By the early 1970s, E.J. O'Neill (USFWS) voiced concern about declining numbers of geese stopping at Klamath Basin National Wildlife Refuges (NWR) during autumn migration in northern California. In 1979, publications revealed an alarming decline of cackling Canada geese (*Branta canadensis minima*) and Pacific white-fronted geese (*Anser albifrons frontalis*) which nest on the Y-K Delta and winter in California (O'Neill 1979, Timm and Dau 1979). King and Conant (1983) were recording only one-tenth to one-third the numbers of geese in the 1980s compared to the late 1950s.

In 1951, Spencer et al. did not believe that hunting on the Y-K Delta had an adverse impact on total bird production, but that there was a depressing effect around villages. By the mid-1960s it was recognized that the Y-K Delta supported the largest concentration of Eskimo people in the world and that their annual rate of increase was one of the most rapid in the world (Klein 1966). Estimated harvest of geese by these people was about 83,000 (of 5 species) including as much as 15 percent of the spring populations of cackling and white-fronted geese (Klein 1966). Timm and Dau (1979) concluded that the year-around kill of white-fronted geese far exceeded that necessary for a stable population and they urged better rapport between Y-K Delta residents and management agencies. Last year, Director of the USFWS, R.A. Jantzen (1983) acknowledged that subsistence hunting by natives and a diminished population of cackling geese were major problems.

What has happened? The objectives of this paper are to: (a) summarize data on goose populations; (b) describe actions taken and their effects on goose populations; (c) explore some difficulties and misunderstandings between native hunters and sport hunters; and (d) make recommendations for data gathering, education, and decision making.

Status of Goose Populations

Geese Which Nest on the Outer Y-K Delta

The outer fringe of the Y-K Delta is the major nesting range for four populations of geese (Table 1). Nearly all cackling geese and Pacific Flyway white-fronted geese winter in California (Nelson and Hansen 1959, Miller et al. 1968, Lensink 1969, King and Lensink 1971). In the 1960s, peak numbers of white-fronted and cackling geese monitored at their major autumn concentration area in the Klamath Basin of California exceeded 450,000 and 350,000, respectively (Figure 1). Since 1979, numbers of white-fronted geese averaged 81,000 and numbers of cackling geese averaged 69,000. Cackling geese declined to 36,000 in 1982 and to 26,000 in 1983 (Appendix).

Up to 50 percent of the black brant (*Branta bernicla nigricans*) which winter along the Pacific Coast of North America (nearly all in Mexico) originate from the outer Y-K Delta (Tech. Comm. Pacific Flyway Council 1978). J.G. King (in Bellrose 1976:173) estimated the late summer population of brant on the Y-K Delta in 1968 at approximately 150,000. The Technical Committee of the Pacific Flyway Council (1978) management plan for brant proposed that hunting seasons be closed if the 3-year moving average winter population size falls below 120,000 geese. The current 3-year (1982–84) average is 121,000 and has declined steadily from the 1979–1981 average of 157,000.

King and Lensink (1971) estimated the autumn population of emperor geese at about 150,000 in the 1960s. Inventories along the Alaska peninsula suggest a decline of emperor geese by as much or more than 34 percent between the 1960s and 1981 (Petersen and Gill 1982).

Geese Which Nest Elsewhere in Alaska

Two small populations of geese nest away from the Y-K Delta and winter in California (Table 1). The Aleutian Canada goose (*B. c. leucopareia*) was almost extirpated by

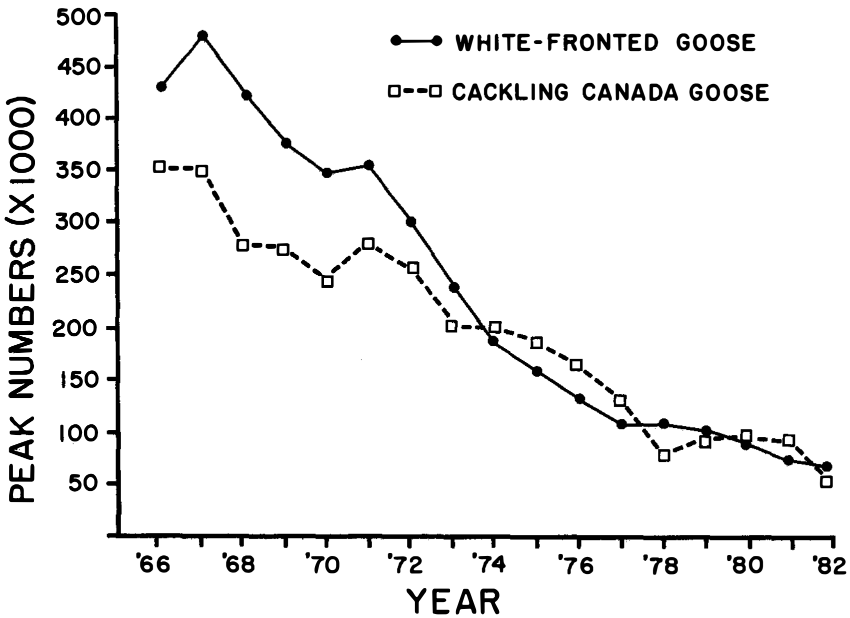

Figure 1 Peak numbers of white-fronted and cackling Canada geese recorded during aerial inventories in autumn at Tulelake and Lower Klamath National Wildlife Refuges. Data are expressed as three-year moving averages which smooth out year-to-year fluctuations caused by a variety of factors (e.g., poor weather conditions during surveys). Some values expressed in O'Neill (1979) from the same area were peak numbers from each refuge from different dates. As geese readily move between these two refuges, some of O'Neill's figures are probably overestimates. The annual peak estimates used for this figure are listed in the appendix.

Table 1. Status of most goose populations nesting in Alaska.

Population	Primary Nesting Range[a]	Primary Winter Range[a]	Recent Status[b]
Cackling Canada goose	Outer Y-K Delta	California	Declining, >85%
Pacific Flyway white-fronted goose	Outer Y-K Delta	California	Declining, >85%
Black brant	Outer Y-K Delta	Mexico	Declining[b]
Emperor goose	Outer Y-K Delta	Aleutian Islands, Alaska	Declining, ≥34%
Aleutian Canada goose	Aleutian Islands, Alaska	California	Increasing >240%
Tule white-fronted goose	Cook Inlet, AK	California	Increasing >150%
Taverner's and lesser Canada geese	Inner Y-K Delta, Interior and Northern Alaska	Washington and Oregon	Increasing (47% in Oregon)
Mid-continent white-fronted goose	Interior and Northern Alaska; Western Canadian Arctic	Texas and Mexico	Increasing (ca. 380%)

[a] See Bellrose 1976 for summary, and references in text.
[b] See text.

introduction of arctic foxes (*Alopex lagopus*) (Jones 1963, Springer et al. 1978). Numbers of these geese have increased 240 percent, from 790 in spring 1975 to 2,700 in spring 1982 (Springer et al. 1978, Woolington et al. 1979, Pomeroy and Springer 1982). The tule white-fronted goose (*Anser albifrons elgasi*, following the taxonomy of Delacour and Ripley 1975), is a distinct race (Krogman 1979) which nests in a restricted range in Cook Inlet, Alaska (Timm et al. 1982) and winters in central California (Bauer 1979, Timm et al. 1982). Numbers of tule geese inventoried in California increased from about 2,000 to 5,000 between 1978–79 and 1981–82 (Wege 1984).

Canada geese which nest in interior and northern Alaska [Taverner's Canada goose (*B. c. taverneri*) and lesser's (*B. c. parvipes*) (e.g., see Johnson et al. 1979)] comprise a significant portion of all Canada geese which winter in Washington and Oregon (Timm 1974, King and Hodges 1979, Parker and McCaughran 1979, Simpson and Jarvis 1979). Numbers of Canada geese in Washington have not varied in a systematic manner between 1970–74 and 1975–81 [averaging 61,300±7,900 (S.E.) during 1970–1981, calculated from data in Pacific Flyway Representative (PRF) 1983]. In Oregon, average numbers of Canada geese rose 47 percent from 71,400±7,600 (S.E.) during 1970–74 to 104,800±5,700 (S.E.) during 1975–82 (t=3.553, P<0.01) calculated from data in PFR 1983).

White-fronted geese (*A. a. frontalis*) which nest to the interior and north of the outer Y-K Delta in Alaska and in the western Canadian arctic migrate through the Central Flyway to Texas and Mexico and are classified as the western segment of the mid-continent population (Miller et al. 1968, Lensink 1969). Their numbers have increased over at least the past 15 years and the spring population now exceeds 240,000 compared to 40,000–60,000 during the 1960s (Central Flyway Representative 1982, Benning 1983).

Harvest and Management Actions in Relation to Population Status

I will report here only on those geese which nest on the Y-K Delta as they are the populations experiencing declines.

Black Brant and Emperor Geese

Annual sport harvest of brant from Alaska through California has averaged 5,570±1,290 (S.E.) (range 2,250–15,230) (1971–72 through 1981–82) which was 4 percent of the average winter population inventoried during the same time span (calculated from data in PFR 1983). Total harvest of brant in Mexico is unknown, but most brant in Mexico are in relatively inaccessible locations. The only readily accessible population is in San Quintin Bay where hunters killed between 1,740 and 6,500 brant during the 1974–75 and 1975–76 hunting seasons, respectively (Kramer et al. 1979). I conclude that sport harvest alone could not be responsible for the recent decline of the entire Pacific population of brant.

Washington and Oregon closed their brant seasons for 1983. California closed parts of two bay estuaries to hunting in 1981 and, for 1983, reduced its bag limit to three and changed the dates of its hunting season to reduce harvest pressure and shift harvest from adults to immatures. Beginning in 1980, Mexico reduced bag limits on brant and limited hunting to three days a week.

Annual sport harvest of emperor geese in Alaska averaged 1,495±325 (S.E.) (range 307–3,862) during the 1970–82 hunt seasons (calculated from USFWS annual reports on harvest and hunter activity—also see Timm 1974). This harvest is less than 2 percent of the population and could not be responsible for its decline.

White-fronted and Cackling Geese

Approximately 86 percent of the sport harvest of Pacific white-fronted geese (Timm and Dau 1979) and 75–89 percent of the sport harvest of cackling geese [Nelson and Hansen 1959, Calif. Dept. of Fish and Game (CDFG), unpubl. data] occurs in California. Therefore, I will detail here only the data pertaining to California.

From 1975 to the present, the CDFG has closed three large areas to hunting of Canada geese: two counties on the northwest coast for the entire season, parts of the Sacramento Valley (SV) from the opening of the season in late October or early November until December 15, and parts of the San Joaquin Valley (SJV) after December 15. These closures were originally intended to benefit the Aleutian Canada goose (see Springer et al. 1978), but these actions should have also substantially reduced harvest on cackling geese. Closures in the SV reduced the season length to 30–35 days in an area from which 28–47 percent of band recoveries occurred (Nelson and Hansen 1959, CDFG, unpubl. data). When Aleutian Canada geese remained in the SV beyond December 15, the hunting closure was extended. In 1982–83, e.g., the hunting season for Canada geese in the SV special zone was only 9 days long. As cackling geese do not arrive in the SJV until mid-December, closures in this area, which had accounted for 9–16 percent of band recoveries (Nelson and Hansen 1959, CDFG, unpubl. data) were tantamount to a cessation of hunting of cackling geese.

Further restrictions on bag limits and seasons for hunting Canada and white-fronted geese in the Klamath Basin (KB) and Central Valley (CV) were instituted in 1979 and have been in place in various forms to the present (Table 2). The KB was the location of 16–38 percent of band recoveries of cackling geese (Nelson and Hansen 1959, CDFG, unpubl. data). During 1979 and 1980, hunting of white-fronted geese was not allowed in the areas closed for hunting of Canada geese described above.

The impact of these restrictions can be assessed partially by examination of harvest estimates provided by the USFWS and CDFG. Hunters are asked how many geese they killed, but they are not asked to identify species. Lesser snow geese (*Anser caerulescens caerulescens*) and Ross' geese (*Anser rossii*) are both abundant in California (O'Neill 1979, McLandress 1979) and make up large portions of the goose harvest. Therefore, total harvest in relation to restrictions described (Table 3) above provides only an index of the impact of these regulations. Note that estimates of the absolute numbers of geese killed by hunters differ substantially between USFWS and CDFG surveys, but that *proportionate declines* in kill *were nearly indentical* in each survey. Harvest of geese in California was greatly reduced (67 percent lower in 1979–82 than in 1970–74) and, although numbers of hunters also declined greatly, the kill per hunter was reduced.

Since different subspecies of Canada geese are not identified in USFWS species composition surveys, estimates of harvest of Canada geese cannot be applied to cackling geese. However, subspecies of Canada geese are identified at hunter-check stations on federal and state managed areas in the KB and CV. Harvest of cackling geese was reduced 78 percent in the CV after 1975 and reduced 51 percent in the KB after 1979 (Table 4).

The impact of changing hunting restrictions in California on total harvest of cackling geese can be estimated by applying the data of Table 4 to the distribution of harvest in the state based on recoveries of geese banded in Alaska which were nearly equally divided

Table 2. Daily bag and possession limits for dark geese (whitefronts and Canada geese singly or in combination) in California.

Year	Area of state[a]	Season length	Daily bag	Possession limit
Before 1978	Northeastern[b]	Mid Oct.–mid Jan.	3	6
	Balance of state[c]	3rd weekend of Oct. thru 3rd weekend of Jan.	3	6
1979	Northeastern[b]	Oct. 27–Jan. 13	2	4
	Balance of state[c]	Oct. 20–Jan. 20	1	1
1980–83	Northeastern[c]	Mid Oct.–mid Jan.	1	2
			for first 14 days	
			2	2
			for balance of season	
	Balance of state[c]	1st week of Nov.– 3rd week of Jan.	2	4
			in 1980	
			2	2
			in 1981–83	

[a] Large portions of state closed to hunting of Canada geese–see text.
[b] Primary concentration area is the Klamath Basin.
[c] For this report, refers to other locations in which cackling and white-fronted geese concentrate.

Table 3. Estimates of harvest of geese (all species) and numbers of hunters in California (× 1000).

Time Period	Harvest estimates[a] State	Harvest estimates[a] Federal	No. of hunters[b]	Kill per hunter[c] State	Kill per hunter[c] Federal
1970–1974	349.1±14.5[d] (296.7–3.77.7)[e]	240.5±26.7 (173.3–331.2)	161.8±8.4 (144.6–188.9)	2.17±0.09 (1.95–2.42)	1.48±0.66 (1.16–1.75)
1975–1978	243.0±24.7 (188.6–297.0)	173.7±25.2 (112.9–235.4)	132.8±4.2 (124.1–143.3)	1.82±0.15 (1.52–2.20)	1.30±0.17 (0.91–1.74)
1979–1982	115.6±8.0 (100.2–137.8)	80.6±11.4 (53.2–108.8)	113.3±3.6 (107.2–122.8)	1.02±0.08 (0.93–1.27)	0.71±0.10 (0.50–1.00)
Statistical testing			1970–74 vs. 1975–78		
	t=3.90, P<0.01	t=1.78, P=0.12	t=2.85, P=0.05	t=2.12, P=0.07	t=0.89, P<0.4
			1975–78 vs. 1979–82		
	t=4.90, P<0.01	t=3.37, P<0.002	t=3.53, P<0.02	t=4.78, P<0.001	T;=2.94, P<0.05
			Magnitude of Changes Among Time Periods		
1970–74 vs. 1975–78	−30%	−28%	−18%	−16%	−12%
1975–78 vs. 1979–82	−52%	−54%	−15%	−44%	−45%
1970–74 vs. 1975–82	−67%	−67%	−30%	−53%	−52%

[a] State from Calif. Dep. Fish and Game (1983); federal from U.S. Fish and Wildl. Serv. annual reports on waterfowl harvest and hunter activity.
[b] From sales of migratory bird hunting and conservation stamps.
[c] Harvest ÷ no. of hunters.
[d] Mean ± standard error of mean.
[e] Range.

Table 4. Harvest of cackling Canada geese on state and federal waterfowl management areas in California[a].

Time period	Location	Kill[b]	Statistic	Change
1970–1974	Central Valley	2038±276 (1507–3076)		
1975–1982	Central Valley	456±121 (148–1183)	t=6.02, P<0.001	−78%
1970–1978	Klamath Basin	2596±330 (1580–3250)		
1979–1982	Klamath Basin	1280±199 (960–1790)	t=2.65, P<0.05	−51%

[a] From data compiled by Pacific Flyway Representative (1983).
[b] $\bar{x}$±S.E. (Range).

between the KB and CV (Nelson and Hansen 1959). Total harvest of cackling geese in California was reduced by 39 percent due to area closures in the CV and 65 percent when these closures were combined with bag limit restrictions in the KB and CV (Table 5). These estimates assume that compliance of hunters on private areas was the same as on agency managed hunting grounds.

Kill of white-fronted geese in California can be calculated using the USFWS species composition survey data (estimates in PFR 1983). Harvest during 1970–78 averaged 42,700±4,160 (S.E.) and was reduced 59 percent during 1979–82 to an average of 17,500±3,090 (S.E.) t=2.32, P<0.05). Reduction of harvest on managed areas was also greatly reduced (Table 6) and these data can be used to approximate the reduction of harvest in the state (Table 7) using the procedure defined above for cackling geese. The close agreement between the estimated reduction in harvest from kill and species composition surveys (59 percent) and that provided by use of data from managed areas in conjunction with distribution data from band recoveries (Table 7, 57 percent) suggests that hunters on private lands behaved as those on managed areas.

Table 5. Estimated reduction of harvest of cackling geese in California in response to hunt season restrictions.

	Proportionate harvest in:			
Time period	Klamath Basin	Central Valley	Total harvest	Change
1970–74[a]	50[b]	50[b]	100	
1975–78[c]	50	11[c]	61	−39%
1979–82[d]	24[d]	11[d]	35	−65%

[a] Before restrictions of recent years.
[b] Distribution of harvest based on band recoveries (Nelson and Hansen 1959).
[c] Area closures in Central Valley reduced harvest by 78 percent (from Table 3; 50×0.78=39; 50−39=11).
[d] Restrictions in Klamath Basin reduced harvest by 51 percent (from Table 3; 50×0.51=25.5; 50−25.5=24.

Table 6. Harvest of white-fronted geese on state and federal waterfowl management areas in California[a].

Time period	Location	Kill[b]	Statistic	Change
1970–1978[c]	Klamath Basin	9,804±856 (7,270–14,930)		
1979–82[d]	Klamath Basin	3,350±497 (2,190–4,520)	t=4.867, P<0.0001	−66%
1970–78[c]	Central Valley	1,306±160 (543–2,005)		
1979–82	Central Valley	622±110 (311–793)	t=2.673 P<0.05	−52%

[a] From data compiled by Pacific Flyway Representative (1983).
[b] $\bar{x}$±S.E. (Range).
[c] Before restrictions of recent years.
[d] Area closures in 1979–80 and 1980–81 and bag limit and season length restrictions (see text and Table 2).

Table 7. Estimated reduction of harvest of white-fronted geese in California in response to hunt season restrictions.

Time period	Proportionate harvest in: Klamath Basin	Proportionate harvest in: Balance of state	Total harvest	Change
1970–78[a]	35[b]	65[b]	100	
1979–82	12[c]	31[d]	43	−57%

[a] Before recent restrictions.
[b] Distribution of harvest based on recoveries of geese banded in Alaska (data in Pacific Flyway Representative 1983). White-fronted geese were included in the Central Valley area closures of hunting for Canada geese in 1979 and 1980 but not in other years.
[c] Restrictions in Klamath Basin reduced harvest by 66 percent (from Table 5; 35×0.66=23; 35−23=12).
[d] Restrictions in the rest of the state away from the Klamath Basin reduced harvest by 52 percent based on data from Central Valley management areas (from Table 5; 65×0.52=34; 65−34=31.

Other Research on White-fronted and Cackling Geese

Research has not indicated that factors other than harvest were instrumental in the decline of cackling and white-fronted geese. Over 1,600 whitefronts were marked with neck-bands between 1979–1981 and over 1,400 cackling geese were neck-banded during 1982–83 to allow for more intensive study of the timing of their migrations, distribution during winter and mortality (Ely and Raveling 1980, 1981, 1982, Johnson and Raveling 1983). While analyses are yet incomplete, these studies have not revealed that changes in migration pattern could account for declines of the magnitude observed. Levels of contamination with toxic materials are far below that presently known to be deleterious (Anderson et al. 1984). Age-ratios of geese trapped or observed at KB in autumn (CDFG, USFWS, unpubl. data) do not indicate problems with production of young. No known die-offs due to disease or starvation have occurred with the consistency or magnitude necessary to account for the long-term population declines. While loss of wetland habitat and changes in agricultural patterns and intensity continue in California, it is my judgement that available areas and food supplies used by the geese are more than adequate to sustain much larger populations.

Discussion and Conclusions

The clear implication is that harvests of geese on the Y-K Delta are excessive for all geese and alarmingly so when combined with harvest in California. This is correlated with a 42 percent increase in the human population of coastal Y-K Delta villages between 1960 and 1980 (Copp and Smith 1981)[1] and rapid advances in availability of modern technology. In the 1950s many people on the Y-K Delta still lived in sod houses and used kayaks and even a one h.p. motor was a luxury (Peterson and Fisher 1955:372, 378, 380). Dog teams were a major means of travel for the spring goose hunt in the 1960s (Klein 1966). By 1972, about 2,000 boxes of shotgun shells were sold in one village of about 550–600 people (D. Eisenhauer in Timm and Dau 1979:288). Boats now commonly have motors of 25–75+ h.p. (often twin engines). Most families now have a snowmachine whereas they were a relative scarce luxury in the mid-1970s (personal observation). This technology enables even short-term hunts to commonly exceed 20 miles (32 km) in distance from villages (Copp and Garrett 1983).

This is not to suggest that the dramatic declines of white-fronted and cackling geese were due solely to harvest by native peoples. The large-scale reductions in harvest in California are less than the reductions in the size of the populations. Therefore, even this reduced harvest in California may be more adversely affecting these populations than a few years ago because of the greatly diminished numbers of these geese. However, the fact that brant and emperor geese have also declined suggests that harvest by natives themselves is excessive, and when combined with harvest in California is near catastrophic.

This situation has created frustration for managers because: (a) useful data on kill of geese by natives are meagre so that judgements on impact are inferential and biologists cannot make meaningful analyses of harvest in relation to population size; (b) cultural differences between native and non-native groups contribute to misunderstandings and lack of action or agreement on courses of action; (c) California hunters feel they have made sacrifices without corresponding efforts by other users; and (d) resource agencies in Alaska have not provided needed information and are widely perceived as not having vigorously tried to do so.

Harvest by Natives

Harvest of geese by northern natives is an important, traditional activity. Kills of 40–60 geese (up to 130+) per hunter are common (Klein 1966, Boyd 1977, Prevett et al. 1983). Biologists studying geese on the Y-K Delta have witnessed large-scale shooting when geese arrive in spring, flushing geese on nests with snow-machines in order to drive them to hunters, shooting geese on nests, taking of eggs, and shooting or capture of geese with broods. If one contemplates a direct relationship, however small, between the increased

[1]Data are from: Kwigillinok, Kipnuk, Chefornak, Nightmiute, Tununak, Newtok, Hooper Bay, Chevak, Scammon Bay, Sheldon's Point, Alakanuk, Emmonak, Kotlik, Stebbins, St. Michael (1960 population = 3,500; 1980 populations = 4,985; the human population of the entire Delta increased 67 percent from ca. 9,000 to > 15,000; geese are also killed in other villages and by people who travel to the coast from more interior locations, especially Bethel).

human population of the Y-K Delta and their greater mobility and technology in recent years with harvest levels reported by Klein (1966) for the early 1960s, one has no trouble in predicting disaster for the geese. However, we do not have comparable data. Direct observations reveal that harvest continues. For example, Eisenhauer (1977) observed one party of hunters who collected 657 eggs and 51 geese in a 10 hour period; hunters were frequently encountered when geese were molting and 10 hunters had killed 215 flightless brant; 7.7 percent of the 207 newly banded goslings were killed within 10 days and 4 km from the time and location at which they were originally captured. How wide-spread are these activities and what is their impact on population levels? Why do we not know the answers to these questions?

Pacific Flyway Council Actions. Minutes of the Technical Committee and Council meetings of the Pacific Flyway reveal that concern over goose populations has long been expressed, but that major declines occurred before formal actions were recommended (Table 8; compare to Figure 1). The issue of spring harvest had a long incubation period from concern (1974) to formal Technical Section recommendations (1978) to endorsement by Council (1983). But, Flyway representatives can only recommend; only the Alaska Department of Fish and Game (ADFG), USFWS, and native hunters can take direct action to provide information and limit harvest.

Table 8. Consideration of problems and recommendations of the Technical Committee and Council of the Pacific Flyway with respect to white-fronted and cackling geese.

Year	Actions by Pacific Flyway Technical Committee (TC) and Council (C)
1974	TC—AK thought harvest of white-fronted geese (WFG) excessive.
1976	TC—AK recommended additional research on WFG.
1977	TC—AK reported on policies with respect to spring hunting of waterfowl.
1978	TC—recommended resolution to request USFWS and AK seek cooperation of Y-K Delta residents to refrain from taking snow, cackling (CG), WFG geese and brant (B) in recognition of their diminished numbers and actions by states to decrease harvest on these geese; C—deferred action.
1979	TC—briefing on protocol with Canada with respect to subsistence hunting; C—opposed regulations which would legalize subsistence harvest of waterfowl in excess of current levels until impacts are determined; TC—proposed additional restrictions for hunting, additional aerial inventories and recommended work with AK to reduce harvest of B, CG, and WFG on Y-K Delta; C—accepted recommendations for sport hunting restrictions and discussed, but did not act on, subsistence issue.
1980	TC—recommended yet additional coordinated inventories of geese over a broader area and further discussed subsistence issue; C—accepted inventory recommendation.
1981	TC—formed a C/WFG subcommittee and recommended 6 additional research programs including measurement of harvest on Y-K Delta; C—adopted recommendations.
1982	TC—recommended additional research on CG; C—action not required.
1983	TC—recommended specific research and management programs and two resolutions: (a) an urgent effort to evaluate the USFWS subsistence survey and to use expertise of social scientists to assure effective data gathering; (b) hunters of the Y-K Delta, the USFWS and AK take actions necessary to significantly reduce take of CG and WFG; C—adopted both resolutions.

Alaska Fish and Game Actions. Despite the facts that ADFG created a special Division of Subsistence in recognition of the importance of this activity for rural residents (Kelso 1982) and that some of their own biologists called attention to problems with geese (cf. Timm and Dau 1979, Table 8), I am not aware of any direct effort by ADFG to assess harvest of geese by natives. This issue is complicated by political divisions of responsibility and land holdings in Alaska. Ultimate responsibility for migratory birds rests with the USFWS and, as part of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980, 20 million acres (810,000 ha) of the Y-K Delta were made into a National Wildlife Refuge. The apparent view that geese are "federal animals" has not done the geese any good—nor the people who use them. I conclude that ADFG has been remiss in fulfilling its responsibilities when faced with knowledge of the rapid disappearance of geese important to their constituency.

USFWS Actions. In ANILCA, Congress explicitly declared its policy was to support continuation of subsistence uses of fish and wildlife on public lands of Alaska *consistent with sound management principles and conservation of healthy populations of fish and wildlife*. The law also mandated the Secretary of the Interior to undertake *research* on fish and wildlife and subsistence uses.

The USFWS initiated a study of waterfowl harvest by Y-K Delta natives in 1980. Responsibility for design and conduct of the program was assigned to staff of the Yukon Delta NWR (YKNWR). The study involved interview of consenting native hunters in a sample of villages on numbers and kinds of waterfowl taken between April 1—June 30. The USFWS contracted with the University of California, Davis (UCD) in 1981 to provide assistance in organization and analysis of data already collected and to make recommendations. This analysis revealed many weaknesses in selection and training of interviewers and sampling procedures (Copp and Smith 1981). The program continued with few changes in 1982 and 1983 and the most recent analysis (Copp and Garrett 1983) revealed the same problems remained, a deterioration in quality of data, differences between harvest observed and reported, and problems with identification or reporting of subspecies of Canada geese. Copp and Garrett (1983) concluded that this program is unlikely to meet its objective, and they provided several specific recommendations for improvement.

To assist education and communication between native peoples and agencies, the YKNWR employs a Delta resident as Native Liason Officer. His efforts were vital to explaining refuge programs and facilitating cooperation (cf. Copp and Smith 1981). The refuge also employs native people in both permanent and temporary staff positions. In 1982, an information officer joined the staff at the refuge. The USFWS has sponsored visits by native representatives to California and invited them to meetings.

Gathering of biological data on geese of the Y-K Delta has followed an erratic course. Studies in place through 1979 were ended for 1980 and new proposals were denied or discouraged. Expansion of refuge programs began in 1981 and a contract was made with UCD to provide assistance and recommendations (e.g., Anonymous 1981, Aldrich and Byrd 1981, Aldrich et al. 1981). An expanded refuge biological program was carried out in 1982 and 1983 and has provided a great deal of new information on the status and biology of geese (e.g., Byrd et al. 1982, Butler 1983, Garrett 1983). This program is heavily dependent on temporary staff and volunteers. The role of research staff of USFWS has been limited to one field study of the status and biology of emperor geese in 1982 and 1983 (Petersen 1982, 1983) with additional support for the UCD field study in 1983.

Refuge programs have been severely hampered by instability in staff tenure and lack of continuity. Since 1976, YKNWR has had significant portions of time in at least two years without a manager, three different managers, and a fourth will be assuming duties in 1984. Similar instability occurred with assistant managers and biologists. This is a deplorable situation for a 20-million-acre (810,000 ha) refuge encompassing the most valuable nesting grounds of geese in the U.S.

Minutes of Pacific Flyway meetings reveal a difference between desires and reality of USFWS programs with respect to subsistence harvest. In March 1979, the USFWS suggested that the *problem may be solved* with the U.S.-Soviet Treaty recognizing the need for regulated subsistence hunting and the protocol agreement between the U.S. and Canada. In 1980, the USFWS reported that they were giving the subsistence hunting issue *high priority* and launcing a *major effort* to educate natives to the problems and to reduce take of geese on the Y-K Delta.

Persons of good intentions may disagree on interpretation. I submit the USFWS effort was neither major nor of high priority. I believe the geese would agree with me.

Native Actions. The people of the Y-K Delta are aware and concerned that there are many fewer geese. The Pacific Flyway Council was assured at 1979 and 1980 meetings that natives would reduce their harvest. Natives reported to the Flyway in 1981 that they undertook efforts to urge voluntary restraint of harvest on cackling and white-fronted geese. Notices were sent to villages expressing concern about brant and taking of their eggs.

Since there are no adequate baseline data, one cannot evaluate whether or not voluntary actions were effective at the village level. As with California, even if harvest by natives was reduced substantially, the populations are so low that impacts of reduced harvest may be more harmful than in the recent past. Despite assurances provided the Flyway Council, there are indications of increased harvest activity in at least some local areas (personal observations, Garrett 1983).

Sport Hunter Actions. The California Waterfowl Association (CWA) and Waterfowl Habitat Owner's Alliance (WHOA) represent the interests of organized California hunters. Their executives have been active participants at Flyway and other meetings and a CWA representative visited Alaska in 1979 where he was assured that harvest by natives would be reduced to match reductions in California. Frustrated by the lack of meaningful data on harvest in spring-summer and the continuing decline of goose populations despite large-scale reduction of hunting in California, CWA has admonished the Pacific Flyway Council and USFWS for avoiding the issue and threatened legal actions to require enforcement of the Migratory Bird Treaty. Sharing responsibility is the cornerstone of the Flyway Concept.

Recent Agreements. In recognition of problems with goose populations, the Association of Village Council Presidents (AVCP) of the Y-K Delta formed a Waterfowl Conservation Committee (WCC) in August 1983. During autumn-winter of 1983–84, a series of meetings of the WCC-AVCP with representatives of ADFG, USFWS, CDFG, CWA and WHOA resulted in agreements by the AVCP to stop hunting of cackling geese and to restrict harvest of white-fronted geese and brant to time periods before egg-laying and after resumption of flight in 1984. In exchange, sport hunting of cackling geese would be closed and regulations sought that would reduce kill of white-fronted geese and brant by about 50 percent (already accomplished in California for brant for 1983). As a result of these meetings, California enacted an emergency closure of Canada goose hunting for the last 12 days of their 1983–84 season.

These meetings represent a positive development in communication and education for all organizations. The emperor goose was, however, neglected in these negotiations. If natives direct their hunting to emperor geese to replace harvest of other geese, this species is likely to suffer dramatic declines beyond that already occurring.

Cultural Differences

A major difficulty in obtaining data on harvest in Alaska and in effective communication is a result of cultural differences between natives and sport hunters. Misunderstandings contribute to suspicion and hamper development of effective programs.

Hunting: Needs and Methods. Sport hunters have difficulty understanding the value of hunting to native peoples. Subsistence is equated to primitive, inefficient methods. Modern technology coupled with harvest of numbers of animals per hunter far in excess of what a sportsman can take conjure up images of unnecessary slaughter; the taking of eggs and killing of adults on nests or with dependent off-spring are considered not only detrimental, but immoral.

These attitudes conflict with the reality of Eskimo life, especially the view that the land and its wildlife is their "grocery store." Technology makes hunting easier, as it has for sport hunters. Although social and economic change is occurring rapidly, wildlife continues to provide essential economic and cultural benefits to natives (Kelso 1982). Traditions which allowed survival over millenia will not change quickly; e.g., people must kill animals to live and the animals know this and their death is not permanent (cf. Nelson 1980:50, 69, 100, 171). Hunting is life and identity as an Eskimo (Nelson 1973:288, 311; Nelson 1980:50, 97, 172). Taking food for granted and emotional attachment to animals are luxuries afforded only by those who do not gather their own food; as in any society, a highly successful provider gains power and respect (cf. Nelson 1980:9, 34, 52, 60). An abundant harvest is commonly shared not only with immediate family but with others (Nelson 1980:60, 141; Kelso 1982). Although waterfowl are secondary to other game, they provide important variation in diet and, at times (at least in recent memory), an essential supplement arriving at just the right time (Klein 1966, Nelson 1969:154–158). When a non-native thinks it is easy for a native to substitute foods of another culture, he should ponder how easily he could accept the natives' foods and methods of preparation (Nelson 1969:158). Appreciation of the meaning of culture may then follow.

Sensitivity to the importance of hunting, however, should not stifle recognition of dwindling resources. While the behavior of people in rural, indigenous societies is now commonly recognized as the outcome of adaptations to natural environments (Kelso 1982), it is naive and destructive to ignore the impacts of expanding human populations and technology. Sympathy with the past should not obscure realistic evaluation of changes. A decrease in knowledge of wildlife and skills in hunting and traditional survival abilities by young natives has long been obvious (cf. Nelson 1969:383). Many hunts have taken on a sport character when one considers the cost of machines and fuel and amazing waste of costly ammunition in relation to some harvests (personal observations; see also Macauley and Boag 1974). Failure to deal with these issues will result in collapse of the resource bases which form the goal of subsistence policy to maintain productivity for human use.

Some observers have cautioned against overemphasis on harvest as this may lead to misleading characterization of ecosystem dynamics (Kelso 1982) such as confusion of correlation with cause and effect and negligence in recognizing other potential causative factors (Copp and Garrett 1983). These concerns are legitimate and caution is wise as a principle. However, in this case, they have far less basis for concern than that on harvest. The fact remains that it is only the harvest that we can control in the short term.

Native hunters have difficulty understanding the value of hunting to sport hunters who are considered wealthy and do not need to hunt. Commercial exploitation is suspected, as easily witnessed by the ubiquity of goose-down clothing.

These attitudes also conflict with reality as they fail to respect intense, emotional relationships that tie sport hunters to wildlife. Native and sport hunters share many traits and rewards (Copp 1975, 1979). Native hunters need to recognize that licenses, fees, and special taxes paid by sport hunters support acquisition and management of habitat and studies of the status of waterfowl. Approximately 69 percent of the remaining wetland habitat in California is maintained by private owners to provide waterfowl hunting (Gilmer et al. 1982). Without hunting, most of that land would be converted to agricultural uses. Since 1970, the numbers of waterfowl hunters in California have declined 44 percent from 189,000 to 107,000, which represents a major loss of revenue and support for waterfowl programs. The staff of the Waterfowl Section of CDFG has dwindled from 12 to 5 at a time when we need them more than ever.

The commonly expressed concern about commercial exploitation illustrates how far we have to go in providing meaningful education in the native community. It is, of course, not true, but that fact will not help until native peoples understand that.

Legality. The fact that spring hunting violates the Migratory Bird Treaty with Canada hampers data collection and working together. The treaty is a classic example of a law made by groups remote from, and without consultation with, all people affected. Native hunters had no choice but to consider a law affecting their ability and right to gather food as an intrusion or irrelevant. Such a law is a failure because it compels illegal activity (Kelso 1982), is politically unenforceable in the north (Boyd 1977), and fails to recognize spring-summer harvest as a necessary component to rational management.

The obvious long-term solution is to proceed with modification of the Migratory Bird Treaty with Canada. There are serious concerns over wording of the treaty amendment (cf. Copp 1981) that need to be addressed, but it has been more than four years since the process began. The costs of the delay are serious; we do not have a legal foundation for acquiring data and formulating management policy. The problem is obvious. A short-term solution is needed to help goose populations long before a long-term solution can be effective.

Recommendations

Educational Needs. Native people must understand that they share responsibility with other groups for the welfare of migratory bird populations. The issues are far more complex than that of gathering and presenting data; they involve special problems in communication, beliefs, trust, and politics. Resource agency personnel generally have little or no formal training or expertise in these matters. Educational materials should be designed by experts who understand native culture, human psychology, and effective use of communication media in cooperation with native representatives.

Sport hunters need to recognize that they share responsibility for depleted goose populations and that their views of native life are often ill-informed. Agencies have been painfully slow to provide in-depth analyses of data on population and harvest statistics, reticent about suggesting that sport harvest can be a problem, and relatively inactive in communicating concerns through their own or public information channels. The seriousness of the decline of the geese warrants a greater effort.

Data Gathering. Attempts to survey harvest by natives have provided some benefits and insights, but have been a failure in terms of the major goal. The USFWS must either devote the money and expertise needed to upgrade the effort or consider alternative programs. Interview research must be designed and conducted by experts in this type of study and by those who understand the social dynamics of native peoples. Biologists and managers know what kind of information is needed but, regardless of dedication and intelligence, they are ill-prepared to conduct this type of research. Copp and Garrett (1983) provided a detailed critique of the program and recommendations for improvement that should be implemented.

Regardless of the fate of the harvest-survey study, there are many other more indirect studies that could provide needed insights and be of value in assisting understanding by natives of their impact on wildlife. Examples include the effect of human disturbance on nest success, distribution and success of geese in relation to distribution of human activity, the impact of harvest by age-sex class and time of year (eggs, goslings, adults, summer and winter), and the role of waterfowl in the present economy of natives.

The recently expanded refuge biological data gathering program represents a positive response to needs for information. These data are vital to providing the baseline upon which to measure future responses of populations to management actions. Continuity in methods and direction is vital and the program could be usefully assisted by more support, as could the involvement of the research branch.

Organizational Needs. The Pacific Flyway in general, and these geese in particular, have been relatively neglected. The complexity of the problem has exceeded the ability of agencies to deal with it as add-on responsibilities to already over-loaded personnel. Tasks have been assigned to personnel who do not have the experience, training, authority, or resources needed to effectively complete them, thus placing them in an untenable position. Team-approach and use of expertise beyond that available in-house have not been effectively employed. Methods of selection of personnel compatible with living and working conditions and needs on the Y-K Delta should receive special attention.

An individual, or committee, needs the freedom and authority to devote full-time to the total complex of problems in order to provide continuity and coordination. Redirection of personnel and money is needed. A multi-membership task force, including native representatives could provide oversight similar to that developed for endangered species recovery teams. The parallel is not made loosely; extension of population declines illustrated in Figure 1 forecast threatened or rare categorization in less time in the future than it has taken us to generally acknowledge and publicize the problem. Perhaps a National Academy of Sciences panel should be convened to make recommendations.

The alternatives to immediate, effective action are unpleasant. Legal actions could increase suspicion and hostility and promote a situation where resources are damaged even further in a power struggle. Yet, lack of effective action leaves no alternative to legal recourse. The losers are the geese—and the people who cherish them for whatever reason. An entire generation of hunters has begun to pay the price for the past lack of effective action; they will be paying a heavier price for the next 10–20 years even if we take effective action now. Such depleted populations will certainly not foster the maintenance of traditional ties with land by natives or the opportunity to renew those ties by sport hunters.

Summary

Numbers of geese nesting on the Yukon-Kuskokwin (Y-K) Delta, Alaska have declined even though harvest in winter is insignificant (brant, emperor goose) or curtailed by as much as 59–65 percent (Pacific white-fronted goose, cackling Canada goose, respectively). Autumn inventories indicate alarming decreases of 85 percent of Pacific whitefronts from 450,000 to < 100,000 and of cackling geese from 350,000 to < 50,000. Numbers of geese nesting elsewhere in Alaska have increased (Taverner's, lesser and Aleutian Canada geese, tule and mid-continent white-fronted geese). Tule white-fronted geese and Aleutian Canada geese occupy large portions of the winter range in California used by Pacific whitefronts and Cackling geese. Restrictive hunting regulations should have benefitted all these populations.

The implication is that impacts of human activity on geese of the Y-K Delta are excessive, and combined with harvest in California, are near catastrophic. This is correlated with a 42 percent increase in the coastal population of Yupic Eskimos since 1960, who now hunt more efficiently with modern means of travel.

The remoteness and size of the Y-K Delta, the fact that spring-summer hunting of waterfowl violates the Migratory Bird Treaty with Canada, and cultural differences between native and non-native groups result in great difficulty in gathering pertinent data, recognition of resource problems, and working effectively for solutions. Native hunters consider a law interfering with their right and ability to gather food as an unwelcome intrusion or not applicable. Opponents argue that such needs have been abrogated by changes in law and life-style and threaten legal action to require enforcement of the Migratory Bird Treaty. Both groups frequently exhibit a lack of understanding of the needs of each other and the necessity of working together for mutual interests.

In the long term, modification of the Migratory Bird Treaty is needed to allow for regulated, legal harvest of birds and eggs in spring. This eventuality, however, seems years away. Effective action is needed now. Agencies responsible for protection of migratory bird resources have not devoted sufficient attention to these problems. Better organization, addition and/or redirection of personnel and money is needed. Specific needs include more intensive and extensive efforts to involve native groups at every level of increased data gathering and analysis, problem recognition and solving, and education. These programs need an identifiable and responsible authority and the assistance of experts in fields outside those normally represented in resource agencies (e.g., social scientists, modelers, media consultants).

Lack of immediate, effective action will likely lead to further polarization of viewpoints via political and legal confrontation while resources continue to suffer. Such depleted populations negate the goal of maintenance of traditional ties of natives to wildlife and the opportunity to renew those ties by sport hunters.

Acknowledgments

This paper presents information collected over many years by a large number of dedicated biologists. It was my purpose here to collect in one place the results of much of their efforts. It would take several pages to mention all the individuals responsible; they know who they are and I hope this report provides some measure of reward for their toil. Specific mention is, however, due to several individuals for their efforts in drawing together the data and my thoughts: D.P. Connelly (CDFG) for excellent coordination and cooperation in compilation of California and Flyway information; J.C. Bartonek (USFWS) for summarization of data on populations and perspectives on the Pacific

Flyway as a whole; D.E. Timm (ADFG) for compiling data for management plans and information for Alaska; D.V. Derksen (USFWS) for coordination and summarization of data and issues in Alaska; R.L. Garrett (USFWS) for designing an excellent expanded program of biological data gathering on the nesting grounds; J.D. Copp for his penetrating insights into the psychology of hunting, research on humans, and the culture of native Americans.

I wish to also extend my generous thanks to my Yupic Eskimo guides, friends, and acquintances who shared with me their love of wildlife and knowledge of the Y-K Delta. Finally, this paper is dedicated to Edward J. O'Neill (USFWS, retired) who experienced so much frustration at trying to convince us to do something about the alarming disappearance of waterfowl that he was documenting. Hopefully, we will not be too late with too little and that Ed can witness a recovery of these populations to help provide for a fulfilling retirement.

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Appendix. Peak numbers of white-fronted and cackling Canada geese estimated in autumn at Tulelake and Lower Klamath National Wildlife Refuges, California.

Year	Peak numbers[a]	
	White-fronted goose	Cackling goose
1965	303,200	384,000
1966	492,900	351,000
1967	495,500	322,400
1968	457,700	376,100
1969	310,600	143,000
1970	353,500	314,000
1971	383,600	289,000
1972	320,600	234,400
1973	196,200	244,800
1974	199,600	136,300
1975	165,300	217,900
1976	112,300	212,300
1977	117,700	62,000
1978	100,700	118,300
1979	114,900	60,200
1980	97,000	123,800
1981	64,200	98,700
1982	48,000	35,500
1983	80,100	26,200

[a] Rounded to nearest 100

Avian Cholera in Nebraska's Rainwater Basin

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Introduction

The first report of avian cholera in North America occurred in northwestern Texas in winter 1944 (Quortrup et al. 1946). In 1975, mortality from avian cholera occurred for the first time in waterfowl in the Rainwater Basin of Nebraska when an estimated 25,000 birds died (Zinkl et al. 1977). Avian cholera has continued to cause mortality in wild birds in specific areas of the Basin each spring since. Losses of waterfowl from avian cholera continue to be much greater in some of the wetlands in the western part of the Basin than in the east. Several wetlands in the west have consistently higher mortality and are most often the wetlands where initial mortality is noticed each spring (Figure 1).

The establishment of this disease in Nebraska is of considerable concern because of the importance of the Rainwater Basin as a spring staging area for waterfowl migrating to their breeding grounds. The wetlands in this area are on a major migration route used by an estimated 5 to 9 million ducks and several hundred thousand geese. A large portion of the western mid-continental greater white-fronted goose (*Anser albifrons*) population stage in the Basin each spring. Occasionally, whooping cranes (*Grus americana*) use these wetlands during migration, and lesser sandhill cranes (*Grus canadensis*) staging on the nearby Platte River sometimes use wetlands where avian cholera occurs (Anonymous 1981).

Our objectives were to determine whether certain water quality variables in the Rainwater Basin differed between areas of high and low avian cholera incidence. These results would then be used for laboratory studies involving the survivability of *Pasteurella multocida*, the causative bacterium of avian cholera. Those studies will be reported elsewhere.

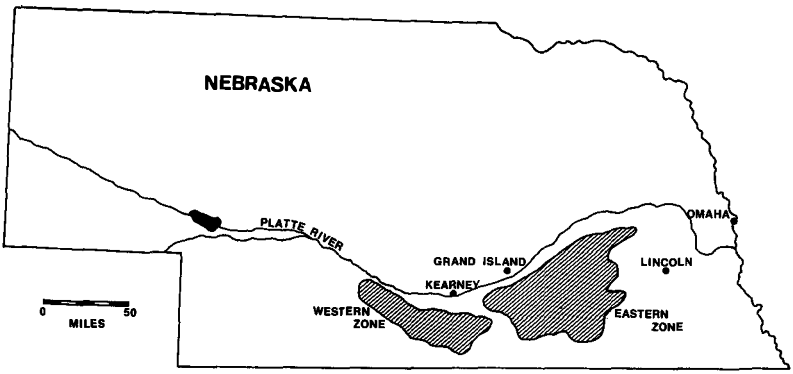

Figure 1. Nebraska's Rainwater Basin Area. The western zone is an area of major avian cholera mortality, the eastern zone experiences relatively little avian cholera problems.

Methods

Waterfowl Mortality

Field personnel surveyed wetlands for dead and sick birds in the Rainwater Basin each year during spring migration. Once mortality began, carcass collection was initiated while surveillance continued elsewhere.

Searches for carcasses were conducted using all-terrain vehicles and airboats, as well as on foot. Carcasses were identified by species and numbers of each species were recorded before carcasses were incinerated.

Water Quality Analysis

Three water samples were collected from each of six Type III wetlands, in the western portion of the study area (Funk Lagoon, Prairie Dog Waterfowl Production Area [WPA], and Gleason WPA) and three in the eastern portion (McMurtrey WPA, Harvard WPA, and Massie WPA).

Water analyses were conducted to determine levels of specific conductance, calcium and magnesium hardness, and concentrations of ammonia, nitrate, and orthophosphate between mid-February and mid-April of 1981–1983. Weekly samples were collected eight times in 1981, six times in 1982, and five in 1983.

Water samples were collected between 0900 and 1500 hr. One-liter polyethylene containers were submerged 5–10 cm below the surface for water collection. Specific conductance was measured on-site by using a portable conductivity meter with a tungsten element probe. Sample bottles were chilled and transported to the laboratory for analysis.

Samples were analyzed within 10 hr of collection for calcium and total hardness using Environmental Protection Agency (EPA)-approved Hach methods based on the American Public Health Association Standard Methods procedures (Hach Chemical Company 1982). Calcium hardness subtracted from total hardness was used to derive magnesium hardness as calcium carbonate (American Public Health Association 1976). Analysis was also conducted for ammonia (Nessler method), nitrate (cadmium reduction method), and orthophosphate (amino acid method) the same day of collection using spectrophotometric methods and Hach chemical procedures (Hach Chemical Company 1982).

Analysis of sodium, chloride, and sulfate concentrations at each site was conducted once in March 1983; this analysis was undertaken after learning other researchers observed differences in these ions in groundwater adjacent to our study sites (Arendt et al. 1980, Spalding 1981). Water was collected in the same manner as for the other samples. Samples were analyzed for these ions at the Nebraska Department of Environmental Control Laboratory. Atomic absorption, direct aspiration (EPA method 273.1) was used for sodium determination. Chloride concentrations were determined using the automated Ferricyanide method (EPA 325.2). Sulfate analysis was conducted using the turbidimetric determination (EPA 375.4) as described by the Environmental Protection Agency (Anonymous 1983).

Two-way analysis of variance was used to test the null hypothesis that all study wetlands are the same for each of the six water quality variables monitored during the 3 years. A significance level of $p<0.01$ was used for rejection of the null hypothesis.

Results

Waterfowl Mortality

The total number of waterfowl carcasses found in the Rainwater Basin is 75,234 (Table 1). Estimates of total waterfowl mortality are between 160,000–188,000.

A total of 69,327 (92 percent) waterfowl deaths occurred in the western area of the Basin, although the western area contains slightly less wetland acreage and receives slightly less waterfowl usage than the eastern area. In contrast, the eastern wetlands had only 5,907 (8 percent) of the waterfowl losses.

The species most commonly found during avian cholera die-offs in the Rainwater Basin were mallards (*Anas platyrhynchos*), northern pintails (*A. acuta*), and greater white-fronted geese (*Anser albifrons*) (Table 2). Mortality also occurred among Canada geese (*Branta canadensis*), American wigeon (*Anas americana*), and snow geese (*Chen caerulescens*). Several other duck species suffered incidental losses.

Water Quality Analysis

Our results indicate differences exist in water quality variables among wetlands. Specific conductance, calcium hardness, and magnesium hardness were higher in the western area of the Basin than in the eastern area (Table 3). The inter-area differences in all three variables in all 3 years were significant ($p<0.01$).

Mean levels of ammonia, nitrate, and orthophosphate were not significantly different between areas. Mean ammonia concentrations averaged 2.7 mg/l for the study sites (mean range 1.1 mg/l to 5.8 mg/l). Average nitrate concentrations were 3.5 mg/l (mean range from 1.9 mg/l to 5.5 mg/l). Orthosphosphate mean levels were 2.3 mg/l; means ranged from 0.5 mg/l to 4.7 mg/l over the 3 years of the study among the six study sites.

Table 1. Number of dead waterfowl collected in the Rainwater Basin of Nebraska during avian cholera outbreaks.

Year	Number of waterfowl collected	Dates of waterfowl mortality
1975	13,748	April 11 – April 21
1976	7,453	February 25 – April 20
1977	4,340	March 18 – April 16
1978	106	March 14 – April 7
1979	375	March 15 – April 24
1980	30,677	March 2 – May 1
1981	2,904	February 22 – April 10
1982	11,954	February 25 – April 6
1983	3,677	February 23 – April 5
Total	75,234	

Table 2. Species composition of waterfowl found dead during avian cholera outbreaks in Rainwater Basin of Nebraska 1975–1983.

Species	Number observed	Percent of total collected 1975–1983
Mallard	20,906	27.8
White-fronted goose	20,212	26.9
Northern pintail	16,553	22.0
Canada goose	8,410	11.2
American wigeon	3,980	5.3
Other	5,173	6.9

Concentrations of chloride, sulfate, and sodium ions were much higher at Funk Lagoon in the western area than at any of the other study sites (Table 4). Differences in water quality were noted between years for the study sites, particularly in the western areas.

Discussion

Waterfowl Mortality

The Rainwater Basin must be considered an enzootic area for avian cholera along with the Panhandle of Texas and the Central Valley of California (Friend 1981a). Annual waterfowl mortality varies in the Rainwater Basin, but any losses should be viewed with concern as the losses from avian cholera occur at a time just before the breeding season. Mortality among the greater white-fronted geese especially should be viewed with alarm because this species suffers the heaviest mortality in relation to population numbers within the Basin. Causes for these higher losses among the greater white-fronts are unknown. Increased susceptibility to avian cholera, feeding patterns, or other behavioral characteristics peculiar to this species may contribute to this disproportionate mortality.

Table 3. Means ± Sd of specific conductance, calcium and magnesium concentrations, of Rainwater Basin wetlands during spring (1981–1983).

	Wetlands in major avian cholera problem area[a]				Wetlands in avain cholera non-problem area[b]			
Year Year	Funk Lagoon	Prairie Dog	Gleason	Three areas combined	McMurtrey	Harvard	Massie	Three areas combined
Specific conductance (mhos/cm)								
1981	1,885±895	436±32	—[c]	1,523±1,000	464± 60	673±129	533±58	557±124
1982	740±406	260±61	235±46	451± 355	335±129	327±102	233±83	300±115
1983	1,230±550	143±88	179±67	600± 642	163± 44	293±146	255±76	238±111
Calcium[d] (mg/l)								
1981	428±154	163±26	—[c]	36± 177	149± 29	218± 34	134±39	167± 50
1982	185±120	73±22	60±21	116± 97	84± 44	76± 42	46±27	69± 41
1983	424±150	55±54	43±10	211± 214	32± 13	83± 76	47±19	52± 47
Magnesium[d] (mg/l)								
1981	156±113	40±18	—[c]	126± 110	19± 11	36± 23	27±15	27± 18
1982	70± 45	35±17	34±15	49± 35	33± 17	46± 22	35±15	38± 19
1983	88± 73	48±35	58±25	67± 55	40± 18	35± 13	39±20	38± 17

[a] Western portion of the Rainwater Basin.
[b] Eastern portion of the Rainwater Basin.
[c] —No data collected.
[d] As calcium carbonate.

Table 4. Chloride, sulfate, and sodium concentrations in surface waters collected from selected Rainwater Basin wetlands March 13, 1983.

	Wetlands in western portion of basin			Wetlands in eastern portion of basin		
	Funk Lagoon	Prairie Dog	Gleason	McMurtrey	Harvard	Massie
Chloride (mg/1)	56	5	5	6	11	17
Sulfate (mg/1)	437	12	2	6	98	25
Sodium (Dis.) (mg/1)	107.5	3.5	4.8	3.2	19.9	9.6

To date no losses of whooping cranes from avian cholera have been known to occur; however, twice during the last 9 years, as a precautionary measure, whooping cranes were hazed off of Rainwater Basin wetlands experiencing avian cholera mortality.

Water Quality

Our results showed differences existed in several water-quality variables among wetlands in the Rainwater Basin. Arendt et al. (1980) and Spalding (1981) also observed variations in several ions from groundwater in the Basin; we observed variability in these same ions in our surface water samples. We think variation in rainfall and snowmelt may have diluted the waters in some areas at different times and may be partially responsible for the observed differences between years. Other unknown factors may also have contributed to those differences.

Water quality differences between the wetlands in the west and those in the east can be attibuted largely to Funk Lagoon. Funk Lagoon consistently had higher levels of specific conductance and concentrations of calcium and magnesium than any of the other five study sites. Such differences support our idea of water quality involvement in the avian cholera cycle as Funk Lagoon has been considered one of the the "hot spots" for these outbreaks. For this reason, in recent years scare devices were periodically placed on this wetland to discourage bird use.

The factors responsible for differences in the water quality among Basin wetlands were not determined during this study. Similarly, changes in water quality that may have occurred in recent decades have not been evaluated.

Environmental conditions overall have changed in the Rainwater Basin and some of these changes may have affected the avian cholera disease cycle. Dramatic increases in irrigation, fertilizer application, and feedlots have occurred. Such practices and their resultant runoff into wetlands can alter the aquatic environment that waterfowl are using, and may affect groundwater quality. Deep well irrigation systems and the diversion of river waters via canals may affect surface waters and contribute to the water quality differences observed in this study. Once it is known whether differences in water quality affect the avian cholera die-off cycle, positive steps can be taken to find the contributing factors for these differences and to make progress towards altering those factors.

Using information from this study, a profile of an avian cholera wetland can be drawn. Other ions may eventually be identified that could be added to this profile. Based on the findings of this study, such a wetland would have high specific conductance levels, increased concentrations of calcium, magnesium, sodium, sulfate, and chloride with medium levels of ammonia, nitrate, and orthophosphate. Absolute levels cannot be given at this time, and to do so would be inappropriate until the connection between these variables and occurrence of avian cholera can be collaborated by laboratory studies and evaluations of wetlands in other enzootic areas. Based on our findings, laboratory studies were initiated at the National Wildlife Health Laboratory to evaluate the role these water quality variables play in the survivability of *Pasteurella multocida*.

Perhaps a "high" concentration of any of these variables is not important, but rather some lower or medium level is optimum for survival for the bacteria. A synergistic effect may exist involving various water quality conditions not evaluated in this study.

A variety of microenvironmental conditions in aquatic habitats have a direct or indirect influence on the bacterial populations within that habitat (Hendricks 1972, Sjogren and Gibson 1981, Singleton et al. 1982). For example, recent research on *Vibrio cholerae*, the causative bacterial agent for human cholera, has demonstrated that changing the NaCl concentration in solutions effects survival of *V. cholerae* (Singleton et al. 1982). The same principle may be true with *P. multocida* although these two organisms are not closely related.

Management Perspectives

The epizootiology (natural history) of avian cholera in waterfowl and other wild birds is at best poorly understood. This study investigated one aspect of a complex biological question. Many other aspects of avian cholera require resolution before a sound understanding of this disease in wild birds is obtained. Questions that should be investigated include: What are the movement patterns among wetlands of waterfowl using the Rainwater Basin? Where specifically do these birds originate? Are there carriers of the bacteria among the waterfowl themselves? Does the American crow (*Corvus brachyrhynchos*) play a role in the spread of the disease? Are there reservoirs within domestic animal populations that can initiate avian cholera outbreaks in migratory waterfowl? Can the bacterium survive in the natural environment from one year to the next?

The study described by this report does not negate the necessity of evaluating other hypotheses. Management of wetlands and the surrounding areas where avian cholera losses occur is dependent on our understanding of the disease process. Once that understanding is attained, tools available in management may be applied to reduce these losses. Such management tools may include water manipulation, chemical treatment, or vegetation cropping procedures.

Control of avian cholera is the ultimate aim of studies such as the present study. The understanding of the environment and its affect on the disease process helps us to better manage our resources and ultimately reduce disease mortality (Friend 1981b).

Differences in water quality conditions in the Nebraska wetlands, the research accomplished on other microorganisms, and research currently in progress involving the influences of water chemistry on organismal survival tend to support the hypothesis that microenvironmental differences may be involved in the avian cholera disease cycle in migratory waterfowl in Nebraska. If such a relationship exists, we may some day be able to control avian cholera.

> In closing, the following quote from Aldo Leopold (1933:325) is provided: Most laymen and many scientists entertain mental reservations as to the practical utility of wild-animal disease studies. 'You cannot doctor sick birds.'. . .
>
> He, of course, overlooks the obvious fact that 'doctoring' is of recessive importance in health control, even in domesticated species and human beings. He overlooks also that

the real determinants of disease mortality are the environment and the population, both of which are being 'doctored' daily, for better or for worse, by gun and axe, and by fire and plow.

Pessimistic attitudes toward disease control are further accentuated by the extreme complexity of many of the disease mechanisms so far discovered. A better argument is that this very complexity increases the possible points of attack, one of which may some day be used for control measures.

Acknowledgements

The authors thank the many staff members from the following agencies who have provided assistance in working with the avian cholera problem: Nebraska Game and Parks Commission, U.S. Fish and Wildlife Service's Kearney Wetlands Management District Office and Pierre Area Office, Nebraska Department of Environmental Control, and the National Wildlife Health Laboratory. In particular, we thank M. Dietzman for field assistance and graphic preparation, M. Burwitz for typing, and L. Sileo and personnel at the Fish and Wildlife Service Editorial Office for reviewing the manuscript.

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Examining Economic Efficiency of Mangement Practices That Enhance Waterfowl Production

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Introduction

There is an increasing need to provide wildlife for people through management, yet many management practices are applied to the land without a good knowledge of economic effectiveness. Cringan (1971) noted that waterfowl management costs were becoming substantial and that managers needed to select those projects that were most worthwhile. Nobe (1971) suggested that economics could increase management efficiency by providing a framework for decision making by managers. In many wildlife management endeavors, it may be difficult to evaluate efficiency because there may be several goals, some quite subtle. However, efficiency is sufficiently important that managers should endeavor to evaluate activities in terms of achieving primary objectives.

Considerable and continuing investments in land, labor, and capital have been made to provide a habitat system to increase and maintain waterfowl populations in North America. A primary expenditure in northern North America has been made to provide waterfowl production habitats. It follows that increased waterfowl production is a primary effort of waterfowl management activities on the breeding grounds, and results realized there should be related to that goal.

The number of young ducks fledged is a measurable output of waterfowl management. It is possible to estimate cost per bird and relative economic efficiency of each practice through a benefit-cost appraisal by comparing the yield of fledged ducks from each management option versus expenditures. The benefit-cost analysis is used widely by economists (Pearse and Bowdon 1968) as a basis for decision making because all input costs are included.

Herein I evaluated from a benefit-cost standpoint some of the options available to managers for enhancement of waterfowl recruitment. While I assessed the management costs of producing a fledged duck, benefits derived from management practices, such as increased production of other wildlife, were not evaluated. As a result, the fledged duck costs derived in this paper are inflated because other benefits of waterfowl management were not assigned values. Wetlands, a necessary part of all waterfowl breeding habitats, while not treated in this paper, were assumed to be present. It was not possible in this type of analysis to evaluate the effect of wetland protection on waterfowl recruitment. The cost of using land was not included in this paper because land has a wide array of benefits whereas the management costs can be assessed directly to waterfowl production.

Methods

Waterfowl management practices examined were primarily those endeavors intended to increase nest success. I considered current practices for which there were relevant published and unpublished data on duck production rates. Data were examined for two different geographic areas important to breeding waterfowl and containing natural wetlands: the pothole region of North and South Dakota, and western Minnesota.

Specific management treatments examined included (1) planting introduced grass-legume cover, (2) planting native grass cover, (3) constructing man-made islands (over 0.1 acre [0.04 ha]), (4) constructing small rock islands (less than 0.01 acre [0.004 ha]), (5) managing predators at fields of grass-legume cover, (6) managing predators on private farmland, (7) erecting nest baskets, (8) constructing electric fences, (9) constructing small impoundments (average less than 5 acres [2 ha]), and (10) excavating level ditch ponds.

For all treatments, except impoundments and ponds, the management benefits were based on the total number of fledged ducks of all species. For small impoundments and level ditch ponds I defined management benefits as the number of duck breeding pairs attracted per surface acre. The primary species enhanced by all of the management methods were mallard (*Anas platyrhynchos*), gadwall (*A. strepera*), blue-winted teal (*A. discors*), pintail (*A. acuta*), and northern shoveler (*A. clypeata*). These five species accounted for about 90 percent of the ducks affected by these management practices.

In most studies of management practices, duck production was considered as the number of young hatched. To determine the number of birds fledged, I multiplied the number hatched times an estimated average survival rate of 0.54. This rate was determined from mallard fledging data (Ball et al. 1975, Talent et al. 1983, Lokemoen, unpubl. rep., Northern Prairie Wildlife Research Center [NPWRC], Jamestown, ND).

Production was expressed as the net increment of young fledged as a direct result of each specific management practice. For instance, the number of young reported to have fledged in planted cover was the difference between the total number fledged and those fledged on unmanaged farmland. The production resulting from cover protected by electric fences or predator management was the number of young fledged in addition to those fledged in grass-legume cover control fields without fences or predator management. For islands and nest baskets, production was expressed as the number of young fledged from these features as compared to the number of young fledged by an equivalent number of hens nesting in unmanaged habitat.

From discussion with managers and descriptions in the literature, I delineated the work required to complete each management task. Using this guide, the expense of implementing the various management practices was determined using 1982 cost figures for labor, transportation, and material. The expenses for management administration and owning land were not included in the formula. Current rental charges were used to standardize cost estimates for equipment. Vehicle costs for personnel transportation were based on commercial rental rates for pickup trucks of $0.33/mile. Seed prices were taken from a February 1, 1982, dealer seed price list issued by Heartland Company at Bismarck, North Dakota. The cost of native seed harvested by managers was estimated to be one-half the commercial seed cost (W. Olson, pers. comm., Mid-Continent Waterfowl Management Project [MCWMP], Fergus Falls, MN). I used the U.S. Wage Grade 5 rate of $6.50/hour for labor costs.

Based on discussion with managers, a reasonable life expectancy was assigned to each management endeavor. Predator management is a continuing effort and was given a useful life of 1 year. Introduced grass-legume cover was assigned a life of 10 years because plant vigor declines with time. Man-made islands, nest baskets, electric fences, and level ditches were assigned a life of 20 years. Warm-season native grass plantings, small rock islands, and man-made impoundments were given a 50-year life. With anticipated rapid changes in technology and management philosophy, it is probably unreasonable to plan beyond 50 years.

Costs were prorated for the life of each management option by the Water Resources Council standard amortization rate of 0.07625. The formulation rate includes the costs of using capital over a period of time. By multiplying the proper formulation rate times the initial cost, it is possible to estimate annual costs. All costs in this paper were expressed on an annual basis. Calculations of costs and duck production are included in the appendix.

Results

The estimated number of ducks hatched and fledged as a result of each alternative management practice varied greatly. In the pothole region of the Dakotas on mixed farmland with no management practices applied, an estimated 0.06 ducks were fledged per acre per year (Duebbert and Kantrud 1974, Higgins 1977). In managed situations, the increased production resulting from management varied from 0.06 young fledged per acre on mixed farmland where predator management was applied to 4.79 young fledged per acre on man-made islands (Table 1). An estimated average of 0.03 young fledged on mixed farmland with no management in western Minnesota. On managed areas, the number of additional ducks fledged per acre varied from 0.10 on native grass cover to 1.84 on natural islands (Table 2).

Introduced Grass-legume Cover

Nesting cover composed of introduced grass and legume species has been widely seeded on waterfowl management areas in the northern Great Plains. Plants commonly used in the vegetative mixtures include smooth brome (*Bromus inermis*), intermediate wheatgrass (*Agropyron intermedium*), alfalfa (*Medicago sativa*), and sweet clover (*Melilotus* sp.) (Duebbert et al. 1981). On most sites, vegetation of good height and density resulted in a cover form attractive to upland nesting ducks.

In the pothole area of the Dakotas, use of grass-legume cover by nesting ducks has been evaluated by Duebbert and Lokemoen (1976), Klett and Duebbert (1984), and others (Table A-1). These investigators found an average of 0.36 more young per acre were fledged in fields of introduced grass-legume cover than on unmanaged farmlands (Table 1). In western Minnesota, introduced grass-legume cover produced an additional 0.21 young fledged per acre over the unmanaged situation (Table 2) (Doty, unpubl. rep. MCWMP, Fergus Falls, MN).

Most field operations needed to establish introduced grass-legume cover are currently conducted by a cooperating farmer. The farmer accomplishes the land tillage, packing, and the seeding; in exchange, he receives use of the land rent-free for 2 years. The waterfowl manager pays for seed and some weed spraying. The cooperating farmer technique reduces management expenses by one-half or more, but there is a loss of benefits because no young are produced for 2 years while the land is being cultivated. The expense of establishing introduced grass-legume cover was estimated at $15.11 per acre (Table 3) when accomplished by a cooperating farmer versus $44.18 when the managers must accomplish the task. When the total annual establishment and maintenance expenses per acre were divided by the ducks fledged per acre, the resulting cost per fledged duck was $7.89 in the Dakotas and $17.19 in Minnesota (Table 4).

Table 1. Estimated net annual yield of ducklings from various management practices applied primarily in the pothole region of the Dakotas.

Management practice	Unit of measurement	No. of ducks hatched/unit[a]	(range)	No. of ducks fledged/unit[a]	(range)
Mixed farmland	Acre	0.11	(0.02–0.21)	0.06	(0.01–0.11)
Grass-legume cover	Acre	0.67	(0.15–1.13)	0.36	(0.08–0.61)
Native grass cover	Acre	0.38	(0.27–0.72)	0.20	(0.15–0.39)
Man-made islands	Acre	8.88	(8.55–8.96)	4.79	(4.61–4.83)
Small rock islands	Each	0.80	(0.20–1.29)	0.43	(0.12–0.80)
Predator management at grass-legume cover	Acre	6.53	(3.08–8.37)	3.53	(1.66–4.52)
Predator management on mixed farmland	Acre	0.12	(0.12–0.12)	0.06	(0.06–0.06)
Nest baskets	Each	1.44	(0.67–2.89)	0.78	(0.41–1.78)
Electric fences around grass-legume cover	Acre	7.83	(3.15–11.56)	4.23	(1.70–6.24)
				No. of pairs attracted/unit	(range)
Impoundment construction	Acre			1.67	(1.40–1.89)
Level ditch ponds	Acre			8.41	(1.91–19.24)

[a] The figures for ducks hatched and ducks fledged are net values. To obtain the total yield of fledged young for a particular management practice, refer to Tables in the appendix.

Table 2. Estimated net annual yield of ducklings from various management practices applied primarily in western Minnesota.

Management practice	Unit of measurement	No. of ducks hatched/unit[a]	(range)	No. of ducks fledged/unit[a]	(range)
Mixed farmland	Acre	0.06	(0.01–0.11)	0.03	(0.01–0.06)
Grass-legume cover	Acre	0.38	(0.32–0.48)	0.21	(0.18–0.26)
Native grass cover	Acre	0.18	(0.14–0.22)	0.10	(0.08–0.12)
Natural islands	Acre	3.40	(3.40–3.40)	1.84	(1.84–1.84)
Small rock islands			No comparable data		
Predator management at varied cover types	Acre	0.75	(0.75–0.75)	0.41	(0.41–0.41)
Predator management on mixed farmland			No comparable data		
Nest baskets	Each	0.48	(0.48–0.48)	0.26	(0.26–0.26)
Electric fences around grass-legume cover	Acre	2.33	(1.13–3.00)	1.26	(0.61–1.62)
				No. of pairs attracted/unit	(range)
Impoundments			No comparable data		
Level ditch ponds	Acre			4.95	(3.65–6.25)

[a] The figures for ducks hatched and ducks fledged are net values. To obtain the total yield of fledged young for a particular management practice, refer to Tables in the appendix.

Table 3. Estimated cost in dollars to provide various management practices for breeding waterfowl in the pothole region of the Dakotas and western Minnesota, 1982.

Management practice	Expected life in years	Unit of measurement	Dakota pothole region			Western Minnesota		
			Cost/unit to apply	Annual amortized cost	Annual maintenance cost	Cost/unit to apply	Annual amortized cost	Annual maintenance cost
Grass-legume cover	10	Acre	$ 15.11	$ 2.21	$ 0.63	$ 15.11	$ 2.21	$ 1.40
Native grass cover	50	Acre	43.06	3.37	1.44	43.06	3.37	1.44
Man-made islands	20	Acre	9,845.00	974.66	93.50	9,845.00	974.66	93.50
Small rock islands	50	Each	91.50	7.16	2.84	—	—	—
Predator management at grass-legume cover	1	Acre	11.90	11.90	—	0.77	0.77	—
Predator management on mixed farmland	1	Acre	0.12	0.12	—	—	—	—
Nest baskets	20	Each	40.56	4.02	2.64	40.56	4.02	2.64
Electric fences	20	Acre	41.25	4.08	5.97	52.38	5.19	5.97
Impoundments	50	Acre	2,100.00	164.22	52.50	—	—	—
Level ditch ponds	20	Acre	6,503.00	643.80	—	6,503.00	643.80	—

Table 4. Estimated annual cost in dollars for each fledged duck produced or each breeding pair attractetd as a result of various management practices in the pothole region of the Dakotas and western Minnesota.

Management practice	Dakota pothole region		Western Minnesota	
	Establishment and maintenance cost	Cost/fledged young	Establishment and maintenance cost	Cost/fledged young
Grass-legume cover	$ 2.84	$ 7.89	$ 3.61	$ 17.19
Native grass cover	4.81	24.05	4.81	48.10
Man-made islands	1,068.16	223.00	1.068.16	580.52
Small rock islands	10.00	23.26	—	—
Predator management at grass-legume cover	11.90	3.37	0.77	1.88
Predator management on mixed farmland	0.12	2.00	—	—
Nest baskets	6.66	8.54	6.66	25.62
Electric fences around grass-legume cover	10.05	2.38	11.16	8.86
Impoundment construction	216.72	129.77	—	—
Level ditch ponds	643.80	76.55	643.80	130.06

Native Grass Cover

Native grass cover pertains to a mixture of planted warm-season grasses such as big bluestem (*Andropogon geradii*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*). This vegetative type has been planted rather extensively on waterfowl management areas in the eastern quarter of the Dakotas and western Minnesota. Managers have seeded native grasses because this plant community does not have to be reseeded every 10 years as do exotic grasses. Also, native grasses are more colorful and aesthetically pleasing than exotic species. Information on the yield of fledged ducks from native grass cover is just beginning to emerge (Klett and Duebbert 1984, and others (Table A-2)). It appears that duck production from native grass is about one-half that of introduced grass-legume cover (Tables 1 and 2).

Seed grown commercially in Nebraska was used in most early native grass plantings. In recent years, waterfowl managers have reduced the expense of establishing native grass by using locally-harvested seed. Also, most managers have further reduced costs by using cooperating farmers to accomplish the ground preparation, weed removal, and seeding tasks. In native grass plantings, the farmer trades his work for free use of the land for 3 years.

Expenses for establishing native grass cover are, on the average, higher than those incurred for establishing introduced grass-legume cover (Table 3). Native grass seed harvested by managers is moderately expensive and most native plantings contain some expensive seed obtained from commercial sources. Maintenance of established warm-season native grass entails weed spraying on 5 percent of the acres annually and a cover maintenance burn every 5 years. As a result of high establishment cost and low rates of duck production in warm-season native grass plantings, young fledged are expensive. In the Dakotas, each young fledged was estimated at $24.05 and the cost in Minnesota was $48.10 (Table 4).

Man-made Islands

Man-made islands were earth mounds of at least 0.1 acre [0.04 ha] constructed in dry impoundments. The islands were situated 500 feet from (152.4 m) from shore and rose 2–3 feet (0.6–0.9 m) above the normal water level. Each island was covered with a topsoil layer which was planted to introduced grass-legume cover or snowberry (*Symphoricarpos occidentalis*) and Wood's rose (*Rosa woodsii*) roots. If necessary, the islands were riprapped to prevent erosion by wave action.

Production of fledged young from man-made islands was the highest for any management practice in both the pothole region of the Dakota (Table 1) and western Minnesota (Table 2). Studies by Giroux (1981) and two others (Table A-3) found remarkably similar duck production estimated at a net 4.79 young fledged per acre for man-made islands in the Dakotas. Doty (unpubl. rep., MCWMP, Fergus Falls, MN) provided the only Minnesota data on islands where 1.84 young were fledged per acre (Table A-3).

Island construction involved the use of costly, heavy machinery. The expense to construct 1-acre (0.4 ha) islands in a dry impoundment was estimated at $9,845.00 (Table 3). When fill material must be moved any distance, the expense is considerably higher. Given a 20-year life, the average annual amortized cost of an island would be $974.66. Maintenance would be an additional $93.50 per year. Although a relatively large number of ducks were fledged from man-made islands, construction costs were high, and fledged duck costs were estimated to exceed $200.00 per bird (Table 4).

Small Rock Islands

The small (less than 0.01 acre [0.004 ha]) rock islands consisted of rocks placed in small wetlands and covered with topsoil. Adequate vegetation for nesting eventually volunteered on the earth substrate. Small rock islands were studied at a single location in eastern North Dakota by Johnson et al. (1978) and later by Higgins (unpubl. rep., NPWRC, Jamestown, ND).

Duck use and production from the small islands declined between the first study in 1976 and the second study in 1982 and 1983 (Table A-4). The average number of young fledged ducks estimated to have been produced by hens nesting on these structures was 0.43 young per island (Table 1). Each island was estimated to cost $91.50 to construct and $2.84 annually to maintain (Table 3). Duck costs were estimated at $23.26 for each young fledged (Table 4).

Predator Management

I defined predator management as the reduction of primarily small carnivores by lethal baits, shooting, or trapping during the nesting season. In the pothole region of the Dakotas, the predator management scenario was generally patterned after that reported by Duebbert and Lokemoen (1980). In this system, one individual was responsible for reducing predator populations on 10 fields of introduced grass-legume cover, each 80 acres (32.4 ha) in size. To be effective, animal reduction must extend 2 miles (3.2 km) from the center of each cover plot onto the surrounding private farmland. As a result, each treated area would encompass 12.6 square miles (32.6 km^2). Benefits from reduced predation would occur at grass-legume cover plots and the adjoining private farmland. Predator management data for western Minnesota was obtained from the Balser et al. (1968) study at Agassiz National Wildlife Refuge (NWR) where two employees reduced predators on 19,142 acres (7,752.5 ha) (Table A-5).

The net duck production per acre from grass-legume cover where predators were limited in the pothole region of the Dakotas was estimated at 3.53 fledged young (Table 1). This density was exceeded only by the density of young fledged from man-made islands and from grass-legume cover within electric fences. The yield of ducks from private farmland within the entire 12.6-squre mile (32.6 km^2) area where predators were reduced was low on an acre basis, but resulted in a doubling of produciton in relation to lands with no management (Duebbert and Kantrud 1974) (Table 1). At Agassiz NWR, production of young on predator management areas was estimated to increase 1.7 times over the unit without predator management.

Predator reduction costs in the pothole region of the Dakotas amounted to $11.90 per acre for planted cover only, or $0.12 per acre for the entire 12.6-square mile (32.6 km^2) area (Table 3). In western Minnesota at Agassiz NWR, the costs were estimated at $0.77 per acre.

In the Dakotas, the lowest costs for fledged ducks resulted from practices involving predator management (Table 4). Predator management produced ducks most inexpensively in the eastern Dakotas on private land. Under this system, the cost per fledged duck was $2.00 each. The estimated cost of a fledged duck resulting from predator management at fields planted to introduced cool-season cover was $3.37. In western Minnesota, the lowest cost, $1.88 per fledged duck, was for predator reduction implemented at Agassiz NWR.

Nest Baskets

Nest baskets evaluated in this report were open, cone-shaped devices made of wire and lined with straw nesting material (Table A-6). Baskets were affixed to metal poles which are placed in wetlands where the water was 1–3 feet (0.3–0.9 m) deep. Studies of nest baskets (Lee 1982) in the late 1960s found about 50 percent of the structures being used by ducks which experienced good nesting success. The most recent study of nest baskets (Johnson, unpubl. rep., Arrowwood NWR, Pingree, ND) also found high breeding success of hens using baskets but reduced overall use. In the pothole region of the Dakotas, an average of 0.78 young were fledged for each basket erected (Table 1). In western Minnesota, Doty (unpubl. rep., MCWMP, Fergus Falls, MN) found an average of 0.26 ducks fledged per wire nest basket (Table 2).

Expenses for constructing and erecting nest baskets (Table 3) were in the midrange of all management establishment costs. Biannual visits for nest basket maintenance were expensive and increased annual costs by 66 percent. If nest basket repairs were accomplished each year, maintenance costs exceeded the annual amortized installation cost. Fledged duck costs for the two geographic areas amounted to $8.54 per bird in the Dakotas and $25.62 per bird in Minnesota (Table 4).

Electric Fences

Information regarding electric fences was compiled from feasibility studies of electrical barriers constructed around fields of introduced grass-legume cover (Lokemoen et al. 1982, Greenwood and Arnold, unpubl. rep., NPWRC, Jamestown, ND) (Table A-7). Predators inside the fences were removed by live traps, steel traps, or lethal baits. Predators outside the fences were denied access by the energized wire barrier.

In the Dakotas, the production of young from hens nesting in grass-legume cover encircled by electric fences was on a per acre basis, second only to the production of young from man-made islands (Table 1). In western Minnesota, the number of young fledged from each acre of grass-legume cover with electric fences was also second to the number of young which were fledged from islands (Table 2). Electric fence construction costs were estimated at $41.25 per acre in the Dakota pothole country and at $52.38 per acre in western Minnesota for fences that enclosed 80 acres (32.4 ha) (Table 3). Fence operation included a weekly visit during the nesting season, which resulted in annual maintenance expenses that exceeded the annual amortized cost of construction. Costs of ducks fledged from cover protected by electrical barriers were $2.38 in the Dakota pothole region and $8.86 in western Minnesota (Table 4).

Small Impoundments and Level Ditch Ponds

Small impoundments were created in the pothole region of the Dakotas by constructing dams across coulees that contained intermittent streams. Level ditch ponds were created in both geographic areas by excavating earth from areas with high water tables to create open water. Level ditch ponds were placed in close proximity to large marshes.

The values of small impoundments and level ditch ponds for duck production were difficult to determine because ducks do not normally nest on the ponds. Ponds were evaluated in relation to breeding pairs attracted. The number of breeding pairs using impoundments in the eastern Dakotas averaged 1.67 pairs per surface acre based on data presented by Duebbert (1972) and Kruse (1972) (Tables 1 and A-8). The number of breeding pairs attracted to an average surface acre of level ditch pond in the Dakotas was 8.41 pairs (Nelson 1972, Hammond, unpubl. rep., J. Clark Salyer NWR, Upham, ND) (Tables 1 and A-9). In western Minnesota (Carlson, unpubl. rep., Minnesota Department of Natural Resources [MN DNR], Fergus Falls, MN), an average of 4.95 breeding pairs were attracted to each acre of level ditch pond (Table 2). Construction of both types of man-made wetlands required heavy equipment, and construction costs were high (Table 3). Although production data were not obtained, the annual cost of each pair attracted exceeded $76.00 in both sampled areas (Table 4).

Discussion

Five management practices in the Dakotas and 2 in Minnesota of 10 evaluated yielded fledged ducks that cost less than $10.00 each. Five of these 7 management endeavors included direct predator management to reduce nest predation. The other 2 practices employed indirect predator management, including predator-proof nest structures and dense nesting cover. Those management practices where fledged birds cost more than $10.00 each generally involved the use of heavy machinery or expensive materials.

The practice which resulted in the lowest cost per duck fledged in the eastern Dakotas was predator management on private land. Similarly, predator management in Minnesota, in conjunction with wetlands and cover existing at Agassiz NWR, was responsible for the lowest cost fledged ducks in that region. The next least costly methods for enhancing duck production were direct predator control at fields of introduced cover and electrical barriers in conjunction with introduced cover. Use of predator control and electrical barriers in combination with planted cover raised total expenditures but increased the number of ducks fledged and decreased the cost per bird. Nest baskets were the next least expensive method of increasing waterfowl production. Costs of nest baskets were moderate and production of ducks was good in relation to expenditures. The only other management technique that resulted in costs of less than $10.00 per fledged duck was the establishment of introduced grass-legume cover with no predator management.

Small rocks islands, like nest baskets, provided a more secure nest site for ducks. However, on a cost basis, fledged young were produced more economically in baskets. The costs of ducks fledged from fields of native grass cover were high because most plantings required expensive seed, some fields need to be replanted, and the yield of ducks was low. Man-made islands produced ducks at the highest rate, but islands were costly to construct and ducks fledged from them were expensive. Giroux (1981), in his study of man-made islands, estimated that each duckling cost $4.80. However, he did not amortize contruction costs, include maintenance expenses, nor consider duckling mortality between hatching and fledging.

Adding surface water to a waterfowl production habitat with impoundments or level ditch ponds can attract additional breeding pairs. However, wetland construction is expensive and the cost was high for each pair attracted. If the wetland development project has no planned method to enhance nest success, the additional pairs using created wetlands may have a low success rate. If these pairs have the same success that Cowardin and Johnson (1979) calculated for mallards breeding in North Dakota of 0.50 young hens fledged per adult hen, then each pair would produce an average of 1 young. With this production rate, the cost of each progeny would be the same as the cost for each pair attracted.

It costs more to produce a fledged duck in western Minnesota than in the eastern Dakotas. Costs were probably higher in Minnesota because the duck breeding population was lower and hen success and duckling production was less than that in the Dakotas. In Minnesota, higher expenses were incurred for weed control and fence construction.

Land values have increased dramatically since World War II and now are a major cost consideration in any management scheme. Purchased land can provide benefits to a variety of users. These several benefits of the land should be identified and the land costs apportioned among them. If land is being acquired primarily for waterfowl production, a major portion of the land expense should be assigned to management. Based on the current amortization rates, the annual equivalent expense of owning land is valued at $7.82 per $100.00 of cost per acre. This cost is quite close to the annual lease fee for 1 acre (0.4 ha) of land, which is about 8 percent of the current selling price.

As the value of land increases, the cost of producing fledged ducklings rises accordingly (Figure 1). The rate of increasing costs is closely associated with the intensity of management applied to the land. The unit cost of waterfowl produced on purchased land that is unmanaged rises rapidly with increasing land values because duckling yield is low. By using more productive management schemes, the unit cost of producing waterfowl rises at a decreasing rate with increasing land costs. Adding cover or a combination of cover

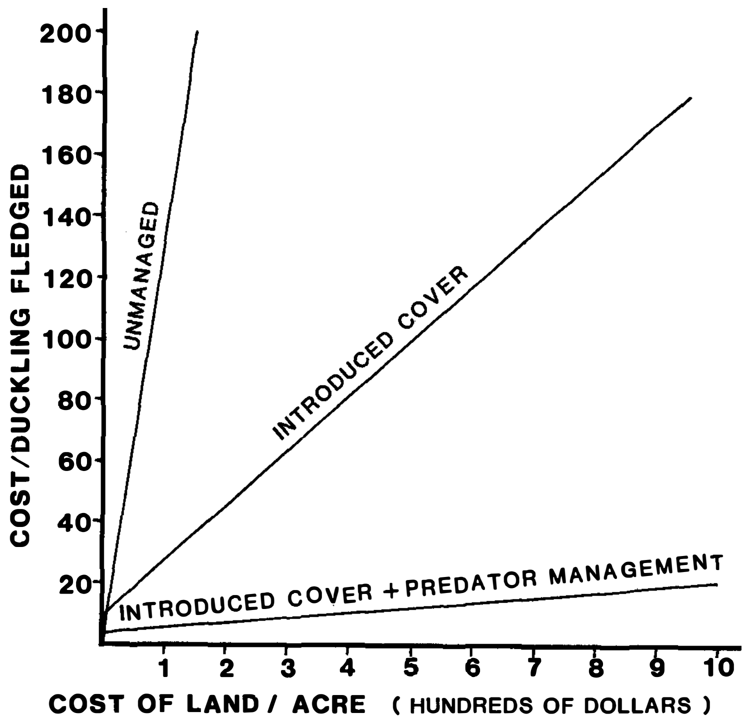

Figure 1. Cost of each duck fledged in the Dakotas as a function of increasing land costs for three management practices.

and predator management to a parcel of land increases total costs but greatly raises the production of young per unit of land, thereby decreasing the cost per individual.

There appears to be excellent potential for producing waterfowl more economically on lands dedicated to wildlife by purposeful management. Reports by Balser et al. (1968), Drewien and Fredrickson (1970), Smith (1971), Duebbert and Lokemoen (1980), and Duebbert et al. (1983) indicate that high densities of waterfowl can occur at a single location given the correct arrangement of environmental factors. In northwest North Dakota, Duebbert et al. (1983) found a minimum of 15,960 ducklings hatched from an 11-acre (4.4 ha) natural island during a 5-year period. Production from man-made islands has not reached this level, but research may improve man-made island design and increase waterfowl production. Also, the placement of electric fence barriers around fields of introduced grass-legume cover shows good potential for increasing hen productivity (Lokemoen et al. 1982, Greenwood and Arnold, unpubl. rep., NPWRC, Jamestown, ND).

Conclusion

My purpose for preparing this analysis was to stimulate thought and discussion regarding economic efficiency in waterfowl management. Budgets for wildlife programs are always limited, and management effectiveness would be enhanced significantly if expected benefits, costs, and productive efficiency were calculated for each management operation. Information contained in this paper provides to waterfowl managers estimates of average management expenses and anticipated duck production. These data should enable managers in the northern prairies to estimate costs and production benefits before initiating projects that may be expensive or of low productivity.

The most important parameter in producing waterfowl most efficiently is the cost per bird produced, not the total dollar expenditure or the yield of young per acre. Of the management methods examined, man-made islands, as an example, showed the highest rate of duck production. Yet, islands were expensive to construct, the cost of each individual produced on islands was quite high, and dollars spend on islands were not efficiently used. It is beneficial to expend additional dollars on intensifying management until the cost per bird produced rises above a prescribed standard. Concentrating management effort at fewer units is usually economically wise because initial costs to lease uplands, preserve wetlands, establish cover, and to survey and post boundaries are incurred less often. Also, travel time and transportation costs are less if managed units are fewer and larger.

Currently, most management practices used to produce young waterfowl are costly when measured in terms of ducks raised to flight stage. If management is going to play a significant role in the produciton of waterfowl in North America, the efficiency of management endeavors must be increased considerably. Fledged duck benefit-cost ratios can be improved primarily by increasing waterfowl productivity and secondarily by increasing management efficiency. Expenses, such as labor, transportation, and materials, are mainly fixed costs which are difficult for managers to reduce. Managers, however, have the ability to raise duck production substantially. To be effective and efficient, a well-managed waterfowl breeding environment must provide superior habitats for all phases of the reproductive period.

Acknowledgements

L.M. Cowardin deserves special thanks for his editorial review of the paper and for his encouragement while the manuscript was being prepared. I am grateful to P.M. Arnold and J.R. Foster of Arrowwood NWR, and to H.A. Doty and W. Olson, Fergus Falls, Minnesota, for their comments on early drafts of the paper and for use of their unpublished information. The aid I received from economists M. Hay and J. Leitch was quite useful. I also appreciate the support I received from R.C. Stendell and G.A. Grau, Director and Assistant Director for Northern Prairie Wildlife Research Center, and from C.W. Dane and R.D. Sparrowe of the Washington Office research staff.

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Appendix

Table A-1. Estimated duck production, establishment costs, and maintenance expenses for 1 acre of introduced grass-legume cover.

Duck production estimates			
Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Duebbert and Lokemoen (1976)	0.66	Doty, USFWS, Fergus Falls, MN	0.21
Klett and Duebbert (1984)	0.14	Doty, USFWS, Fergus Falls, MN	0.29
Gilbert, USFWS, Madison, SD	0.67		
Higgins, USFWS, Jamestown, ND	0.38		
Averages[a]	0.42		0.24
No. young produced no mgmt.	−0.06		0.03
Annual net production	0.36		0.21

Establishment cost estimates			
Materials (lbs. PLS.)[b] used for Dakota posthole region	Total cost	Materials (lbs. PLS.)[b] used for western Minnesota	Total cost
Tall wheatgrass (4.5)	$ 5.18	Tall wheatgrass (4.5)	$ 5.18
Intermediate wheatgrass (4.0)	6.00	Intermediate wheatgrass (4.0)	6.00
Alfalfa (1.0)	1.25	Alfalfa (1.0)	1.25
Sweetclover (0.5)	0.16	Sweetclover (0.5)	0.15
Cost/acre	12.59		12.59
10-year factor	× 0.1465		0.1465
Annual cost/acre[c]	2.21		2.21

Maintenance cost estimate			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Labor (0.05 hr.)	$0.32	Labor (0.05 hr.)	$0.32
Transportation (0.625 mi.)	0.21	transportation (0.625 mi.)	0.21
Spraying (0.025 ac.)	0.10	Spraying (0.225 ac.)	0.87
Annual cost/acre	0.63		1.40

[a] These averages are weighted by the size of the study areas.
[b] Pounds of pure live seed planted per acre.
[c] Costs increased 20% because cover is not available during the 2-year seeding period.

Table A-2. Estimated duck production, establishment costs, and maintenance expenses for 1 acre of native, wram-season grass cover.

Duck production estimates			
Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Klett and Duebbert (1984)	0.21	Doty, USFWS, Fergus Falls, MN	0.11
Gilbert, USFWS, Madison, SD	0.45	Wallace, USFWS, Fergus Falls, MN	0.15
Averages[a]	0.26		0.13
No. young produced no mgmt.	−0.06		0.03
Annual net production	0.20		0.10

Establishment cost estimates			
Materials (lbs. PLS.)[b] used for Dakota pothole region	Total cost	Materials (lbs. PLS.)[b] used for western Minnesota	Total cost
Big bluestem (5.3)	$19.88	Big bluestem (5.3)	$19.88
Indiangrass (3.0)	11.25	Indian wheatgrass (3.0)	11.25
Switchgrass (0.9)	2.51	Switchgrass (0.9)	2.51
Cost/acre	33.64		33.64
50-year factor	× 0.0782		0.0782
Annual cost/acre[c]	3.37		3.37

Maintenance cost estimate			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Labor (0.05 hr.)	$0.32	Labor (0.05 hr.)	$0.32
Transportation (0.625 mi.)	0.21	Transportation (0.625 mi.)	0.21
Spraying (0.025 ac.)	0.19	Spraying (0.225 ac.)	0.19
Burning (every 5 years)	0.72	Burning (every 5 years)	0.72
Annual cost/acre	1.44		1.44

[a]These averages are weighted by the size of the study areas.
[b]Pounds of pure live seed planted per acre.
[c]Costs increased 28% because cover is not available during the 4-year seeding period and there is an estimated 20% failure rate.

Table A-3. Estimated duck production, establishment costs, and maintenance expenses for 1 acre man-made islands.

Duck production estimates			
Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Giroux (1981)[a]	6.12	Doty, USFWS, FergusFalls, MN	2.39
Auffworth, USFWS, Upham, ND	6.12		
Willms, USFWS, Upham, ND	5.90		
Averages[b]	6.08		2.39
No. young produced no mgmt.	−1.29		0.55
Annual net production	4.79		1.84

Establishment cost estimates			
Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Earthmover[c]	$7,900.00	Earthmover[c]	$7,900.99
Rock riprap[d]	690.00	Rock riprap[d]	690.00
Topsoil[e]	1,005.00	Topsoil[e]	1,005.00
Surveying, etc.	250.00	Surveying, etc.	250.00
Cost/acre	9,854.00		9,845.00
20-year factor	× 0.0990		0.0990
Annual cost/acre	974.66		974.66

Maintenance cost estimate			
Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Trapping (8 hr.)	$52.32	Trapping (8 hr.)	$52.32
Transportation (50 mi.)	16.50	Transportation (50 mi.)	16.50
Equipment (boat, traps, etc.)	25.00	Equipment (boat, traps, etc.)	25.00
Annual cost/acre	93.50		93.50

[a] Diving duck production, which comprised 28% of the total was deleted from these figures as diving duck production on comparative islands in the eastern Dakotas is minimal.
[b] These averages are weighted by the size of the study area.
[c] An island 7 feet high with a 5:1 side slope would entail 15,714 cubic yards. A large bulldozer moves about 200 yards/hour, or 79 hours for total.
[d] Estimated 185 cubic yards (6 feet wide, 1 foot deep) of rock carried by a 4-cubic yard truck for riprap.
[e] Estimated a 4-inch covering of topsoil with buckbrush and rose roots on one-half of island

Table A-4. Estimated duck production, establishment costs, and maintenance expenses for small man-made islands.

Duck production estimates			
Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Johnson (1978)	0.91	No comparable data	
Higgins, USFWS, Jamestown, ND	0.14		
Averages[a]	0.56		
No. young produced no mgmt.	−0.13		
Annual net production	0.43		
Establishment cost estimates			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Trucking (1 hr.)	$39.00	No comparable data	
Loading (1 hr.)	52.50		
Cost/unit	91.50		
50-year factor	× 0.0782		
Annual cost/unit	7.16		
Maintenance cost estimate[b]			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Labor (0.1 hr.)	$0.65	No comparable data	
Transportation (2 mi.)	0.66		
Earthmover (0.025 hr.)	1.53		
Annual cost/acre	2.84		

[a] These averages are weighted by the size of the study areas.

[b] Maintenance includes an examination of all islands every 3 years and repairing 0.5% of all islands every 3 years.

Table A-5. Estimated duck production and establishment costs for 1 acre of introduced grass-legume cover with predator management.

	Duck production estimates		
Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Duebbert and Lokemoen (1980)	5.18	Balser et al. (1968)	0.41
Sayler and Stromstad, UND, Grand Forks, ND[a]	2.78		
Averages[b]	4.35		0.41
No. young produced no mgmt.	−0.82		0
Annual net production	3.53		0.41
	Establishment cost estimates		
Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Labor (64hr.)	$416.00	Labor (1,280 hr.)	$ 8,320.00
Transportation (1,260 mi.)	415.80	Transportation (8,000 mi.)	2,640.00
Equipment (traps, boats, etc.)	120.00	Equipment (traps, boats, etc.)	3,750.00
Annual cost/unit	951.80		14,710.00
Annual cost/acre	0.12		0.77

[a] Because only one nest search was conducted, the number of young observed hatching was doubled to make the figures comparable with other studies where two or more next searches were made.

[b] These averages are weighted by the size of the study areas.

Table A-6. Estimated duck production, establishment costs, and maintenance expenses for each wire nest basket.

Duck production estimates

Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Lee (1982)	2.03	Doty, USFWS, Fergus Falls, MN	0.34
Johnson, USFWS, Pingree, ND	0.47		
Averages[a]	1.01		0.34
No. young produced no mgmt.	−0.23		0.08
Annual net production	0.78		0.26

Establishment cost estimates

Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Construction		**Construction**	
Labor (1 hr.)	$ 6.50	Labor (1 hr.)	$ 6.50
Pipe (10.5 ft.)	14.70	Pipe (10.5 ft.)	14.70
Welded wire (3.3 ft.)	4.29	Welded wire (3.3 ft.)	4.29
Iron rod, bolts, etc.	6.89	Iron rod, bolts, etc.	6.89
Cost/unit	32.38		32.38
Installation		**Installation**	
Labor (0.75 hr.)	$ 4.88	Labor (0.75 hr.)	$ 4.88
Transportation (10 mi.)	3.30	Transportation (10 mi.)	3.30
Cost/unit	40.56		40.56
20-year factor	× 0.0990		0.0990
Annual cost/unit	4.02		4.02

Maintenance cost estimate[b]

Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Labor (0.135 hr.)	$0.81	Labor (0.125 hr.)	$0.81
Transportation (22.5 mi.)	0.83	Transportation (22.5 mi.)	0.83
Supplies (bolts, straw, etc.)	1.00	Supplies (bolts, strawm etc.)	1.00
Annual cost/unit	2.64		2.64

[a] These averages are weighted by the size of the study areas.

[b] Maintenance includes an examination of each basket every other year with one man maintaining 30/day.

Table A-7. Estimated duck production, establishment costs, and maintenance expenses for 1 acre introduced grass-legume cover with an electric fence barrier.

Duck production estimates

Data source for Dakota pothole region	No. fledged per acre	Data source for western Minnesota	No. fledged per acre
Lokemoen et al. (1982))	4.31	Lokemoen et al (1982)	2.25
Greenwood and Arnold, USFWS, Jamestown, ND	6.45	Doty, USFWS, Fergus Falls, MN	0.72
Averages[a]	5.50		1.70
No. young produced no mgmt.	−1.27		0.44
Annual net production	4.23		1.26

Establishment cost estimates

Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Labor (3 hr.)	$19.50	Labor (3.5hr.)	$22.75
Wire (693 ft.)	12.69	Wire (693 ft.)	12.69
Supplies (posts, chargers, etc.)	9.06	Supplies (posts, chargers, etc.)	17.00
Cost/acre	41.25		52.44
20-year factor	× 0.0990		0.0990
Annual cost/unit	4.08		5.19

Maintenance cost estimate[b]

Operations and materials used for Dakota pothole region	Total cost	Operations and materials used for western Minnesota	Total cost
Labor (0.45 hr.)	$2.92	Labor (0.45 hr.)	$2.92
Transportation (6.25 mi.)	2.06	Transportation (6.25 mi.)	2.06
Supplies (batteries, etc.)	0.99	Supplies (batteries, etc.)	0.99
Annual cost/acre	5.97		5.97

[a] These averages are weighted by the size of the study areas.
[b] Annual maintenance includes a weekly visit to ecach fence from 4/7 to 7/7.

Table A-8. Estimated number of breeding pairs attracted, establishment costs, and maintenance expenses for 1-surface acre of man-made impoundments.

Duck production estimates			
Data source for Dakota pothole region	No. pairs per acre	Data source for western Minnesota	No. pairs per acre
Kruse (1972)	1.89	No comparable data	
Duebbert (1972)	1.40		
Averages[a]	1.67		

Establishment cost estimates			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Earth moving (1,300 yd^3)	$1,950.00	No comparable data	
Surveying	50.00		
Seeding	100.00		
Cost/acre	2,100.00		
50-year factor	× 0.0782		
Annual cost/acre	164.22		

Maintenance cost estimates			
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Earth moving	$ 975.00	No comparable data	
Surveying	25.00		
Seeding	50.00		
Annual cost/acre	1,050.00		
Repair rate[b]	× 0.05		
Annual cost/acre	52.50		

[a] These averages are weighted by the size of the study areas.

[b] An estimated 5% of impoundments will need repairs each year which will require expenses estimated at 50% of new costs.

Table A-9. Estimated number of breeding pairs attracted and establishment costs for 1-surface acre of level ditch ponds.

	Duck production estimates		
Data source for Dakota pothole region	No. pairs	Data source for western Minnesota	No. pairs
Hammond, USFWS, Upham, ND	19.24	Carlson, MN DNR, Fergus Falls, MN	6.26
Nelson (1972)	1.91	Carlson, MN DNR, Fergus Falls, MN	3.65
Averages[a]	8.41		4.95

	Establishment cost estimates		
Operations needed for Dakota pothole region	Total cost	Operations needed for western Minnesota	Total cost
Earth moving (6,453 yd^3)	$6,453.00	Earth moving (6.453 yd^3)	$6,453.00
Surveying	50.00	Surveying	50.00
Cost/acre	6,503.00		6,503.00
20-year factor	× 0.990		0.0990
Annual cost/acre	643.80		643.80

[a] These averages are weighted by the size of the study areas.

Registered Attendance

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Guy Baldassarre, James R. Davis, Ralph E. Mirarchi, Stuart Lindsey Paulus, John Pritchett, John D. Thompson, Rich Turnbull

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