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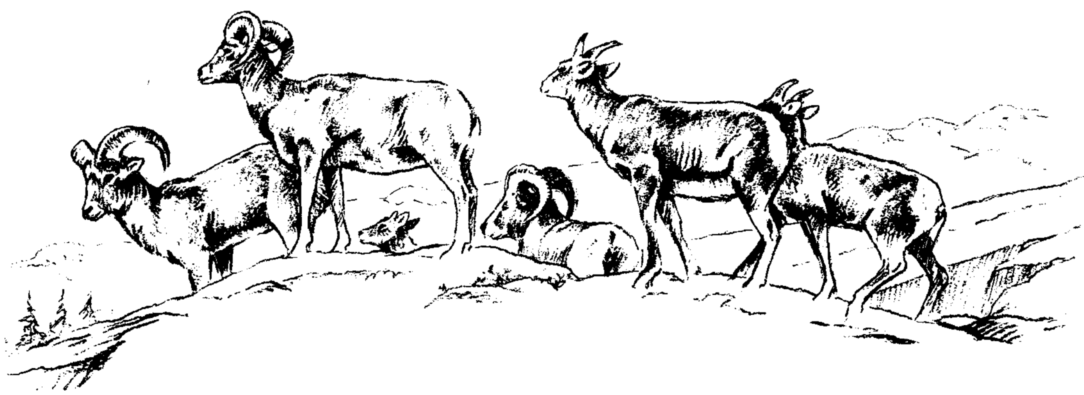

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THE WHITE HOUSE

WASHINGTON

February 4, 1986

In February of 1936, the pioneers of conservation assembled at the behest of President Franklin D. Roosevelt for the first North American Wildlife Conference. From that meeting emerged two powerful ideas: that the United States should declare the perpetuation of our game animals and especially waterfowl a matter of national concern, and that the Federal government should join the States in a partnership to conserve the natural systems our country's wild creatures depend on to survive.

The mid-1930's were far from a promising time to declare yet another "national interest." The nation was mired in the worst depression in our history. Fully 14 percent of our work force was unemployed. Moreover, in the "Dust Bowl" some quarter-billion acres of farmland were ravaged, bankrupting tens of thousands of farmers in 19 States. In an era of such widespread human distress, even despair, how could anyone worry about creatures of the wild? Or, more to the point, how could financial resources be spared to preserve our wildlife?

The farsighted conservationists who preceded you offered an answer. They proposed that the Federal excise tax on sporting arms and ammunition, which had been going into the U.S. Treasury's general fund, be earmarked for wildlife conservation. These funds would support projects monitored by Washington, but designed by the States. The resulting proposal, co-sponsored by a Nevada Senator and a Virginia Representative, sped through both houses of Congress. President Franklin D. Roosevelt signed it into law on September 2, 1937.

As I have made clear since taking office in 1981, I am no friend of taxes. Yet the $1.6 billion in Federal revenues and the $500 million in matching State funds made available since 1938 by the Federal Aid in Wildlife Restoration Act -- familiarly known as the "Pittman-Robertson Act" after its Congressional sponsors -- reflect a sound philosophy of finance: let those who benefit most from a government program shoulder most of its burden if they are able.

Since 1938, when Pittman-Robertson funds totalled $1 million, to 1985, when its revenues exceeded $120 million, outdoorsmen have been doing precisely that -- they have freely consented to tax themselves to conserve wildlife. Long before 1970, when many of our environmental laws were written, hunters were taxing themselves to buy land for wildlife, restore or improve habitat, and finance research that transformed wildlife management from a combination of traditional husbandry and educated hunches into a sophisticated science. If sportsmen had failed to put their money where their hearts were at a critical point in our history, many of the species that flourish today might not have survived.

I am pleased that your community of sportsmen and scientists, manufacturers and administrators, will observe the golden anniversary of the Pittman-Robertson Act during 1987 by sharing with your fellow citizens the story of this law's rich legacy.

I know you join other Americans in concern for a nation strong enough economically, socially, and militarily to sustain our way of life. But as wildlife professionals you will focus these proceedings on the special concern that is yours: to guarantee that there will always be space in our land for the flight of the loon and the falcon, the migration of the elk, and the work of the beaver. For such creatures, great and small, are a precious and irreplaceable part of our heritage.

My best wishes to you all for a memorable and productive 51st conference.

Ronald Reagan

Identifying Needs and Opportunities to Improve Natural Resources Management

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Moscow, Idaho

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President, International Association of Fish and Wildlife Agencies
Executive Director, Tennessee Wildlife Resources Agency
Nashville, Tennessee

Opening Remarks

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

Good morning, ladies and gentlemen. Welcome to the 51st North American Wildlife and Natural Resources Conference.

We soon will enter the golden anniversary year of the Federal Aid in Wildlife Restoration Act. Sponsored by Senator Key Pittman of Nevada and Representative A. Willis Robertson of Virginia, it is widely known as the "Pittman-Robertson" or "PR" Act. Its funding comes entirely from manufacturers' excise taxes paid by hunters and shooters on sporting firearms, ammunition and archery gear. It provides matching grants to state wildlife agencies for approved projects.

Before the PR Act went into effect, state wildlife agencies commonly encountered political interference in their hiring of personnel and use of license funds. The Act and subsequent regulations lessened such destabilizing events by ruling out diversion of license fees, by requiring the hiring of qualified personnel, and by limiting financial assistance only to projects of a substantial nature. To help meet personnel needs created by the Act, colleges and universities began to develop and offer major courses of study in wildlife science. All of these interlocking requirements and reactions brought consequent benefit to wildlife administration and practice at both state and federal levels.

In a 1940 report of his Senate Special Committee on the Conservation of Wildlife, Senator Pittman predicted that "This act. . . . over the years, will have a greater effect and benefit on wildlife restoration than any other single act passed by Congress, save and except only the Migratory Bird Treaty Act and subsequent legislation to carry it out."

With today's half-century hindsight, it can be said that no single congressional enactment has brought such substantial result to a broader spectrum of wildlife, to the outdoor-minded public, and to the practice of scientific wildlife management. The PR program is a unique and mature partnership of industry, sportsmen and government. It is the envy of wildlife enthusiasts worldwide. It should be defended against all incursions, both deliberate and ignorant.

There is pertinence today, too, in Senator Pittman's reference to the Migratory Bird Treaty Act. Canada and the United States are nearing approval of a North American Waterfowl Management Plan. With its mutual continental habitat goals and species population objectives, the plan provides for coordinating the two countries' management of a highly mobile and habitat-sensitive wildlife resource. It is hoped that Mexico will join this effort soon.

So much for the good news.

More than 200 years ago, Thomas Paine, writing in *The American Crisis,* described the revolutionary days as being ". . . the times that try men's souls." Today, the souls of men and women engaged in managing the nation's renewable natural resources are being tested by an upheaval of another kind. That test is embodied in the Administration's Fiscal Year 1987 budget—coming as it does as a hyperextension of a series of record deficits, annual budget decreases and the Gramm-Rudman-Hollings deficit-reduction exercise.

Virtually no existing federal program involving wildlife or its habitat is untouched. Some would be reduced even beyond the disappointing levels of the last few years. Others would be terminated. Many wasteful, habitat-destroying programs and government give-aways would be continued. Both, oddly, at a time and by an Administration that preaches but does not practice much the opposite. The wildlife community must be tough and resourceful in the months ahead.

We can be resourceful by demanding that federal funds do double-duty. The Food Security Act of 1985—better known as the Farm Act—offers such opportunity. Millions of acres of erosion-prone land may be removed from crop production under the Conservation Reserve title. The Act's Sodbuster and Swampbuster provisions are intended to discourage bringing new land into unneeded production. Farmers owing the Federal Home Administration will be eligible to restructure their debt in exchange for easements of not less than 50 years for conservation, recreation and wildlife purposes.

Wildlife interests should strive to piggyback the billions of dollars that are slated to fuel farm programs. Your contacts in Washington have been working to help develop appropriate regulations. But that is not enough. Wildlife interests must work closely with agricultural agencies and groups and with farmers and ranchers out on the land where everything comes together. Never before has Congress and an Administration appeared more desirous of demonstrating broader public benefit from a farm program. The challenge is to translate words into deeds.

The outlook is less promising for the emergency wetlands-acquisition legislation, favorably reported in the House and awaiting Senate markup. The Administration's position has changed. Gone is its support for a short-term draw on the Land and Water Conservation Fund for emergency wetlands protection. Rather than requiring refuge visitors to possess a current duck stamp or pay an entry fee with all receipts going to the wetlands fund, the Administration would split the pot—40 percent to wetlands, 40 percent for refuge maintenance and 20 percent to itself.

The Administration still favors increasing the duck stamp fee. Certainly, waterfowl hunters do not object to a higher fee. But should they agree to it in this instance, their gullibility would overshadow their generosity. Duck hunters must realize that their wallets are no match for federal tax credits, accelerated depreciation and other incentives that stimulate and underwrite wetland destruction. It is the system that encourages wetland destruction that must be changed, not the price of the duck stamp.

You will hear this morning from the executive director of the new President's Commission on Americans Outdoors. The Commission is holding public listening sessions to gather ideas about meeting outdoor recreational demands. One session was held here yesterday. The Commission has the near–impossible assignment to report by the end of the year.

For any major recommendations to succeed, the Commission must identify sources of funding, either from new sources or from the elimination or modification of current ineffective activities. I hope it will move to shake off the conventional parks–are–recreation mindset of federal and state governments, and explore ways of encouraging access to and recreational use of the nearly two-thirds of the nation that are in private ownership and the many millions of acres administered by the U.S. Forest Service and the Bureau of Land Management. State fish and wildlife agencies and allied interests are in a position to suggest approaches for expanding opportunities to accommodate dispersed outdoor recreation. The Commission has invited them to do so, and I urge them to comply.

Before calling on Dr. Gibb, I want to comment on one other matter. That is use of nontoxic shot by waterfowlers as a means of reducing serious loss of waterfowl and easing a mortality factor for eagles.

The parties to this issue—state and federal wildlife agencies, industry, sportsmen and associated groups—could suffer serious disservice if they permit all phases of it to be settled by the court rather than by those who know the problem best. The question no longer is *why* nontoxic shot should be required. It is *where* and *when*.

This issue should be resolved, and soon, by those who bear legal responsibility for wildlife and, therefore, are most directly involved. It should not be trusted to the court, because on this issue, justice may well–prove to be blind. Nor can it be or should it be addressed by any kind of a "quick fix" by Congress. Congressional involvement to date has needlessly prolonged satisfactory resolution of the problem. It has, in fact, spawned serious problems for wildlife administrators, confused and divided sportsmen, provoked public resentment, and saddled industry with vexsome planning, investment and marketing decisions.

Negotiation, not continued confrontation, offers the best alternative for drawing the curtain on this troublesome issue. We should demand that negotiation get underway immediately.

Changes Required to Avoid Soil Degradation and Loss

The Honorable Herbert O. Sparrow
Deputy Chairman
Standing Committee on Agriculture, Fisheries and Forestry
The Senate of Canada
Ottawa, Ontario, Canada

Covering half a continent, Canada, like the United States, has a widely varied geography and climate with widely varying soil conservation problems. Canada's agricultural productivity is dependent on a very thin mantle of topsoil, averaging around 6 inches (15 cm)—much less than many areas of your own country, which is very vulnerable to abuse. The thinness of this layer is a major factor in the relative severity of her conservation problems.

Canada is often thought of as the land of ice and snow, but as your compatriots from the northern states will not hesitate to tell you, the cold climate does not halt the degradation process. The freeze–thaw cycle is a major cause of erosion across the country. Also, with the cold climate, growing seasons are short, less than one-third of the year in many areas, and soil formation processes operate slowly.

The practices that cause or exacerbate soil degradation are row crop monoculture, cultivating up and down slopes, unnecessary fall tillage, excessive summer fallowing on certain soil types, overtillage and cropping of land prone to degradation. These practices have led to a decline in the productivity of the soil and, in addition, have caused serious water pollution problems such as the siltation of waterways and chemical pollution of surface and groundwaters and decreases in the diversity of wildlife because of the destruction of natural habitats. The economic cost to society, to say nothing of the environmental cost, is enormous.

Attempts have been made to establish the losses due to soil degradation across Canada. Water erosion has caused topsoil losses of as high as 16.2 tons per acre (40 t/ha) in the Fraser Valley of British Columbia. Yields have been reduced by 30–40 percent on severely eroded lands in Ontario and in New Brunswick, and land in row crops can erode at rates as high as 40.5 tons per acre per year (100 t/ha/year). Conservative estimates of the dollar loss due to water erosion are between $266 million and $382 million per year.

In my own part of the world, the Canadian Prairies, wind erosion is a major problem, particularly in southern regions of Alberta, Saskatchewan and Manitoba, where crops have been completely wiped out during spring storms before seedlings become established. During years of drought, when there has been no snow cover, wind erosion has also been a serious problem during winter months. The cost of yield losses and higher input costs due to wind erosion have been found to amount to $218 million to $225 million on an annual basis.

Salinization, particularly secondary or man–induced salinity, is a very serious problem, again in the Prairie provinces, estimated to be increasing at a rate of 24,710 acres per year (10,000 ha/year). Along with compaction and acidification, which are more prevalent in the humid regions of the country, it is reasonably safe to say that almost every hectare of agricultural land in Canada is subject to one form of soil degradation or another, at a cost, in my opinion, a very conservative estimate, of $800 million per year.

This is not to mention, of course, the actual effect of erosion on waterways which is equally as serious and also very costly. In one province of Canada alone, Ontario, it is estimated that the dollar cost of erosion on waterways, sedimentation of ditches, damage to inland lakes, reservoirs and channels, and so on, was over $100 million in 1984. The actual cost in terms of wildlife, physiological stress to fish by clopping their gills and increasing susceptibility to disease, or the chemical damage to aquatic life and habitats from herbicides, pesticides and fertilizers washed into the water resources, is incalculable.

The reaction of most Canadians to the soil problems that they read about in the newspaper, or to the blowing soils that they are shown periodically on television, is that "Well, it's a big country; even if these soils are damaged, there is always more land to bring into production." Maps can sometimes be misleading. Canada's total land area is 2.28 billion acres (922 million h), but only 7 percent of this is farmland, and less than 5 percent is under cultivation. "Prime" agricultural land represents only one-half of 1 percent of the country's area. "Dependable" land, not seriously constrained by climate or soil type, covers about 5 percent of the area. The remainder is either too far from markets or in areas that are not climatically suited to agriculture. Agricultural lands in Canada are finite! They do not go on forever and must be conserved to the best of our ability.

To date in Canada, a comprehensive national soil conservation policy has not been developed. This is, in part, due to the shared federal–provincial jurisdiction over agriculture, and the fact that, while the provinces have jurisdiction over natural resources, the federal government has the research capability. Most provinces do have programs that attempt to deal with local problems, some of them very successful. The federal government does have agreements with provinces to treat specific problems but there remains no full–scale national program.

As conservationists in your country are aware, such a program must be developed carefully, and must contain a number of elements. It must be site–specific, low–cost and cost–effective. It must also be designed to complement the knowledge and the expertise of the farmer, because it is not the bureaucrats and the scientists or the wildlife managers who can save the soil resource. It is the farmers with their closeness to and their understanding of the land who can and must.

These farmers do require the right information and, in some instances, financial assistance to make conservation an economically viable option for them. The use of soil conservation techniques and the removal of marginal lands from cultivation can both stop and prevent soil degradation and can go a long way to maintaining and restoring habitats for wildlife.

When the Senate Committee on Agriculture, Fisheries and Forestry held its hearings across the country during 1984 and subsequently at many other local meetings that I have addressed, the reaction has been the same: acknowledgment that problems do exist in their own region; surprise that similar problems exist elsewhere in the country; desire to do something about it; and frustration that the resources required aren't available.

Since the release of the Senate Committee's report, *Soil at Risk*, many more urban dwellers have become aware of the plight of Canadian agricultural lands. This has come about to some extent through media follow–up on the report and through a major effort on the part of the Committee to make the report available to schools and community groups. Because soil conservation is becoming an issue with the electorate, the federal and the provincial governments have become more positive in their approach towards soil conservation. I have to admit that it will take more time, and a greater effort, to address the wildlife issue in conjunction with soil conservation, as it deserves to be addressed.

One of the weaknesses of human nature is to be inward–looking, to see what matters directly to you and not beyond. I have mentioned that initially this was the attitude that the Senate Committee found in the different regions of Canada. Canadians now are beginning to realize that they need each of the parts of Canada to make up our country. All of Canada's land must be cared for and conserved. The same philosophy can be applied in a broader context. Each country must look after its own soils but we all have to look after the soils of the world as a whole. To allow one area to fall into a state of irretrievable degradation may not be catastrophic in itself but the possibility that this might happen again and again is frightening.

The watchworks of Soil Conservation Week in the United States for 1986 come from *Proverbs* 29:18: "Where there is no vision, the people will perish." I think that there can be no more important thought for us all as we go into this Conference.

USDA: Commitment to Conservation

James Spitz
Special Assistant to Assistant Secretary of Agriculture for Natural Resources and Environment
U.S. Department of Agriculture
Washington, D.C.

It is a pleasure to represent Peter Myers and the U.S. Department of Agriculture at this meeting. Peter regrets that he cannot be with you. He would have enjoyed the opportunity to speak with you, because he has a deep personal interest in wildlife management. Back in Missouri, he served as Commissioner of the Missouri Department of Conservation. Now in Washington, he's continuing to work for sound stewardship of our natural resources.

Perhaps the first thing I should do is tell you a little about myself. I've been with USDA for nearly 30 years. For most of that time, I worked for the Soil Conservation Service. It was there that I first had the opportunity to work with Peter Myers. Recently, I accepted the position of Deputy Director of Environmental Coordination for the U.S. Forest Service. I enjoyed my time with SCS, and I'm looking forward to working with the Forest Service. I feel very fortunate to have the opportunity to work with two of the finest agencies in the federal government and to work for something I believe in—resource conservation.

When Peter discovered that he couldn't be with you, he asked me to convey his thanks to the members of the wildlife conservation groups who worked so hard to make the Conservation Title of the 1985 Farm Bill a reality. Dan Poole and Larry Jahn are two individuals who certainly should be mentioned as prime movers in that effort. Your work *is* noticed and appreciated, and I think almost everyone agrees that your work was innovative and worth the effort.

The Conservation Title of the Food Security Act of 1985 is a prime example of a broad coalition of interests working together effectively. The legislation provides for measures that will not only provide erosion control but will also benefit wildlife habitat, improve water quality and establish woodlands. And the benefits accrue not only to farmers and ranchers, but broadly to the American people. Anytime you can achieve multiple–purpose soil and water benefits with one piece of legislation, there's been some real good politicking going on.

I don't believe we could have gotten the Conservation Title through Congress a couple of years ago. The fact that it did get through—and with near-unanimous support—is a tribute to the maturity of the environmental movement and to old–fashioned teamwork.

People think of the late 1960s and early 1970s as the heyday of the environmental movement. But we've grown since the time when headline–grabbing stunts were seen as a step forward. And we've grown past the point where spasmodic legislative efforts applied "cures" to our problems and often made matters worse. Now it seems that people of different interests and purposes are working together, finding areas of mutual concern and agreement, and devising sound proposals that will work when implemented.

While we deserve to celebrate our success in getting a good agriculture legislation package passed by Congress last year, we may need in the future to guard our collective zeal and support for some environmentally driven legislation that would put the federal government deeply into the land–use and regulation business—a role traditionally left to state and local governments. The management of public lands is one thing; management and regulation of private lands and private property rights are quite another. We in USDA will continue to work diligently to deliver broad program benefits to the public in the traditional sense. That includes the implementation of the new conservation authorities that complement our traditional programs.

I've mentioned a couple of points already that I'd like to examine in more detail. First, I mentioned that USDA, and Peter Myers as an Assistant Secretary, have a deep interest in wildlife conservation. A reasonable question is: "How has that interest been reflected?"

One of the ways that interest is reflected is that USDA adopted a Fish and Wildlife Policy that takes a back seat to no other agency in stating a commitment to enhancement of fish and wildlife habitat.

The United States has more than 2 billion acres of farm, forest and range lands, plus associated water and wetlands. These acres provide habitats for more than 3,000 species of birds, mammals, fishes, reptiles and amphibians.

USDA's Fish and Wildlife Policy states that it is our prime responsibility ". . . to help maintain sufficient and efficient production capability of farm, forest, water, and rangeland resources for the public benefit, now and in the future, *and to encourage and support proper use, management, and conservation of those natural resources*."

Now, how is that commitment to conservation of natural resources translated into an emphasis on fish and wildlife management? The regulation sets up a USDA Fisheries and Wildlife Issues Working Group with representatives from 10 USDA agencies, plus a representative from the Office of General Counsel and the Office of Budget, Planning and Analysis. This working group is cochaired by representatives from the Forest Service and Extension Service. This group works within USDA and with other government agencies to promote efforts beneficial to wildlife habitat enhancement.

I think it's important to note that this management direction applies Department–wide. It incorporates wildlife management into all USDA resource programs. It establishes as policy that agencies in USDA will recognize the economic, ecological, educational, recreational, scientific and aesthetic values of fish and wildlife, and that fish and wildlife habitat be enhanced, where possible, as the Department carries out its overall missions.

So, by adopting a strong policy, USDA has shown an understanding of and commitment to wildlife resource values. But, we believe commitment should be followed by action, and that brings me to the second point I'd like to talk about today—some of the efforts the Soil Conservation Service and Forest Service are involved with that benefit fish and wildlife habitats.

Three items of interest contained in last year's agriculture legislation that Peter Myers worked for—and many of you worked for—are the Conservation Reserve and two similar initiatives, the Sodbuster and Swampbuster efforts. The Conservation Reserve program is already up and running, and we're pleased with the response it's gotten from landowners.

As most of you probably know, the purpose of the Conservation Reserve is to provide an economic incentive to farmers to retire highly erodible lands from crop production for at least 10 years, and to stabilize the soil through planting of grass or trees.

Nationwide, we expect to enroll up to 45 million acres in the reserve during the period of 1986 through 1990. While this program is often thought of as simply a soil conservation effort, it is obvious that the land put in the reserve will enhance fish and wildlife habitats.

The Sodbuster and Swampbuster efforts are not yet operational. Implementing regulations are still being prepared on these two programs, but in a nutshell, these programs will withhold commodity program benefits from any landowner who breaks out grassland or drains wetland for crop production. A landowner can still do it, but will do so without government financial support for the commodities produced.

The legislative authority for the Secretary of Agriculture to take conservation easements on highly erodible cropland, wetlands and uplands is in the Credit Title of the new Farm Bill. Under this authority, the Secretary may take easements in exchange for Farmers Home Administration debt forgiveness. There is some interest in using this approach, but a pilot program may first be tried. Most of this land would be improved as wildlife habitat.

We think these approved programs will send a message to landowners that the USDA is not only involved in commodity production, but also promotes natural resource conservation in the broader sense. You will be hearing more about Sodbuster and Swampbuster, Conservation Compliance and Conservation Easements in the near future.

Another program that has gained a lot of attention and will continue to do so is the Forest Land Management Planning effort the Forest Service is conducting. The National Forest Management Act of 1976 directed the Forest Service to develop comprehensive land management plans that would provide for multiple use and sustained yield of forest resources and services. Wildlife and fish production and protection have long been part of the agency's multiple–use management of forest land, and the planning process provides an excellent opportunity to explore ways to improve wildlife and fish habitat management.

Aldo Leopold, in his book *Game Management,* made a point that I think is appropriate to a discussion of all long-range, natural resource management planning. He wrote: "The game manager . . . is playing a game of chess with nature. He but dimly sees the board, the men, or the rules. He can be sure of only two things: for intricacy and interest, any other game pales into insignificance; he must win if wildlife is to be restored."

So the task of planning long–range forest management, in which wildlife management is only one component, is a difficult job. Nevertheless, it is a necessary job that the Forest Service has approached with a large commitment of people, dollars and enthusiasm.

Eventually, the Forest Service will have 123 forest management plans covering all national forests. So far, 32 plans have gone through the entire process and have been issued as final plans, and 58 have been published in their draft version. Additionally, 16 draft plans have been reviewed by our Washington Office and will soon be sent out for review by the public.

When the plans are issued in draft form, the public and other government agencies are encouraged to comment on them. These comments are reviewed and considered as part of the preparation of the final plan. Even after that plan is published, the public has an opportunity to file appeals—although we always hope the public won't feel that is necessary.

Of the 32 plans published as final, the Forest Service has received 137 appeals. I think I should point out that many of those appeals concern wildlife management. This shows again that people interested in wildlife management are getting actively involved! Thirty-four of the 137 appeals have been resolved, so we're making good progress in developing and implementing comprehensive plans with a solid base of public support.

If any of you have been doing mental arithmetic, you know that there are 17 plans that are still in various stages of development. Most of those are in the Pacific Northwest. They have been delayed in order to allow for more in–depth study of the issue of wildlife requirements for old–growth habitat. This also underscores the importance of wildlife management in the Forest Land Management Planning process.

The Soil Conservation Service is also engaged in long–range analysis of its soil and water conservation programs as required by the Resource Conservation Act. Every five years, SCS inventories crop, range and pasture land under private ownership. A new appraisal is underway now that we hope will be completed by the end of this year. Assessing the wildlife habitat quantity and quality in rural America is getting a very hard look.

This morning I've mentioned only a few of the efforts by USDA to work for wildlife habitat enhancement. I've focused primarily on the Soil Conservation Service and the Forest Service because that's where my experience is. We in USDA are proud of our past accomplishments, but we also are well–aware that there is much more work that must and can be done. Because there is much more work to be done, we've assumed a leadership role in setting up and contributing to seminars where managing the land for viable wildlife populations is discussed.

I'd like to conclude with a statement made by Aldo Leopold in 1941 that still rings true today. He said, "The art of land-doctoring is being practiced with vigor, but the science of land-health is a job for the future."

Conferences such as this help to open doors to that future.

Needs and Opportunities for Outdoor Recreation

Victor H. Ashe
Executive Director
President's Commission on Americans Outdoors
Washington, D.C.

It is a pleasure to be with you here today. Last year, this Conference celebrated its 50th anniversary as the principal forum for advances in wildlife management in North America. Your half–century of success plays a major role in what Americans do out of doors. Already, only a few months into the work of the President's Commission on American Outdoors, it is clear that millions of Americans spell recreation "f-i-s-h" and "w-i-l-d-l-i-f-e."

Between 1955, when the U.S. Fish and Wildlife Service conducted the first National Survey of Hunting and Fishing, and the last such survey in 1980, the numbers of American fishermen doubled, and the ranks of hunters grew by half. Ninety-three million people actively took part in some form of nonconsumptive recreation based on wildlife and fish by 1980. This increased interest was reflected in total annual expenditures for fish and wildlife recreation, which rose by nearly 10 times, from $2.8 billion to over $27 billion. No matter how you slice the American pie, hunting, fishing and nonconsumptive uses of fish and wildlife are significant recreational activities. Wildlife–based recreation provides vocations for thousands, needed and relaxing avocations for millions, and it makes enormous contributions to our nation's economy.

It is clear that we must have diverse and productive lands, waters and wildlife. Diversity of plants and animals is a foundation for outstanding recreational experiences. When Aldo Leopold spoke of a land ethic, of harmony between man and the land, and stewardship of the plants and animals with which we share this earth, he could just as well have been talking about a philosophy for recreation as for conservation.

With that introduction, let me give you a glimpse into the mission and activities of the Commission.

Need for the President's Commission On Americans Outdoors

The national Outdoor Recreation Resources Review Commission (ORRRC) chaired by Laurance Rockefeller made its report in 1962, 24 years ago. The Rockefeller Commission recommendations shaped outdoor recreation programs for two decades. Many of the most cherished achievements of the past 25 years in recreation were the result of, or had major influences from that report, including:

- The Land and Water Conservation Fund
- The Bureau of Outdoor Recreation
- The Nationwide Outdoor Recreation Plan
- The National Wilderness Preservation System
- The Wild and Scenic Rivers System
- The National Park Concessioners Act, and

- The National Trails System.

Great changes have occurred in outdoor recreation since 1962. For example, the Rockefeller Commission projected large increases in recreational use days by the year 2000, but their projections were surpassed in 1983, some 17 years ahead of schedule. Participation in bicycling and camping grew fivefold; skiing is up, boating has doubled and fishing is now the number two water–based outdoor recreation activity, behind swimming. Activities virtually unknown in 1960, such as rock–climbing, white water rafting, snowmobiling, mountain cycling and winsdsurfing, now attract millions of people.

The land and water resources available for recreation have changed dramatically also, but the changes do not show the same increasing trends we find in use. Take wetlands for example. By 1970, less than half of our country's original wetlands remained. In just one generation, between 1950 and 1970, 9 million acres were converted to other uses. That's an area equal to two states the size of New Jersey. Testimony and papers presented to the President's Commission prominently feature problems that result from the loss of lands and waters available for recreation.

Total land open for recreation has remained nearly constant, but only by the infusion of billions of dollars so that governments could acquire lands to offset conversions from wildland. Much of those monies came directly from excise taxes paid by hunters and fishermen and from the Land and Water Conservation Fund. This land acquisition may not continue. Testimony to the Commission indicates that, today, public recreation program budgets are in jeopardy at all levels of government.

There have also been dramatic changes in who provides recreation. Businesses and nonprofit groups now offer more than two–thirds of all outdoor recreation opportunities. The private sector could do even more with better economic incentives and government cooperation, instead of government regulation. There seems to be a major opportunity to increase recreation supplies if we reverse the trends of poor coordination and frequent conflict between public and private sectors.

It is a time for new ideas, new incentives, new strategies and vital new partnerships for outdoor recreation. We cannot afford the polarization between interest groups that has marked the past. And we cannot afford to assume that government should be the principal provider. We need people from all interests and from both public and private sectors to cooperate in providing the widest variety of affordable recreation to the American people. If we sit still while other economic and political forces shape our land and water policies, there probably will be a decline in both quality and quantity of recreation, and that bodes ill for wildlife and fish habitat as well.

The Commission

The scope of a new commission's work was considered by a private study organized in 1982 by Laurance Rockefeller. Rockefeller's study team included current Commissioners Sheldon Coleman of lantern and campstove fame, and Patrick Noonan of the Conservation Fund and a past–president of The Nature Conservancy. It also included William Penn Mott, currently Director of the National Park Service. Their study recommended creation of a new commission on outdoor recreation. President Reagan appointed the current Commission in 1985, after the U.S. Senate voted unanimous approval of the idea and the House showed heavy support.

Structure of the Commission

The Commission is a 15–member panel chaired by Governor Lamar Alexander of Tennessee. Gilbert Grosvenor, president of the National Geographic Society, is Vice–Chairman. The members possess a broad range of experience and represent a full spectrum of interests, both public and private, regarding outdoor recreation. A staff of about 20 senior experts in fields related to recreation and related professions has been assembled to support the work of the Commission, including at least four people with extensive fish and wildlife backgrounds.

Hearings and workshops are being held across the country through June 1986. The hearing chaired by Congresswoman Barbara Vucanovich here yesterday focused specifically on fish– and wildlife–oriented recreation, its trends, funding, and management. The Commission has requested concept papers, option papers and other essays from literally hundreds of experts on various topics related to outdoor recreation. I am sure many of you in this audience are involved in one or more of these efforts. Commissioners will soon have the results of a large–sample national poll conducted by Market Opinion Research, underwritten by the National Geographic Society. The information and ideas gleaned from the hearings, meetings and papers will form background documentation for what will emerge as recommendations for national policies and programs.

Some of the Early Issues Relating to Wildlife and Fish

In the half–dozen hearings and meetings so far, Commissioners have heard outstanding examples of innovative problem–solving from businesses and government, both local and national.

Two common themes have emerged in early hearings, workshops and brainstorming sessions. One is the need for more effective partnerships. The other is a need for more–effective ways to make recreation opportunities available to Americans.

Three important wildlife and fish issues are commonly discussed: (1) how to find money for more recreation opportunities; (2) how to remove barriers to availability and access; and (3) how to use market forces to help government achieve appropriate balance for recreation among the many competing uses of our lands and waters.

Here is a sample of what we have heard. These are not findings or recommendations of the Commission. They are merely a peek at what people are telling us.

Paying for Recreation Opportunities

Two ideas seem to dominate the issue of how to pay for the production of recreation supplies. First, many witnesses urge continued support for something like the Land and Water Conservation Fund. Several options have been suggested, including a true trust fund endowed through a combination of public and private endeavors. Commissioners have heard suggestions to use the fund both for acquisition, the original purpose of the Land and Water Conservation Fund, and to operate and maintain recreation lands and facilities.

Second, Commissioners hear a lot of argument for more reliance on direct payment for recreational activities by the people who use the resources—user fees, if you will. Payments to private landowners for hunting and fishing have made a big difference in profits on forests and ranches and resulted in better habitat management.

Arguments have been made on all sides of the funding issue. It does appear, however, that traditional ways of funding will change. How often we hear comments such as, "There's no free lunch," and "If it pays, it stays."

Availability and Access: Liability, Trespass, Vandalism

Liability insurance as an issue in availability and access to recreation was not something Commissioners expected to be high on the agenda. But insurance problems have been cited in probably more testimony than has the Land and Water Conservation Fund. Liability is a problem for outfitters and guides on public lands, too. Commissioners are not certain how to address these problems from a national policy level, but at least a documentation of their effect on recreation is in order. It may be a major issue for resolution at the state level. And, it may be that the problem will be resolved in other forums before the Commission completes its work. A proposal of the Council on Domestic Policy to resolve the liability problem was made to President Reagan a week ago, on March 17.

At a recent workshop on recreation on private lands, the Commission heard that the inability to control trespass and vandalism is a major deterrent to owners who might open their lands for recreation. These issues affect not only private lands east of the Mississippi, but also public lands in the West. There, some public lands are islands in privately owned areas, with access only by helicopter or permission of the other lands' owners.

Access issues—liability and trespass among them—are important to wildlife– and fish–based recreation. Private citizens own more than two–thirds of the land in the U.S. About 1.5 billion acres are in crop, forest and pasture/range production. These lands have tremendous potentials for supplying recreational opportunities based on wildlife and fish, and outstanding chances to contribute to biological diversity and environmental quality. If the owners cannot afford to open the lands for people to use, and if those landowners thereby lose more money, then wildlife and fish will lose as much as the recreation–oriented American public.

But the President's Commission hears that private lands are increasingly posted, and that ranch hunting operations close down because of the cost of liability insurance or property damage. The Wildlife Management Institute worked diligently on the new provision for conservation reserves in the 1985 Farm Bill. This legislation could make as much as 40 million acres of land productive and available for fish and wildlife recreation. Can we afford to let slip away the opportunity to provide recreation on diverse and productive private lands, or to fall back on the 750 million–acre federal estate? I think not.

Increasing Use of Market Forces to Augment the Role of Governments

Finally, I need to mention the recurring testimony the President's Commission receives on the value of fish and wildlife recreation and how effective market forces can be to ensure that recreation opportunities are provided, as opposed to government regulation. Just yesterday we heard evidence of how the marketing of hunting and fishing changes land uses in favor of fish and wildlife. At a Commission–sponsored private lands workshop in Washington on March 10, a fellow with many years of experience in land–use planning told us he could travel across the country and not tell any difference in land uses as a result of government land–use planning. He claimed the differences were largely a reflection of market forces—the idea that if it pays, it stays. Another fellow told us the market has failed to allocate recreation fairly. Well, has it really failed? Or have we just failed to give the market a chance? For example, Wyoming is aggressively marketing its wildlife and tourism recreation. We hear of ranchers and forest managers who increasingly turn their practices to produce hunting and fishing recreation, because recreation pays better than do cows and trees. People get more recreational opportunities as a benefit of this trend, and wildlife and fish get more habitat. Is this a market failure?

On another side of the question, a western rancher explained how habitat improvements have led to efforts by state and federal governments to impose their land–use zones, because once–poor wildlife habitats are now productive of waterfowl and bald eagles. How many landowners will improve their lands to provide recreation if they see increased government regulation as the payoff?

When it comes to new ideas and the need for change, perhaps it is time to shift from a policy of governments bearing the principal load of providing recreation, to a new policy of shared responsibility between private and public sectors. Can you give the Commission evidence that cooperative ventures between private and public groups can be effective? How many of you in government are working on projects to provide more recreation opportunities, in cooperation with Trout Unlimited, Ducks Unlimited, the National Wild Turkey Federation, the Rocky Mountain Elk Foundation or the National Wildlife Federation? Partnerships and joint ventures may turn out to be one of the major strategies recommended by the Commission.

Summary

Of course, many other issues surface before the Commission. It is not possible at this time for me to tell you what will be the major themes of the Commission's recommendations. Perhaps some of what I have mentioned this morning will be there; perhaps none of it will. Of one thing, however, we are certain. In December of this year, when the Commission's work ends, your work continues. The Commission will document and recommend new policies. But it will be up to you, your agencies, your organizations and your governments to put into action those recommendations you favor.

Recommendations of the President's Commission on Americans Outdoors may require congressional action. People like you will have to convince your Congressmen of the value of those proposals. Some of the recommendations may require state action, or local action. Your efforts will be even more important there.

If you have ideas and suggestions that would be useful to the Commission, I urge you to get them to us. We have distributed our concept paper format at this conference. Please share it with your colleagues. Come to hearings and meetings in your area and be heard. When the Commissioners report their recommendations to President Reagan and the nation, get to work and make it happen. But, if I may paraphrase Yogi Berra, remember "it ain't over till it's over" on your ground. Even the best of recommendations doesn't work until put into action.

Wildlife and fish are major resources in the picture of Americans outdoors. There is every evidence that they will play an ever–increasing role. It is also clear that traditional methods of paying for and providing wildlife– and fish–based recreation opportunities are changing. You may sit back and watch those changes occur or you can pitch in and help shape them to be fair and effective.

The Commission needs and solicits your help to describe innovative ways to put wildlife and fish recreation in the driver's seat of land management. I am positive that you can help us show how environmental quality, biological diversity, productive wildlife and fish populations, and diversity of recreation are all just facets of the same land ethic, and I urge you to do so.

Strengthening Migratory Bird Management Programs

James H. Patterson
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North Americans can be proud of the tremendous conservation efforts that have been made on behalf of migratory birds by thousands of individuals, numerous private conservation organizations, and the state, provincial, territorial and federal governments. Despite these accomplishments, the North American conservation community faces a major challenge if we are to maintain a diverse and abundant migratory bird resource for the enjoyment of future generations.

The continued loss and degradation of wetland habitat across the continent are adversely affecting a number of migratory bird populations. At the same time, a number of conflicts over the use and enjoyment of migratory birds remains to be resolved.

Clearly, if migratory bird management programs are to be strengthened to maintain our migratory bird heritage, much greater efforts will be required in research, management and habitat protection programs. The need to strengthen migratory bird programs comes at a time when all levels of government are facing substantial fiscal difficulties. In an effort to lower public deficits, governments are likely to reduce expenditures from their treasuries, and not provide additional resources for program expansions.

Identifying the need for strengthening migratory bird management programs at a time of fiscal restraint may seem incongruous. However, I believe that we have a window of opportunity to make substantial advances in strengthening migratory bird programs and benefit the migratory bird resource. In my opinion, the keys to taking advantage of this window of opportunity will be: (1) strengthening the partnerships of all vested interest groups to work towards common objectives; and (2) developing entrepreneurial leadership to generate new resources and new approaches of implementing cooperative programs.

Building partnerships from divergent interest groups is, in itself, a major challenge. In essence, it represents a tug of war between principles and objectives. If divergent interest groups focus their discussion on points of principle, the approach is often defensive and has little chance of resolution. Conversely, if divergent interest groups work towards defining common objectives, there is often a surprising degree of commonality and a relatively good chance of reaching resolution.

Examples and Challenges

Every nation is famous for certain characteristics, and Canada is no exception. One of our favorite pastimes seems to be to engage in endless debates on whether an issue is a federal or provincial responsibility. There are as many views in Canada on the roles and responsibilities of the federal, provincial and territorial governments for migratory birds as there are jurisdictions. It is perhaps for this reason that it took seven years for Canada to finalize and endorse a Canadian Waterfowl Management Plan and develop a position for discussing a North American Waterfowl Management Plan with the United States. On reflection, more than 90 percent of the progress made in Canada occurred in the last year of this seven–year period. A major reason for this was the recognition by all of the players that the provinces, territories and the federal government were full partners in migratory bird conservation. Instead of debating points of principle, wildlife agencies were able productively to address and develop common objectives. This dialogue was not confined to the biologists and managers responsible for wildlife. At each step along the way, wildlife ministers from the provinces, territories and the federal government were involved. As a result, the final Canadian Position on the Canadian and North American Waterfowl Management Plan received unanimous political endorsement by all Canadian jurisdictions.

Although this process was lengthy and had many unexpected challenges, it has resulted in immeasurable benefits to migratory bird management in Canada. Migratory bird management is a subject that is now discussed commonly between wildlife ministers and within respective Cabinets. There is a new political awareness and commitment to migratory bird conservation. For example, the federal Cabinet has endorsed in principle the North American Waterfowl Management Plan and given the Minister of Environment authority to sign the Plan on behalf of Canada. Similarly, the Saskatchewan Cabinet has endorsed the Plan and, in fact, has provided full funding for Saskatchewan to finance its part of implementing the joint ventures called for in the Plan.

I believe it is fair to say that the progress made in Canada is a direct result of all of the responsible agencies working together as full and equal partners. To ensure that this partnership continues, the Canadian Waterfowl Advisory Council will be created in 1986 with the responsibility of planning and coordinating migratory bird management programs across Canada.

Canada and the United States have a long history of working closely and cooperatively in continental migratory bird management. There has been a number of developments in recent years, however, that has strengthened this relationship substantially. In the mid-1970s, there was considerable debate in waterfowl management circles over the impact of harvest on waterfowl populations. The debate probably centered more on regional perspectives than national perspectives, but it did contribute to a certain degree of divisiveness in continental waterfowl management. It was in this context that the two countries undertook to stabilize waterfowl regulations for a five–year period and implement cooperative research and monitoring programs to evaluate more objectively the impact of harvest on populations. I think we would all agree on the value of this cooperative effort, which has as its common objective to develop a greater understanding of the relationship of harvest on waterfowl population dynamics.

The development of the North American Waterfowl Management Plan has again been the result of a full partnership of states, provinces, territories and federal wildlife agencies. I was privileged to be part of the steering committee that produced the Plan. I found it to be an educational and enlightening experience. The committee was made up of a very diverse group of dedicated wildlife professionals who, over time, developed an understanding for the different perspectives and points of view on continental waterfowl management. As this understanding developed, any fundamental differences of principle disappeared and the group was able to make rapid progress in developing a common set of objectives. This degree of cooperation will continue with the creation of the North American Waterfowl Management Plan that will coordinate the implementation of the Plan in North America. Hopefully Mexico will be able to join this undertaking soon, to make it a truly North American partnership.

The magnitude of the task before us to strengthen migratory bird management in North America is greater than the capability of any agency, sector or country. Objectives will only be reached if all agencies and sectors combine their resources in a collective effort. I am optimistic that the North American conservation community will join forces and meet this challenge.

Progress to date in Canada has been the result of not only full cooperation by government wildlife agencies but the close involvement and partnerships of a broad spectrum of nongovernmental organizations. In fact, sportsmen and naturalist conservation organizations have formed the National Habitat Coalition. This focus of a wide range of conservation interests has been instrumental in the development of the Wildlife Habitat Canada Foundation, the development of multisector wetland–protection initiatives such as the Heritage Marsh Agreements, and development of the North American Waterfowl Management Plan.

The North American Plan calls for implementation of joint ventures to undertake major habitat and waterfowl conservation initiatives. These ventures will be planned and managed by all vested interest groups who are able to contribute to their implementation.

Agricultural land–use practices contribute to the most substantial wildlife habitat problem in both Canada and the United States. In Canada, wildlife and agricultural interests have traditionally been at odds. However, as we heard earlier in the program from Senator Sparrow, there is a tremendous opportunity to work cooperatively with the agricultural sector in addressing soil and water conservation issues. This opportunity has led to the creation of an Agriculture/Wildlife Task Force in Canada to identify areas of common interest in working cooperatively to address soil, water and wetland conservation initiatives. The potential impact of the North American Waterfowl Management Plan on the protection and enhancement of wetland habitat complexes will depend to a large degree on the ability of agriculture and wildlife to work together for wise soil and water conservation. I would urge you to read *Soil at Risk,* handed out by Senator Sparrow. The recommendations in this Senate report to achieve soil and water conservation objectives are very similar to those contained in the North American Waterfowl Management Plan.

Last but definitely not least, we in the North American migratory bird conservation community have the opportunity to develop partnerships with northern subsistence users of the resource. Northern Canada is undergoing rapid political and social evolution. Particularly in the Northwest Territories, native people represent the majority of the population and of the legislative assembly. Native people in northern Canada have a very strong and traditional vested interest in the migratory bird resource. They will have more and more of a role in resource management decisions that will affect the protection and enhancement of habitats which are critical to migratory birds. It is in the collective interest of everyone to bring northern subsistence users into the partnership of continental migratory bird conservation and find ways of providing them legitimate and legal access to migratory birds. We can work together for continental migratory bird conservation, which is the desire of native people, or promote a situation where resource management decisions are made by the courts, or non–wildlife negotiators.

Building new partnerships of the various groups that have a vested interest in migratory birds will not be easy. It requires an open mind and an ability to objectively deal with different points of view and work towards common objectives.

If we are able to build partnerships of all of the vested interest groups and work with an entrepreneurial spirit of accommodating different points of view, generating new sources of revenue and developing new innovative ways of achieving objectives, I am optimistic that we can not only strengthen migratory bird management programs but maintain and enhance the migratory bird resource that we share.

Strengthening Migratory Bird Management Programs

Ronald E. Lambertson
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Washington, D.C.

It is a pleasure to be here today to represent the Fish and Wildlife Service and to address this timely and important topic, "Strengthening Migratory Bird Management Programs."

The waterfowl scenario across this continent is one for concern and for opportunity. From western Alaska to the Maritime Provinces to the Mississippi Bottomland Hardwoods and almost everywhere in between, we can find at least one, and often several, species facing serious population declines. Our concern in the Fish and Wildlife Service was reflected in the targeted 25 percent reduction in harvest this past waterfowl hunting season. It was an unusual, even extraordinary measure—but we felt then, and know now, that it was the right move. But as we all realize, the harvest situation represents just a symptom of a more serious malady—the widespread loss of suitable waterfowl habitat, both on the breeding and the wintering grounds.

As the waterfowl surveys of 1985 indicated, we recorded the lowest breeding population since the annual observations were started 30 years ago. The 1985 annual fall flight forecast was 22 percent lower than that of 1984. Mallard and pintail numbers were especially cause for concern throughout much of the country.

While the Service's responsibilities encompass the entire range of migratory birds, from nongame and webless through waterfowl, I will direct most of my remarks today to waterfowl issues. And I would like to focus now on several of the most important waterfowl-related problems facing us and tell you what we are doing to seek solutions.

First, there remains the serious problem of declining goose populations in Alaska, especially in the Yukon–Kuskokwim Delta. Cackling Canada geese plummeted 94 percent, from the 1965 estimate of 350,000 to about 22,000 in 1984. Pacific white–fronted geese fell 78 percent, from 450,000 in late 1967 to the 1984 count of just over 100,000. There are also marked decreases in black brant and Dusky Canada geese. Habitat loss in the lower 48 states and increased predation on breeding grounds are factors contributing to these declines. But most observers agree the main factors for cacklers, white–fronted geese and brant are overharvest by sport and subsistence hunting.

The situation has become more complex since a Federal District Court Judge ruled in January that, according to the Game Act of 1925, these birds could be taken for subsistence use since that 1925 Act superceded the Migratory Bird Treaty Act in Alaska. This decision took the conservation community somewhat by surprise. While it appears to represent a serious setback to the combined harvest reduction initiatives of the Fish and Wildlife Service and others, we believe progress in cutting back on the take is possible. We believe that attitudes on the delta are changing and that increasing numbers of subsistence hunters recognize what is right and will voluntarily reduce their take. We are also developing regulations that can be applied to maintain the management regimen needed in Alaska in the delta if the situation continues to worsen. And we will use this approach if need be. In the meantime, through the Yukon–Kuskokwim Delta Goose Management Plan, we will continue to work cooperatively with the people in the delta to discourage spring harvest and egg taking.

For waterfowl, the greatest threat at present is the continuing loss or degradation of wetland habitats. The half million acres we acquired during the first half of this decade represent lands and waters "saved," if you will, from the dredgeline, bulldozer and drainpipe. But in that same period of time, nearly five times that amount of wetland habitat were converted to agricultural fields, shopping malls, parking lots and suburban developments. While progress has been achieved in apprising the public of the great value of wetlands, we are still witnessing intense market pressures throughout the country to drain and convert these lands to other uses. And the American public, it seems, has yet to reconcile its growing concern for wetland preservation with its abiding fascination for bigger and better suburbs and its hunger for more and more land under cultivation.

Faced with this continuing dilemma, resource agencies will have to continue their efforts at public education, though this approach alone will not ensure immediate wetland protection. We must concern ourselves not only with the quantity of wetlands but also the quality of those currently under management.

While much attention has been accorded to the toxicology of lead shot as a cause of waterfowl mortality, there is a growing concern that other man-made and natural contaminants may also pose serious, long–term threats to the integrity of our national wildlife refuges and the migratory birds that use them.

During the past few years, evidence has come to light clearly linking deaths and birth deformities in grebes, coots and shorebirds to elevated selenium levels. The situation that unfolded at the Kesterson National Wildlife Refuge in California's Central Valley serves as a warning that a comprehensive understanding of the ecological linkages must be developed. As wildlife professionals, we must be seriously concerned about the implications that a Kesterson can suggest and scrupulously committed to discovering what these linkages may be.

We are, in a very real way, only at the threshold of discovery concerning natural trace elements and some manmade chemicals and their effects on natural ecosystems. We cannot and should not expect certitude in our work for some time to come. But when the findings are consistent, replicable and irrefutable, we will act in the best interests of the migratory bird resource.

We are proceeding with a far–reaching, on–going study to assess the degree of contamination on our national wildlife refuges. Our first report, issued in January, shows that Kesterson is unique, but several other refuges will require more study to define further the potential for adverse contaminant impacts on fish and wildlife.

Lastly, with regard to the problems waterfowl and other migratory birds face, I think it's important and appropriate to discuss a matter that's very much on everyone's mind: the current Federal fiscal picture. Obviously, conservationists have expressed great interest lately over the effects of Gramm–Rudman–Hollings on Federal conservation programs. The Fish and Wildlife Service on March 1 effected a 4.3 percent across–the–board budget cut in accord with this Deficit Control Act. No one knows, of course, but mandated reductions for fiscal year 1987 could be greater.

While these cuts are of concern to the conservation community, they should be viewed in perspective and in an overall budget context. The Fish and Wildlife Service has been rather fortunate in advancing its waterfowl habitat–acquisition goals in recent years. During the period from 1981 to 1985, for example, $109.2 million was obligated from the Migratory Bird Conservation Account to acquire more than 235,000 acres of important habitat. During the same period, $166.6 million from the Land and Water Conservation Fund (LWCF) was used to acquire more than 160,000 acres of other valuable lands for national wildlife refuges. Also during that time, we received donated lands totalling more than 138,000 acres. This fiscal year, $28 million in Migratory Bird Conservation funds and more than $70 million from LWCF are available to continue these acquisitions.

If the price of the duck stamp is increased—as has been proposed—from its current $7.50 to $10.00, the Service anticipates at least $16.5 million in duck stamp receipts for land acquisition. This $16.5 million would represent potential wetlands purchases of about 25,000 acres. As I'm sure most of you know, the Administration has requested for fiscal year 1987 no funds for new land acquisition from either the LWCF or the Migratory Bird Conservation loan advance, but did request $1.5 million to administer on–going acquisitions.

Some quick calculating will show that for the preceding five years, Fish and Wildlife Service acquisitions were averaging more than 105,000 acres per year. Now, FY '87 presents the probability of only 25,000 acres—not counting potential land donations. While this shouldn't be construed as our preferred alternative, we can nevertheless find this situation workable—especially when we stop to consider the tremendous potential for waterfowl habitat protection afforded by the recently enacted Farm Bill. I'll mention more about our cooperative plans with USDA a little later on when I address some of the pluses of our waterfowl picture. For now, it is sufficient to note that proposed cutbacks in land acquisition could be materially offset by some significant strides on the agricultural front.

Despite the fiscal contraints I've just outlined, we have been working hard within the Fish and Wildlife Service to strengthen our migratory bird management efforts across the board. We have been able to increase our technical staff in the Office of Migratory Bird Management to better meet our national and international responsibilities for conducting population surveys and analyzing and interpreting data for use with the Flyway Councils to negotiate harvest, and to meet the growing challenges of improved nongame migratory bird management. We are working toward new initiatives in research for the next several years—on disease, intensive management of breeding habitats, waterfowl mortality, and continuing refinement of survey techniques. We have instituted more–intensive management on Service lands to increase production, and are making a major effort to work directly with USDA and the states in implementation of the new Farm Act conservation initiatives.

As I said, the Fish and Wildlife Service is committed to strengthening migratory bird management activities. The task is enormous, however, and we will be asking for more support and direct involvement by states and the private sector.

Fortunately, our waterfowl situation presents us with more than just problems. I would like to touch briefly on a few areas that offer real promise for bolstering our overall waterfowl management agenda.

First, we can point to the draft North American Waterfowl Management Plan as an important document—a blueprint if you will—that signifies the concensus that has been achieved to date in addressing long-term waterfowl needs, with a special focus on habitat. We have not yet scheduled a formal signing ceremony with Canada, since a number of procedural issues are yet to be worked out back in Washington, D.C., but all associated with the Plan are hopeful that it can be expedited—perhaps signing can yet be scheduled this spring. Once the Plan is signed, we will have a formal international document to guide us in our effort to conserve and restore the migratory bird resource.

In addition to the North American Waterfowl Management Plan, the Service has been active in several other international undertakings that merit reference here.

- Last September, the U.S. joined Canada as a signatory to the Convention on Wetlands of International Importance—recognizing, as a nation, both the value of these habitats and the need for international coordination in their protection.
- During the past year, a study of Nearctic avian migrants was completed along with an inventory of Latin American wetlands to match migratory species with specific habitat needs—enhancing our knowledge and bringing focus to technical assistance in the region.
- Recognizing the importance of the wintering habitat needs of North American waterfowl that migrate south of the border, the Service continued its special training efforts with Latin American countries. The head of every mainland wildlife department in Latin America has now received this training.

A second bright spot is our emerging Wetlands Policy. Soon to be released for public review and comment, the Wetlands Policy for the first time articulates the Interior Department's responsibilities in identifying and conserving wetland habitats. It also integrates wetland preservation into the Department's broad array of water policies and programs. Needless to say, your review and input into this document are vitally important.

As noted earlier, the proposed Administration budget for '87 does not call for a large wetland acquisition program. But in recent weeks, we have seen the renewal of efforts in Washington to resuscitate the Emergency Wetlands Resources Act. One provision offered in the proposed act would transfer $75 million per year for 10 years from the LWCF for wetland efforts. In the recent past, this section did not enjoy Administration support. A variation on this proposal, however, is being discussed. It would allow States receiving LWCF funds the option to dedicate a portion to State wetland efforts. Interestingly, this approach would accord wetlands recreational values commensurate with tennis courts, swimming pools and other such facilities that enjoy LWCF support.

Another point that should be emphasized is that our 1987 budget request does reflect our commitment to increase our waterfowl effort. We are seeking an additional $5.1 million to assist in the restoration of waterfowl numbers through increased production on Service management areas. In addition, we are also going to expand our research into mortality factors not associated with waterfowl hunting and that may be offset by altered habitat management practices.

The third area that shows tremendous promise is the new Farm Act. It is, quite simply, one of the most important conservation achievements in recent years, and I think praise and esteem are due to Peter Myers and his colleagues at USDA. The Act's potential will demand long, hard and commited effort on our part, on the part of USDA, state agencies and all the conservation community. At perhaps no other time since the 1930s have we found our interests and those of agriculture so closely meshed. We cannot save and restore waterfowl without a stable habitat base, and we recognize that even larger acreages of upland habitat adjacent to wetlands must be managed properly to sustain the desired benefits, especially for waterfowl. Agriculture cannot restore economic stability to American farming until a more desirable balance is achieved between production and available markets. The current time represents a period of unique opportunity to work productively with the entire agricultural community, from the top leadership of USDA and the Congress, to the economically beset landowner who needs creative assistance to save his land and the integrity of his family's way of life.

We have had several productive meetings and communications thus far with the Department of Agriculture and hope to have many more to address the whole array of mutual interests under the new Farm Act. We are seeking a cooperative effort between the Service and the Farmers Home Administration (FmHA) to assess lands currently on that agency's inventory, and to provide for lasting protection of those possessing high fish and wildlife values.

Lands currently on FmHA inventory list total approximately 1 million acres. We are working with FmHA to determine if the Service and respective state fish and wildlife agencies could survey these lands for possible addition to the National Wildlife Refuge System or State Wildlife Management Area Systems. We will be focusing on lands of marginal value to agriculture in this effort.

The Farm Debt Restructure Provision of the Act authorizes the Secretary of Agriculture, in consultation with the Service, to acquire not less than 50–year conservation easements from farmers unable to repay FmHA loans. Again, the focus would be to select marginal lands, particularly those with wetland restoration potential for inclusion in the program. The easement areas could be administered by the Service, state and/or local government officials, conservation organizations or other entities determined suitable. We see the conservation easement program as having the potential to provide significant wetland restoration benefits.

Perhaps no group of species has suffered habitat loss as severely in the last two decades as upland wildlife in the intensively farmed cornbelt. Many of these populations have declined from 40 to 90 percent in the last 20 to 25 years. The provisions of the 1985 Farm Bill may offer a once–in–a–lifetime opportunity to reverse these trends.

The Sodbuster provision will deny certain federal subsidies to farmers who convert fragile lands to crop production. This will safeguard upland habitat and prevent increases in siltation of wetlands. A companion provision, the Swampbuster, will deny subsidies to farmers who drain wetlands. Swampbuster, along with the Corps of Engineers' 404 permit program, could become one of our most valuable programs for conserving wetlands. And another Farm Act provision, The Conservation Reserve, if fully funded, will convert 45 million acres of erodible cropland to wildlife habitat and could reduce sedimentation by more than 23 percent.

From a conservationist's perspective, these provisions signal some of the most potentially significant land protection measures enacted in the past half–century.

A fourth plus in the overall migratory bird picture is increased citizen involvement. A case in point is the President's Commission on Americans Outdoors, meeting here today in this very hotel as part of its continuing process of hearings around the country to assess the public's perceptions about our nation's needs in outdoor recreation for the years ahead. Wildlife–related recreational issues are very much on the Commission's agenda. This is partly due to the Commission's desire to address this topic, but it also reflects growing public interest in seeing this issue placed in the front rank of outdoor recreational concerns as we approach the 21st century.

For us within the Interior Department, citizen involvement in natural resource protection has been revitalized and refocused in Secretary Don Hodel's "Take Pride in America" initiative. Last year when he was asked at a Senate hearing how more protection could be extended to our public lands to safeguard them from vandalism, theft and other abuses, Secretary Hodel responded by saying there was in fact no way to really protect 700 million acres of America if 240 million American citizens didn't care. As the Secretary later explained, he felt that his reply was honest and that it was correct—yet he himself did not consider it satisfactory. The key issue was caring. Most citizens, he has noted, do care and care very deeply about protection and conservation of our public lands—federal, state and local. Thus, Secretary Hodel arrived at this solution: Why not appeal to the good citizens and afford them the chance to do something worthwhile for this country? Take Pride in America is not just a Department of the Interior program. USDA, the Corps of Engineers and the Department of Education are also actively involved. The goal is to stimulate greater citizen awareness of and active involvement in the protection of publicly held resources.

Although there will be a national Take Pride media campaign mounted by the Advertising Council of America, Take Pride in America will not represent a big spending program. In an era of Gramm–Rudman–Hollings, we're simply not going to have the money to start a vast array of new local-level resource programs. But, as the Secretary noted, money is less important in an endeavor such as this than is attitude.

We have a great opportunity in the Take Pride effort to help people remind themselves to protect, respect and safeguard the fish and wildlife resources we all share.

The fifth and final asset I see in our endeavor to strengthen waterfowl management is not new. In fact, it's been around for quite some time, but should never be regarded as "old hat." I'm speaking of the Pittman–Robertson/Federal Aid in Wildlife Restoration Act, or simply P–R as most of us know it.

Pittman–Robertson has been both a cornerstone and a keystone to modern wildlife management, yet it is largely unknown by the public and frequently taken for granted by the professional wildlife community, sportsmen and the supporting industries. That is why we are utilizing the upcoming 50th anniversary to increase public awareness about what P–R has accomplished. Our objective here is not to glorify the program *per se,* rather we see it as an ideal vehicle to reiterate the timeless message of conservation—wise use of our resources—that is at the very heart of our collective struggle to protect and enhance American wildlife.

Pittman–Robertson is not only viable after 50 years and continues to save wildlife habitat, it also serves to remind us that conservationists have faced difficult times before. And out of times of scarcity and adversity there can emerge a fresh, creative approach that will yield benefits for decades to come.

Effectiveness—The Hallmark of the Natural Resource Management Professional[1]

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Prologue

What I have to say here is, I believe, germane to all the natural resource management professions. It is, however, written from the perspective of a wildlife biologist talking to other wildlife biologists.

Wildlife Biologists—Where Are We Coming From?

Some 25 years ago, I was working for the Texas Game and Fish Commission when a young biologist with the ink drying on his diploma came to work under my supervision. At the end of his first day, spent clearing brush from deer census lines, he exuberantly remarked, "Four years ago I couldn't even spell wildlife biologist and here I are one." We laughed at his joke and shared his joy.

Later, as we sat by the fire and talked late into the night, it became clear to me that he did not have a vocation. He exhibited an overwhelming concentration on *his* dreams, *his* needs, *his* desires. The new job was merely a means to those ends. He had not recognized that this new job was work the world needed to have done.

Maturity brought that recognition. A job evolved into a vocation. With vocation came self–imposed obligations: to grow, to improve, to strive, to serve, to be his best. A job was easy compared to a vocation. For a vocation, the driving mechanism was not the boss but the will; the goal became not money but mission.

Vocation, from the Latin verb *vocare,* is work to which one is called to by the gods (Morris 1976). Frederick Buechner (1973) proposed two criteria by which a true vocation could be judged: (1) it is work the individual most needs to do; and (2) it is work the world most needs to have done.

I believe that many (and certainly the most effective) resource management professionals have a vocation. Those who have a vocation have a precious and rare possession.

The Chinese have a blessing (sometimes described as a curse): "May you live in interesting times." If it is a blessing, we are doubly blessed. We have a vocation and, considering the critical importance of enlightened management of natural resources at this juncture in history, we live in the most interesting of times, the most critical of times, the most challenging of times.

How do we define ourselves? As usual, Leopold (1949:vii) probably said it best:

[1] This is a revised version of a paper first given at the Western Section of the Wildlife Society meeting in 1985 and printed in the *Cal–Neva Wildlife* Transactions (1985), under the title "Professionalism—Commitment Beyond Employment."

"There are some who can live without wild things and some who cannot." We cannot or, at least, we choose not to.

Commitment beyond employment is required to produce wildlife biologists who continuously become all that they can be. I call such people "professionals." That word carries meaning for me beyond the dictionary definition of a profession as "an occupation or vocation requiring training in the liberal arts or the sciences and advanced study in a specialized field" (Morris 1976:1045). That's not nearly enough.

A sense of professionalism lies solely with the individual. Professionalism does not depend on professional societies and organizations, nor on employers. Professionalism is a reflection, through behavior, of vocation with its inherent commitment, and sharply focused will. Those who have those attributes will find or make a way to express their sense of professionalism. Once the individual has defined "professional" in his or her own mind and seared those standards into the soul, a standard for the conduct of a career has been established. This process of definition is personal and individual. Such people never allow their vision of their professionalism to rest in the hands of another.

Philosophical Positions—Contrasts and Conflicts

Many (if not most of us) have something of a split mind about who wildlife biologists are and what they do. The dilemma is manifest in the name given our profession—wildlife management. We have lived with the name so long that we fail to see that the words can be perceived as diametrically opposed in meaning. This is typified by the wildlife biologist's struggle to ensure that wildlife exists in habitats that are more and more controlled by human activity.

I see signs that this does not quite make sense to many wildlife biologists and it shows up in job dissatisfaction and in emotional distress (Kennedy and Mincolla 1985b). For example, consider the role of biologists in the management of our national forests. First and foremost, the wildlife biologist is quite likely dedicated to the welfare of wildlife on wild land. Second, the wildlife biologist is likely to be charged with helping convert wilderness into managed forests that produce wildlife.

The managed forest is comparatively tame and controlled compared to wilderness. The wildlife in the managed forest is as wild as its ancestors, but it is now a product of an environment more and more controlled by humans. Therefore, many wildlife biologists, philosophically dedicated to the preservation of wildness, participate in the purposeful dilution of wildness in order to preserve or produce wildlife in a managed environment. The wildlife is as wild as ever, but the environment is increasingly tame. Being a participant in this process forces many wildlife biologists to face an unanticipated paradox that leaves some confused and unsettled. The wildlife probably does not perceive a difference in the evolving habitat, but some biologists do and have moments of doubt. Those who doubt, perhaps, sense Leopold's (1949) observation that "Man always kills the thing he loves, and so we the pioneers have killed our wilderness. Some say we had to. . . ." Probably so, but for many biologists, it still hurts.

I suspect that there are very different philosophies among natural resource management professionals concerning how man relates to the natural world. Remember, there are no inherent rights or wrongs in these philosophical positions—they merely are. Some groups tend to be anthropocentric in philosophical position and take a utilitarian view of land—i.e., land exists for and is to be managed to satisfy people's needs (Devall and Sessions 1984, Leopold 1949).

Many wildlife biologists, I dare say, are mainly biocentric in philosophy (Kennedy and Mincolla 1985b) and view humans as part of nature (Leopold 1949), and subscribe to the admonition voiced by Sessions (1977:450) to be concerned with ". . . organic wholeness, [and to] love that, not man apart from that. . . ."

When biocentrists are employed by management agencies that, by law and tradition, are essentially anthropocentric in outlook and mission, there is apt to be friction (Devall and Sessions 1984). It is unlikely that most of those involved will recognize the problem for what it is—a basic difference in philosophy.

I am bemused by wildlife biologists who have an anthropocentric view of handling populations of game animals and predators and a biocentric view of forest and range management. Self-examination of basic philosophies and prejudices can be revealing and productive for us all.

The system for dealing with the management of public lands that has evolved in the United States has, in far too many cases, produced an adversarial relationship between wildlife biologists and foresters. In the formalized system that now exists, the land-use planning and allocation procedure can be referred to as *advocacy planning*. In advocacy planning, each interest group is expected to strive for satisfaction of its own welfare. Because compromise is inevitable as the culmination of such a process, each interest group feels that it has lost—a little or a lot. Relationships are apt to become a bit strained. Managers are given "targets" for various products from the forest. The best-defined and driving mechanism for the overall process tends to be timber harvest, followed by stand regeneration. Wildlife goals and objectives are much more difficult to define and quantify. As a result, objectives for wildlife have usually entered into the equation as constraints. Consider the definition of constraint: "A constraining agency or force; a repression of one's own feelings, behavior or action" (Morris 1976:286). So long as wildlife considerations are operative in the management arena as constraints, there will be intensifying conflict. Wildlife must be considered as a desired product—not as a constraint—to receive adequate attention (Thomas 1985).

Wildlife biologists that have a biocentric philosophy should recognize that, if they work for a land management agency or state game and fish department, they are facing an inherently anthropocentric orientation in the work place. Merely recognizing the situation can help biocentrists to be more effective. At least it can help them understand and deal with flashes of schizophrenia that come in the night.

Effectiveness—the Measure of Success

In the end, the measure of success for a professional is demonstrated effectiveness in achieving objectives. The following are considerations in enhancing effectiveness.

Biopolitics—Achieving Results in the Real World

Wildlife biologists are trained to be concerned with the art and science of managing wildlife, habitats and the users of wildlife. Another facet of natural resource management—biopolitics—is not as well understood nor as skillfully practiced as it should be. In fact, biology and politics personify opposing views, in the purist's mind, of wildlife management. Biology implies the gathering, analysis, interpretation and application of data in a methodical and peer–approved process to achieve goals dispassionately derived. Politics, on the other hand, is defined as "the methods or tactics involved in managing a state or government" or the "partisan or factional intrigue within a given group" (Morris 1976:1015). In the sense of natural resource management, biology is never pure and politics are not necessarily corrupting. All data are collected, all analyses conducted and all conclusions drawn by individuals with a point of view established through education and experience (Livingston 1981). And decisions are made within the context of laws, courtrooms, policies and financial resources.

Biopolitics is concerned with interactions between biological facts and theory and the reconciliation of the desires of individuals and organizations within the constraints of law (Peek et al. 1982). It is "the art of resolving biological . . . management problems in a biologically sound and politically acceptable manner" (Greenley 1971:505).

We need to remember that, in most areas of natural resource management, the body politic sets the goals for most endeavors. Appropriately qualified people are then employed to achieve those goals. There is no guarantee that all such goals are well–stated, appropriate, needed or even achievable. Yet the professional must strive to achieve the goals, change the goals or, if the conflict with conscience is too great, to refuse to participate or to resign.

There is nothing inherently wrong with biopolitics. In fact, it is the essence of natural resource management in government agencies and in those agencies' relationships with constituencies (Allen 1962, Poole 1980). Unfortunately, most natural resource managers did not learn about biopolitics in school—not that it exists or how to practice the art.

No natural resource manager can be truly effective, over the long term, without mastery of biopolitics. So far as I know, there are few formal training programs and no degrees in biopolitics. Neophyte natural resource managers learn biopolitics from apprenticeship to a master practitioner if they are lucky and from experience if they are not. They remain perpetually naive and ineffective if they remain ignorant of the art. Perhaps it could be said that natural resource managers are not properly and fully educated until they understand and demonstrate mastery of biopolitics.

The effective wildlife manager is expert in biology *and* is a politician. Biologists know something about what makes elk or deer or ducks or woodpeckers tick. And they know that laws, land–use planning processes, agencies, governing boards and landowners largely determine the goals and objectives for management. A good biopolitician combines biological and political skills to achieve goals and objectives in an acceptable manner while considering prevailing circumstances, and legal and ethical constraints. The fate of wildlife in America depends and will continue to depend largely on effective application of biopolitics (Peek et al. 1982).

Economics—Does It Make The World Go Around?

Money does *not* make the world go around. But biologists just may be a part of the tiny minority of the American population that believes that. Most of the rest of society operates on the premise that money does, indeed, make the world spin on its axis. Biologists are not required to change their views on this matter. But we must recognize that economics dominate biopolitical decisions and the exploitation by and the allocation of natural resources among user groups. More and more, the fate of wildlife is being determined primarily by consideration of cost–benefit ratios when various alternatives of land management are considered. That probably always has been true, but the law now requires consideration of cost–benefit ratios in the management of federal lands.

When wildlife biologists were forcibly thrust into the arena of formalized cost–benefit analysis, they quickly found that, with the exception of game species in some states, wildlife does not have market value. That means that wildlife's value must be indirectly estimated. Value estimates so derived are, in practice, easily distinguished from real dollars and have been, in my view, notoriously ineffective in influencing resource allocation and management decisions to favor wildlife. Craig Rupp, speaking as a Regional Forester for the U.S. Forest Service, summed it up perfectly: "The times are changing. Today it's a matter of dollars and cents. That makes it tough on uses that don't produce much income . . ." (Findley 1982:313). This remains true despite the fact that overemphasis on cost–benefit analysis can lead to ecologically and socially inappropriate decisions.

That observation is difficult to dispute, particularly as it relates to the production of game species for recreational hunting. If wildlife doesn't produce income at least equal to costs the landowner incurs in producing wildlife, there is apt to be a continuing loss of wildlife habitat and wildlife. Purposeful provision of wildlife needs on evermore intensively managed lands will, almost inevitably, exact significant opportunity costs (Thomas 1984). Costs that exceed benefits produce cost–benefit ratios that are unfavorable to maintenance or enhancement of wildlife and their habitats.

This does not mean that all natural resource management issues will, or should be, settled primarily on the basis of economics—but, considering the track record, that's probably the way to bet. Fortunately, there are exceptions. Sometimes there is support from an aroused public to accomplish something because it is so obviously "right" that the cost–benefit ratios are put aside. We chose, at least for now, to have grizzly bears, whooping cranes, peregrine falcons and spotted owls. We chose, at least for now, to clean up Chesapeake Bay though it might be better economics to let it turn into another Houston ship channel. But such decisions are fragile and each will be subject, over and over again, to new arguments based on cost–benefit ratios. This will remain so until the science and art of economics are sophisticated and mature enough to encompass the full measure of costs and benefits. The effective natural resource manager, then, understands: (1) economics; (2) the role of economic considerations in decision making; (3) the capitalistic nature of the economy; and (4) increasing expectations that government assets will produce revenue. In the meantime, those interested in sound natural resource management must continue to strive to ensure that decisions concerning natural resources are made considering factors beyond cost–benefit ratios. These include ecological, social, aesthetic and ethical considerations.

We should remain cognizant of Leopold's (1949:225) exhortation that "The fallacy the economic determinists have tied around our collective neck, and which we now need to cast off, is the belief that economics determines all land-use. . . ." But, while knowing and believing that, biologists must be prepared to live, work and be effective in an atmosphere increasingly permeated by economic determinism.

Communication Skills

Biologists cannot be completely effective without possessing and exercising good communication skills. That includes being able to write in both technical and popular style, converse intelligibly and speak persuasively to groups.

In my youth, I had a vision of what biologists were like. They bore close resemblance to the cartoon character naturalist Mark Trail, who with pipe clenched in teeth, paddled their canoes (with a big shaggy dog in the front) into the glowing sunset. Such paragons communed with nature, avoided people and their works, and were unhurried and at peace. I grew up, became a wildlife manager, and found out that dreams are not necessarily harbingers of the future.

I suspect that the last thing most wildlife managers ever wanted to be in their youth was a salesperson. I gradually discovered that wildlife managers, the truly effective ones, were also salespersons—for wildlife, for programs, for proposals that benefit wildlife and for good stewardship of natural resources.

Today's wildlife biologists stand their watch during a critical time for wildlife in our country and the world. How wildlife fares in the long run probably does not depend on a census perfectly done or a new piece of information on elk behavior or whether a hunting season runs for 7 or 10 days. It does depend, however, on effective communication among biologists, others interested in wildlife and natural resources, and the general public.

We have an obligation, as professionals, to be effective. To be effective, we must communicate well and often. There is no dearth of information on or training in how to improve one's communication skills. The key is to try—over and over. Given the stresses and strains of today's climate as influenced by conflicts over spending, allocation of natural resources and the general economic climate, it is tempting to hunker down and hide from the tempest. That temptation must be resisted. If there has ever been a time for speaking up for proper natural resource management, it is now.

Getting Your Head Straight

The effective professional is, by definition, a winner. By "winner," I don't mean (necessarily) a quick climb up some bureaucratic ladder, making more money or receiving accolades. After all, our profession is not a competitive sport. I mean being effective for wildlife and the sound, holistic management of all renewable natural resources.

There are very few total victories for those interested in wildlife and absolutely none that are final. We have to win for wildlife and appropriate natural resource management what we can, where we can, how we can and be proud, rejuvenated and encouraged by each success.

I watched a situation where several biologists helped consider the fate of a pristine watershed on a national forest. They looked at the fish and wildlife situation carefully and professionally, mustered the available information, and concluded and recommended that the area be included in an adjoining wilderness area. After considering additional pertinent information, the decision makers decided otherwise.

The watershed was allocated to be managed forest and alternatives were considered. The biologist's first recommendation was for "backcountry" status. Again, the decision was otherwise. An alternative was selected, however, in which fish and wildlife received high emphasis. The biologists were ready with recommendations as how to accomplish the goals. Most important, perhaps, they learned something at every step about how to play the game and to be effective, and they came away determined to do a better job next time.

Winners or losers? these biologists played hard, fair, truthfully, ethically and effectively in the only game in town. In the end, wildlife and holistic forest management were well–served by their efforts. I say they were winners.

Only when we do less than our best, are less than truthful or are less effective than we can be are we losers in the professional sense. So, we must think of ourselves as winners. We must always focus on next time—always next time. Yesterday's victories and defeats are, indeed, yesterday. Next time—always next time. We must believe we serve a good and necessary cause. For, I think, people become what they believe in their hearts. Attitude is crucial to effectiveness, and the professional is obligated to be effective.

Doing the Best You Can With What You've Got

Perhaps the greatest challenge that faces wildlife management professionals is the organization and synthesis of information on wildlife into a form that can be applied in management and evaluation. To say "we don't know enough" is to take refuge behind a half-truth and ignore the fact that decisions will be made regardless of the information available. In my opinion, it is far better to examine available knowledge, synthesize it, and combine it with expert opinion on how the system operates, and make predictions about the consequences of alternative management actions. What results are working hypotheses—places to start, ways to derive tentative responses to questions to which there are no certain answers (Thomas 1979). Ecology is made up of successive approximations—there is no final truth (Franklin 1985).

Yet those who produce and certainly those who apply models and other approximations in natural resource management need to hear a whisper saying over and over, "You are dealing only with the essence of what is—nature seen through a glass darkly. it is not real—it is but the shimmering image of the moment that will change as the viewer's perspective and need changes" (Thomas in press).

Do the best you can with what you've got. But remember to tell the truth, all the truth, all the time, about where the information came from, about the assumptions involved and about the level of confidence that you have in the product. Credibility requires that, and credibility is a prerequisite to effectiveness.

Continuing Education—Staying Sharp

The professional is always in the process of education. University diplomas are not proof of education or of competence. Such training is and has always been inadequate. It always will be. A university degree is merely a ticket to board, a license to learn, a platform on which new learning, new skills and experience can be structured and from which wisdom can emerge (Cutler 1982). University degrees signify the beginning of real learning not its terminus. Yet, of all our failings in striving for professionalism, we fail most grievously in continuing to learn and grow as we should (Krausman 1979, Nelson 1980). There is no excuse for that failure.

To my dismay, there are those who are satisfied with an appropriate degree(s), a certificate of blessing from this trade union or that, and a lifetime of going through the prescribed drills. To my mind, such are functionaries—not professionals. To those with vocation, there can be no cessation from learning, no respite from desire to improve, no relief from the demand to serve.

Education cannot make a professional, but a professional cannot exist without appropriate education. And, for the professional, the need for more training and new and better skills never ends.

Universities, professional societies and agencies are paying more and more attention to the needs of professionals in terms of continuing education. Approaches run from short courses, seminars and video tapes to more and better publications. Some employers are unable or unwilling to provide employees such training. That's no excuse. Pay your own way for training sessions. Step up your reading. There is more and better literature than ever before in wildlife biology. But we can't stop there. We must learn more about economics, forestry, range management, fisheries, land-use planning, politics, sociology, philosophy and history. Biologists operate in an increasingly complex world, and if we are to be effective agents for the overall good management of natural resources, we must be conversant in other fields (Cutler 1982, Kennedy and Mincolla 1982 and 1985a).

Yet, we often hear the refrain, "I'm so busy I don't have time to read, to study, to learn." I don't agree. We wouldn't and shouldn't accept such a statement from the lawyers, airplane pilots, financial advisors, physicians and other professionals we employ. We do not and should not accept such statements from any person who aspires to be a professional. The professional strives for and aspires to excellence.

Appearance—Seeing is Critical to Believing

Some time ago, during his anti–establishment period, a colleague had occasion to deliver what could have been a very important briefing to some agency heads. After the briefing, one of them quietly said, "I suspect that what you said was important. But, frankly, I had a hard time hearing you because of the way you look."

The colleague grumbled and rationalized, but came to the inescapable conclusion that his appearance had detracted from his effectiveness. A too–rare chance to really do something for wildlife had been lost. He never lost another chance for that reason.

Too often, we let the dress code of our particular subculture get in the way of our effectiveness to do something for wildlife and for society. Too often people can't hear us because of how we dress or act or talk.

Dress and behavior should be suitable to the occasion. There is a time for field clothes and a time for suits—not because of anything so mundane as an appropriate professional image but because of necessity to enhance effectiveness. Professionals have the obligation to be effective.

Ethics and the Professional Society

As I implied earlier, the definition of professionalism that determines the actions and attitudes of individuals is self–defined and largely self–imposed. Ethics, on the other hand, has to do with a standard of behavior within a group or profession. Most organizations that feature themselves as the standard bearer of any group of people aspiring to professional status, sooner or later comes up with a code of ethics. Those organizations relating to the natural resource management professions are much the same.

The Wildlife Society has a code of ethics and standards for professional conduct and standards of behavior for Certified Wildlife Biologists (The Wildlife Society 1978). They are flowery but good words for professional wildlife biologists to live by. In simple words, they say:

1. Tell folks that your prime responsibility is to the public interest, the wildlife resource and the environment.
2. Don't perform professional services for anybody whose sole or primary intent is to damage the wildlife resource.
3. Work hard.
4. Don't agree to perform tasks for which you aren't qualified.
5. Don't reveal confidential information about your employer's business.
6. Don't brag about your abilities.
7. Don't take or offer bribes.
8. Uphold the dignity and integrity of your profession.
9. Respect the competence, judgment and authority of other professionals.

Implied but not specifically mentioned is the requirement simply to tell the truth. More and more lately, I seem to find myself advising troubled colleagues to tell the truth. It seems so simple. Yet, it can be so liberating. We live in an age of euphemisms, half–truths, obfuscations, double–talk and double–think. This atmosphere has closed in on us so gradually, so cloaked in the camouflage of the committee or team report, so justified by the need to get the job done, that we've come to consider such things the norm. Tell the truth, all the truth, all the time. It's the right thing, the healthy thing, the professional thing to do.

The Professional Society—the Professional's Prop

Some definitions of a profession indicate that the members are organized into an association that is responsible for maintaining and improving the quality of the service. Other definitions say that a profession is defined by the existence of a body of knowledge or literature.

The Wildlife Society serves that role for wildlife biologists. Many of us belong to other professional societies as well. There is no conflict and much benefit in that. The Wildlife Society gives voice and definition to our profession. I cannot imagine our profession existing without it.

Yet, probably more wildlife biologists do not belong to The Wildlife Society than do. But that's the norm for other societies in the natural resource management professions. To paraphrase John Kennedy, it has never occurred to me to ask "What does The Wildlife Society do for me?" The opposite tack seems more appropriate—"What can we do for The Wildlife Society, for the profession, for wildlife?" And truly, service is its own reward, yielding benefits far in excess of the individual's contributions in time and money.

There are those who need The Wildlife Society, who believe in its goals and who are willing to support it with money and service. There are those who don't. Just maybe, the problem does not lie primarily with The Wildlife Society.

That doesn't mean I always agree with the Society's decisions. But I have little respect for those who, upon losing an argument, withdraw support from the Society. We should be bigger than that—the stakes are too high and we are too few to make such action laudable. In short, professional involvement is a required commitment beyond employment.

Summary

Those are my ideas of what commitments beyond employment are required for wildlife biologists to be professionals. I started with an observation about vocation, about how precious and how rare it is to have a vocation instead of a job. More and more of our colleagues—disappointed by disparagement, discouraged by de-emphasis on environmental concerns, beaten down by budget cuts on top of budget cuts—are saying things like, "That's it, I'm putting in the hours I have to and no more" or, basically, "To hell with it."

I've felt the temptation—but it is wrong. If you have a vocation, don't let other people or circumstances make that vocation into a mere job. All that you have can be stripped away—wealth, possessions, status, job, loved ones. The only thing that belongs to you forever unless *you* give it up, is what's in your head and in your heart. Hang on tight. A sense of vocation is a truly rare and precious possession. It is what, down deep, spells the difference between professionals and functionaries.

Cervante's character Don Quixote, in his perceived madness, saw things differently and, strangely enough, more clearly than other men. He recognized that the quest, the striving, was everything. In a musical version of the story, he dared "to dream the impossible dream." We pursue what some say is an impossible dream of maintaining wildlife as a continuing part of our nation's and the world's fabric. Impossible? It is we who bear much of the responsibility for the answer to that question.

We can't afford dropouts nor the insidious slow poisoning of cynicism. Those so afflicted need to cure themselves or move aside. The stakes are too high and there are too many young people who want to try, who don't know they can't succeed, to make such indulgence acceptable. Those with battle scars and gray in their hair must be steadfast and optimistic. We owe that to our successors.

For those interested in wildlife management, indeed in the management of natural resources, these are confusing and often discouraging times. Natural resource management professionals have great responsibilities to keep the faith and serve steadfastly as advocates and agents of good stewardship and management. These are indeed interesting times—times of testing. It is useless to look back for the good old days—they are gone. It is pointless to look around for others to lead—they aren't there. For better or worse, we're it. Whether we recognize it or not, we are agents of change in how natural resources are treated, considered and used. If we succeed, there will be accolades from historians. If we fail, historians will, doubtless, take little note—but history will be much different. In my opinion, we stand at one of those moments in history that is a watershed for our nation in terms of how we treat our natural resources. We need to be fully aware of *who* we are, *what* we are and *where* we are in history.

These are, indeed, interesting times, exciting times, critical times. When the history of conservation in the United States in the 20th century is written, this period will loom as large, for good or ill, I believe, as the did times of Pinchot and Roosevelt.

When I consider the role that natural resource management professionals can play in human affairs at this juncture in history, the words of Shakespeare's Henry V as he contemplated victory over the superior French force at Agincourt come to mind:

> [This day] . . . shall ne'er go by,
> from this day to the ending of the world,
> But we in it shall be remembered—
> We few, we happy few, we band of brothers. . . .

We few, we fortunate few, we band of brothers and sisters, are privileged indeed to stand this watch. What more could we ask but to be here in this time and place with a chance to make a difference? We will be remembered kindly by history if we fulfill our charge of continuing on course to achieving a maturity and skill wherein we can provide the needs of mankind while preserving ". . . the integrity, stability, and beauty of the biotic community" (Leopold 1949:225). It is, indeed, a noble quest and a worthy vocation.

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Wild Sheep Populations, Especially Desert Bighorns: Status, Ecology and Management

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Opening Remarks

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If someone were to write a dissertation on the history of wild sheep management in North America, 1974 would be identified as a crucial time. That year, three significant events took place that resulted in increasing the research and management intensity of wild sheep in North America. More importantly, desert bighorn began getting more intensive research and management attention than in any previous years. The three 1974 events were:

1. The Desert Bighorn Council sponsored a paper entitled "Guidelines for Re-establishing and Capturing Desert Bighorns" (Wilson et al. 1974). Copies of the guidelines were sent to all federal and state agencies having wildlife management responsibilities, as well as to appropriate conservation organizations and interested individuals. This document gave wildlife biologists and managers the tool they needed to initiate reintroduction programs. It also gave wildlife administrators, conservation organizations and others a document they could use to support reintroduction programs. Prior to 1974, there were few successful desert bighorn translocations, and there were few if any restoration programs being considered, primarily because of past reintroduction failures.
2. The Wildlife Management Institute, Boone and Crockett Club, and National Audubon Society published the proceedings of the workshop on the management biology on North American wild sheep. This publication was entitled "The Wild Sheep in Modern North America" (Trefethen 1975), and was the result of wild sheep biologists from throughout North America pooling their knowledge on management of wild sheep populations. The biologists also discussed what

they needed to know to undertake more intensive management programs. For the first time, the state of the art and science of wild sheep management was consolidated in a single document.

3. The Foundation for North American Wild Sheep was organized. The Foundation established as its primary function to provide funds for wild sheep research and management programs. In the past four years, for example, the Foundation has expended $2.2 million for wild sheep programs in North America.

Since 1974, wild sheep managers, researchers and other enthusiasts have been most effective in raising funds, undertaking significant research activities and developing comprehensive wild sheep management programs. The intensity of these programs must be continued. The papers to follow in this session are examples of this important effort.

Even since 1974, little has been accomplished for wild sheep in the judicial, legislative and political arenas. For example, in the United States, there is federal legislation and funding to protect, manage and enhance the habitats of wild horses and burros—exotic species—on public lands. We have no similar legislation to protect the habitat of our native sheep species, particularly the remaining scarce habitats of the desert bighorn. If wild sheep are to prosper in North America, and particularly in the U.S., then an equal commitment has to be made at all levels of governmental authority and responsibility.

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Status of Desert Bighorn Sheep in the U.S. and Current Management Programs

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Desert bighorn sheep (*Ovis canadensis nelsoni, O. c. mexicana, O. c. cremnobates*) in the United States occur in seven states and number approximately 16,000 animals. The overall trend in number is up. This can be attributed to intensive management programs. Three states and two Indian reservations allow limited hunts, involving approximately 180 permits per year.

Sixty desert bighorn sheep reintroductions have been made mostly within the last decade. Water development in arid areas has proven to be an effective method of increasing bighorn in desert habitats. The private sector has become very involved in bighorn management and funding much of the ongoing work.

Texas

It is estimated that there are 35 free–ranging desert bighorn in Texas—all in the Sierra Diablo Range. There are also 70 bighorn behind wire for propagation and research.

Historically, all the mountain ranges west of the Pecos River had bighorn sheep. In 1903, the hunting of bighorn was prohibited. Less than 150 bighorn remained in Texas by the 1940s and they were extirpated by 1960. The first attempt to reintroduce desert bighorn anywhere was made in Texas in 1957. Stock was waterhole trapped in Arizona and released in a 400–acre paddock. The effort was a learning experience in both capture and propagation efforts for all the states with desert bighorn populations.

The Arizona bighorns did well once they were released in the Texas enclosure. Several sets of twins were produced—a rare occurrence in the wild. Nevertheless, the project was less successful than desired. Blue tongue was experienced in the confined herd, and mountain lions preyed significantly on the limited population. However, those early efforts did produce animals that were used to stock other ranges and released into the wild.

Today's management in Texas consists of propagating bighorn in four enclosures. These connected paddocks, financed with sportsman dollars, have 46 sheep. Stock was obtained from Arizona, Nevada, Utah and retrapped Texas–produced animals. Texas hopes to relocate 20 animals at a time until the five mountain ranges deemed suitable for bighorn are fully stocked again. Only a small part of the bighorn habitat in Texas is state–owned land, thus releases are cooperative efforts with private landowners.

New Mexico

It is estimated there are 130 free–ranging desert bighorn in New Mexico. They are found in three mountain ranges. There also are 63 bighorn in a fenced pasture.

Historically, most of the mountain ranges in the southern half of the state were desert bighorn sheep habitat. By 1930, wild sheep found in only four mountain ranges and, by the late 1940's, they occurred in only two. In 1941, the San Andreas Mountains became a National Wildlife Refuge, and in 1972, New Mexico began captive breeding for reintroduction. Six years later, an outbreak of scabies mites depleted the San Andreas Mountain population.

Desert bighorn were state–listed as endangered in 1979. Also, that year an introduction was made into the Big Hatchet Mountains to augment a declining population. In 1980, a reintroduction was made into the Peloncillo Mountains, with ewes and lambs obtained from Arizona and rams from the captive breeding herd. This effort has had losses to diseases. Recent tests have revealed that some of these animals have been exposed to blue tongue and epizootic hemorrhagic disease. Even so, more reintroductions are planned. Scabies is still found in the San Andreas Mountain bighorn despite treatments with Ivermectin. Mountain lions made inroads into the remnant and introduced populations, and the state initiated a lion removal program.

Arizona

Presently, there are between 3,500 and 4,000 desert bighorn in Arizona.

Historically, all mountain ranges in the western third of the state were considered bighorn habitat. There are two national wildlife refuges that were set aside for bighorns in Arizona—the Kofa and the Cabeza Prieta. Approximately 50 bighorn hunting permits are available each year in Arizona. In addition, two Indian reservations have bighorn hunting permits totaling less than five per year.

The Arizona Desert Bighorn Sheep Society actively cooperates with the Arizona Game and Fish Department, and its activities include raising funds for wild sheep management programs. The Society recently celebrated the completion of its one-hundredth waterhole project. This organization also was successful in getting laws passed that permit the state to put one bighorn hunting permit up for auction and one permit to be raffled. These two permits brought in more than $100,000 in 1985, and all of those funds are allocated to bighorn projects in Arizona.

Arizona also has a very successful reintroduction program dating back to 1958. Thirty-three translocation sites have been identified, and 15 releases into historic ranges have been made.

California

The estimate for desert bighorn presently in California is 4,200. Desert bighorn historically occurred in most of desert mountain ranges of the southeastern portion of the state. Today, they occur in about 50 mountain ranges. Bighorn have been fully protected in California for more than 100 years. Bills have been introduced to change the protected status, but they have failed to pass in the Legislature.

The first reintroduction of desert sheep in California was made in 1983. Since then, eight captures have been made and releases made in five mountain ranges. Three separate releases at different sites were made in the Whipple Mountains to try to get bighorn to utilize all of the potential habitat. One release was made within the San Gabriel Mountains in an attempt to reestablish a population, and a release was made in the Sheephole Mountains to augment a declining population of less than five animals.

It is anticipated that trapping and reintroductions will be made every year, assuming funding is available, until all the suitable range is restocked. And it is believed the bighorn numbers can be doubled. More than 40 water development projects to benefit wild sheep have been undertaken with the aid of volunteers and private funding.

Bighorn in the Santa Rosa Mountains of Riverside County have been experiencing low lamb recruitment and a declining population for several years. The Bighorn Research Institute is investigating this problem. Titers for the following viral diseases have been found in this population. Blue tongue, contageous ecthyma, epizootic hemorrhagic disease, parainfluenza. One or some combination of these viral diseases is believed to be predisposing lambs to bacterial pneumonia.

Nevada

Nevada estimates its desert bighorn population at 5,500. Historically, all the mountain ranges in southern Nevada were desert bighorn habitat. Today, the animals occur in 24 mountain ranges.

The 2,482 square mile Desert National Wildlife Range was established in 1936 in Clark and Lincoln counties in southern Nevada to provide protection for bighorn.

Bighorn hunting was closed in 1917 and reopened in 1952. Hunting tags are based on helicopter counts made every two years. Over 100 tags currently are available each year. The state also changed its laws so that one permit is sold at auction each year, and revenue from this special tag has brought in $22,000–$64,000. This finances a very active and successful reintroduction program.

Beginning in 1968 and to date, 20 reintroductions have been made into 15 mountain ranges. In addition, Nevada bighorn have been translocated to Zion National Park in Utah, Colorado National Monument in Colorado and to Texas.

Utah

Utah has at least 2,500 desert bighorn. Historically, desert bighorn occurred in all canyons of the Colorado, Green and San Juan rivers. In 1899, the state was closed to bighorn hunting; it was reopened in 1967, with about 10 permits available per year for trophy hunting.

Relocation efforts began in 1973, with a reintroduction to Zion National Park of 12 desert bighorn from Nevada's Lake Mead National Recreation Area. Through 1985, captures have provided stock for 11 release sites.

Helicopter drive netting is the capture method of choice in this state. Studies, captures and reintroductions are cooperative efforts with the National Park Service, which administers large blocks of bighorn habitat in Utah.

Colorado

Colorado has approximately 110 free–ranging desert bighorn in two locations. It is not well–documented that the bighorn historically found in the extreme western portion of the state and in adjacent Utah were desert bighorn. However, it is a desert type of habitat. Reintroductions began in 1979, with releases made in and near Colorado National Monument and near Grand Junction with stock obtained from Nevada and Arizona.

Management

Bighorn management programs are aggressively pursued in each state with bighorn populations. It was not always so. Management has evolved through a custodial phase, when the states were closed to hunting and refuges were established. Then management progressed to better inventories of the herds and to experiments in water developments and animal handling. The technique capturing of bighorn evolved from trapping a few at water source during the heat of summer to darting single animals from a helicopter, yet mortality remained high. Now there is baiting with fermented apple pulp and trapping with a drop net, although baiting doesn't always work. And with increased dependence on the helicopter, bighorn biologists find that drive netting is working well, especially in Utah and California. As the biologists learn from every effort and from each other, bighorn capture mortality is now very low—probably less than 3 percent.

With opening of limited desert bighorn hunting in Arizona, Nevada and Utah came a growing interest in these animals by the public, and more demand was placed on the states to have active bighorn management programs. There was a proliferation of bighorn sheep societies that raised funds and provided volunteers for work projects. Waterhole projects, in particular, began to pay off and produce sheep. The societies grew in size and success. The total private dollar contribution to bighorn management is not known, but it is in the hundreds of thousands of dollars annually. And bighorn now have advocates in the legislative process and in the agency decision–making process.

The future of desert bighorn sheep is bright, and much of the credit should go to private conservation groups that continue to provide manpower, funds and enthusiasm.

BLM's Desert Bighorn Sheep Program

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Introduction

Populations of desert bighorn sheep (*Ovis canadensis cremnobates, O. c. mexicana* and *O. c. nelsoni*) in the southwestern United States have declined drastically since the early 1800s (Buechner 1960). This decline has been attributed to several factors including exploitive hunting, disease, habitat destruction and especially range overgrazing by livestock. Legal hunting is no longer a cause of decline nor a factor preventing recovery (Kelly 1980) and, in areas where the habitat has recovered, some herds have begun to increase since around 1950 (Cooperrider 1985). Future recovery of desert bighorns will thus be largely through habitat management rather than population management (Cooperrider 1985, Wilson 1975).

About 80 percent of historic and current desert bighorn sheep habitat is on federal land, the majority of which is administered by the U.S. Bureau of Land Management (BLM) (figures 1 and 2). This situation provides a unique opportunity for BLM to work cooperatively with states to enhance recovery. BLM biologists and managers have been working with state wildlife agencies and private individuals to enhance bighorn sheep habitat for over 20 years. However, recent events and increasing awareness and concern for desert bighorns have provided the opportunity to increase and strengthen this effort.

In this paper, I will review the efforts of the BLM in desert bighorn sheep habitat management over the past 20 years, report recent events and activities, and describe plans for the future direction of the recovery program.

Past Efforts

BLM's efforts in desert bighorn sheep management precede the beginning of a formal wildlife program in the agency. As early as 1960, BLM range managers were actively working with biologists from state agencies to improve desert bighorn habitat. In 1960, a BLM range manager presented a paper to the Desert Bighorn Council that outlined the BLM's management responsibilities and practices relating to desert bighorn habitat (Mathews 1960). These practices—cooperation with state wildlife agencies, conservative use of bighorn ranges by livestock, water development, avoidance of shifts from cattle to domestic sheep use, and preservation of critical areas in public ownership—have remained a cornerstone of BLM efforts for desert bighorn since that time. With the hiring of wildlife biologists, beginning in 1961, and the establishment of a wildlife program in 1965, efforts for recovery of desert bighorn sheep have increased.

Although BLM's wildlife program was in its infancy and had to operate with limited personnel and funding, a substantial record of accomplishments in desert bighorn habitat management exists, particularly in Nevada and Utah. A few milestones, as indicated by published reports, serve to indicate BLM's activity during the 1960s.

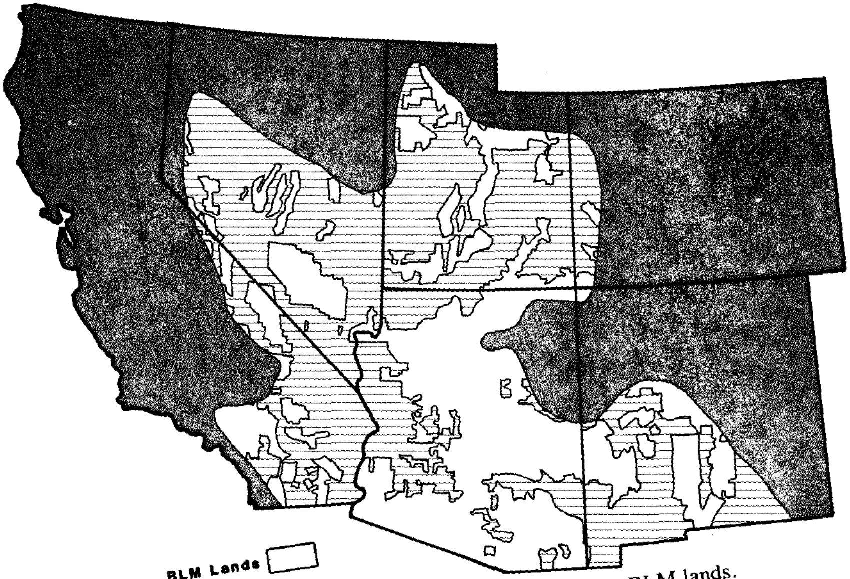

Figure 1. Historic range of desert bighorn sheep and current BLM lands.

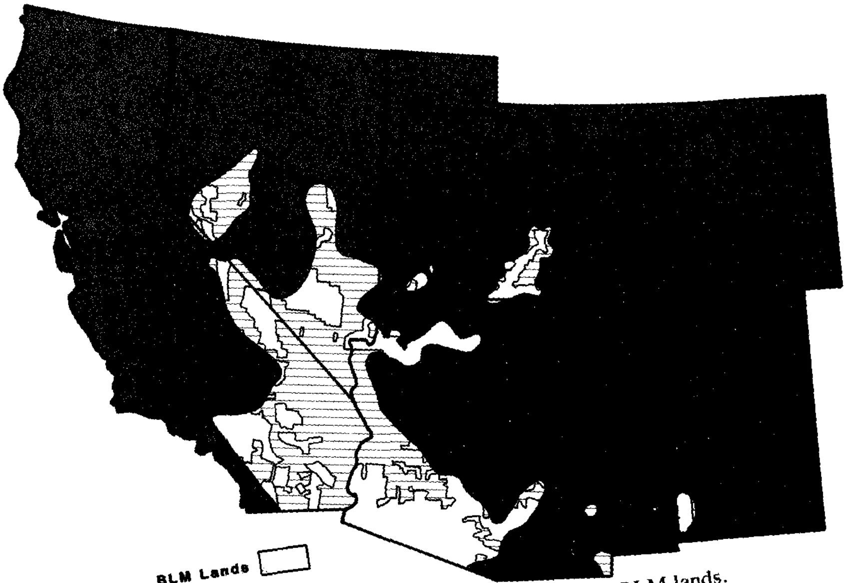

Figure 2. Current range of desert bighorn sheep and current BLM lands.

BLM personnel were responsible for the first review of bighorn reintroduction efforts (Yoakum 1963), one of the first studies of desert bighorn food habits (Yoakum 1964), the first major range improvement program for desert bighorn (Call 1966), the first survey of desert bighorn distribution in southeastern Utah (Wilson 1967), and one of the first habitat management plan for desert bighorn (Warburton 1969).

Most of these efforts were initiated, coordinated and conducted at the local or state level. Therefore, complete summary statistics on numbers of projects, acres of habitat and other factors are not easily obtained. However, a few records exemplify the level of involvement. BLM maintains computer–based records of all on–the–ground rangeland improvement projects involving substantial purchases of materials or significant commitments of labor for construction that required periodic maintenance, such as fences, seedings projects and water developments. As of the end of 1985, BLM built and was maintaining projects for desert bighorn costing over $500,000. Since BLM's budget for wildlife was only $3 million in 1974, this amount indicates a strong interest and concern for desert bighorns.

BLM has also participated fully in reintroduction programs and follow–up monitoring (McQuivey and Pulliam 1981). It also has sponsored numerous studies and research efforts. In 1973, a survey (Yoakum 1973) of desert bighorn habitat and potential habitat on BLM lands indicated that over 7,000 bighorn—roughly 70 percent of the desert bighorn population in the southwestern United States—were on BLM lands (Table 1). Furthermore, the survey indicated an additional 91 sites on 6 million acres of historical habitat were suitable for reintroduction of desert bighorn.

Until that time, the major emphasis of the program had been habitat improvement and protection, particularly water development and segregation of bighorn areas from incompatible uses. With the identification of areas of suitable unoccupied habitat, coupled with the development of techniques for trapping and transporting surplus sheep, many states began active reintroduction programs. The state wildlife agencies in Nevada and Arizona have been particularly active in these efforts. Most of these reintroductions have been into areas in which all or most of the habitat is on BLM lands. BLM personnel have participated actively in this program by providing support to translocate bighorns and monitor habitat and populations following such translocations. Many of these reintroductions have been successful, and this program as well as earlier activities are being continued.

Finally, BLM has the responsibility for regulating livestock grazing and other land

Table 1. Number of desert bighorn sheep, acreage of habitat and potential habitat on BLM lands in 1973 (Yoakum 1973).

State	Estimated number bighorns on BLM lands	Acres of occupied bighorn habitat	Estimated number of reintroduction sites	Estimated acres of unoccupied bighorn habitat
Arizona	3,000	14,000,000	4	170,000
California	3,000	2,500,000	13	340,000
Nevada	700	6,150,000	51	4,461,000
New Mexico	20	100,000	15	711,000
Utah	300	2,600,000	8	700,000
Total	7,020	25,350,000	91	6,382,000

uses that may be detrimental to bighorn sheep and their habitat. In many cases, such conflicts can be minimized by redirecting incompatible activities away from areas occupied by desert bighorn. In other cases, conflicts cannot be easily mitigated, and BLM managers must decide between competing uses. Such decisions require good information on bighorn sheep populations and habitat use as well as impacts on the sheep from the alternative land uses. Unfortunately, such information is often not available or based on very few data.

Current Efforts

In fiscal year 1985, Congress appropriated a Challenge Grant of $300,000 to BLM specifically to facilitate the recovery of desert bighorn sheep. The appropriation stipulated that the grant be matched by private sector funding or in–kind services. With these funds, together with matching funds and in–kind services, BLM initiated 28 projects in addition to ongoing actions from base funds. These included 18 water developments in Arizona, Nevada, and New Mexico; four reintroductions (Ives Peak, Paria Canyon, Grand Wash Cliffs, and Gila Box) in Arizona; four habitat inventory/monitoring efforts in Arizona; and two research studies in California and Utah, directed at determining causes of lamb mortality.

In fiscal year 1986, the special appropriation was continued with the same conditions and approximately the same level of funding. Funds will be used for the same types of efforts (water development, reintroductions, habitat inventory and monitoring, studies, and research).

In addition, BLM is developing a rangewide plan for managing desert bighorn sheep. This plan will consist of strategies and guidelines for carrying out BLM's recovery of desert bighorn sheep. The plan will be used by the BLM Washington Office to allocate funds between states, and by BLM state directors, to allocate funds between projects within a state. Many of the past efforts were planned and done at the local level for a particular range or sheep herd. Although this approach was often successful, it did not always result in the most efficient use of funds appropriated at the national level. A rangewide perspective and plan will help ensure the most effective use of the limited funds available to BLM for future desert bighorn sheep habitat management. The plan should be completed in 1986.

BLM does not intend to develop a rangewide plan by diverting funds and energy into an extended planning effort, but rather to provide a concise statement of measurable and attainable goals, the steps necessary to achieve these goals, and the priorities among the goals. Although goals and priorities within a state may be available or easily developed and agreed upon, priorities among states may be more difficult to establish. Consider the following questions: Is the need for funds to expand the range of bighorn sheep in one state greater than the need for funds for maintaining populations in another? Are some subspecies of desert bighorn sheep more important than others? These questions and others need to be addressed and resolved in a rangewide plan.

Future Activities

The rangewide plan described will provide direction for the future. Although details of the plan are still being developed, the program will continue to feature: close cooperation with the state agencies in all aspects of the program; use of private sector contributions of funds and in–kind services whenever available; a balanced and integrated program of inventory, on–the–ground projects and monitoring; and research and development.

Cooperation with State Wildlife Agencies

BLM has always cooperated closely with the state wildlife agencies in desert bighorn efforts and will continue to do so in the future. The rangewide plan will incorporate state agency objectives. For instance, the Nevada Department of Wildlife has had a cooperative plan and program with BLM since 1976. This program has resulted in 16 successful reintroductions of desert bighorn into historic ranges, as well as numerous on–the–ground habitat improvement projects. This year, Arizona, New Mexico and Utah are developing similar statewide plans either jointly or in close cooperation with the state wildlife agency.

Use of Private Sector Contributions

The State of Nevada and BLM, through the cooperative program mentioned previously, have used over $250,000 in private contributions since 1976. This use of private sector contributions was part of the program long before the 1984 Challenge Grant was appropriated. However, during the last two years since the grant was initiated, over $600,000 in contributed funds and labor have been used by the BLM in cooperative efforts for desert bighorn. In a period of limited funding, these contributions have been crucial to the program and such support will continue to be essential.

Balanced and Integrated Program

Efficient use of funds requires an integrated program in which essential tasks are coordinated. Inventories of desert bighorn habitat and populations need to be completed before effective management actions can begin. These need to be completed not only on areas with existing sheep populations, but also on historic ranges where reintroductions are being considered. Although techniques for physically capturing and transporting desert bighorn are well–developed, knowledge of how to successfully reestablish bighorns into historic ranges is still primitive.

Management projects are generally the core of any program. On–the–ground projects such as desert bighorn reintroductions, water developments, fencing for livestock exclusion, and seedings will continue to be essential to the program. However, BLM has responsibilities for projects on the land in addition to those for wildlife or desert bighorns. Correct decisions on these other activities are just as essential to the program as direct projects. A decision to route a power line or road around a bighorn sheep range rather than through it may be of more long–term benefit than development of one more guzzler. These decisions as well as decisions about bighorn projects require good inventories and knowledge of desert bighorn.

Monitoring is essential to any sound wildlife management program. Knowledge of desert bighorn management has increased dramatically in the last 30 years, but much needs to be learned. Management actions need to be monitored so that we learn from our mistakes as well as our successes. Such monitoring will allow us to design better projects in the future, to make better decisions about managing of desert bighorn habitat and to ensure that we are achieving our management objectives.

Research and Development

Research and development will continue to be needed. BLM has identified five major subject areas that need to be pursued through a research and development effort: disease and genetics; nutritional requirements; impacts of domestic livestock and feral animals; habitat evaluation techniques; and methods for mitigating human disturbance and improving habitat.

Consideration of one of these topics—disease and genetics—illustrates the complexity of the problem and the need for research. Catastrophic deaths from disease continue to be major problems with desert bighorn sheep, often resulting in losses of entire herds. Some herds are in ranges with poor habitat or are in close contact with livestock and their diseases. Most herds are in isolated mountain ranges where there is no longer any interchange of animals from other herds. Thus, these herds may be inbred and may lose resistance to diseases either genetically or through lack of enough exposure to develop an immune response. Nevertheless, these mechanisms are poorly understood. What degree of interchange of animals between mountain ranges is needed to maintain viable populations with sufficient genetic diversity? What level and frequency of exposure to disease are tolerable or desirable so that sheep populations can develop and retain enough resistance to common diseases that catastrophic die-offs do not occur? What is the relationship between habitat quality, poor nutrition, human disturbance and disease? How are these processes correlated with population size? These questions need to be addressed through well–planned, adequately funded, long–term research. More importantly, problems cannot be addressed by studying one sheep herd, but require a rangewide perspective.

Prognosis

Complete implementation of this plan for habitat management, together with the efforts of other state and federal agencies and private groups, should allow for a substantial recovery of desert bighorns. Elsewhere, I have suggested that a recovery of desert bighorn numbers from 10,000 to 50,000 in the next 25 years is possible with proper management (Cooperrider 1985). This would be comparable to the recovery of other ungulates in North America, such as mule deer and pronghorn antelope, that occurred in the early part of this century. BLM cannot bring about such a recovery alone; it will require cooperation and contributions from many private and public agencies and institutions as well as the work of many dedicated individuals. Nevertheless, BLM's effort will be a critical and necessary part of this effort.

Summary

Recovery of desert bighorn sheep in the southwestern United States largely depends on habitat management. The BLM manages a major portion of the historic and current range of the desert bighorn. Although BLM has been involved in desert bighorn management for many years, new funding and direction from Congress has encouraged and strengthened this effort. Implementation of a rangewide desert bighorn sheep plan by BLM should allow for a substantial recovery of sheep within the next 25 years.

Acknowledgments

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The Importance of Small Populations of Desert Bighorn Sheep

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Introduction

Historically, approximately a million desert bighorn sheep (*Ovis canadensis california, O. c. mexicana, O. c. nelsoni*) inhabited the desert mountain ranges of the southwestern United States (Buechner 1960, Cooperrider 1985). However, drastic habitat alteration and destruction by man have eliminated or reduced herds such that less than 12,000 desert bighorn sheep exist in isolated populations scattered throughout their former range (Monson 1980). Weaver (1975) identified 77 populations of mountain sheep in California; only 11 contained more than 100 individuals. In Arizona, there are at least 59 populations, but only 7 are known to have populations in excess of 100 animals (Dave Brown, pers. comm). The pattern is similar in Utah, Nevada, New Mexico and Texas—small (less than 100) isolated populations constitute a significant proportion of the remaining desert bighorn sheep.

These small populations are threatened by man's continued destruction and disturbance of their habitat. Maintenance and management of these small populations present a challenge to managers, particularly with the high demand for trophy hunting. However, Geist (1975) maintained that "relict, natural sheep populations of less than a hundred individuals should not be subjected to hunting, until research has clarified what kind of hunting is still compatible with the maintenance of the populations." Wilson (1979) agreed, but claimed that 125 animals is the minimum number for maintaining a viable population of North American wild sheep. The minimum population for desert bighorn sheep for survival is debatable, but many researchers accept a minimum population size of 50 to preserve fitness and 500 to maintain genetic variance for genetic adaptation in mammals (Frankel 1983). Scientific basis for determining minimum viable population sizes is still in its infancy (Samson et al. 1985), but most populations of desert bighorn sheep are at, below or are approaching what most would consider minimum population levels. In addition, many of the individuals in the small populations may be extreme maintenance phenotypes that suffer from chronic shortages of nutrients for growth (Geist 1983, 1985).

Resource managers responsible for maintaining small populations of desert bighorn sheep face critical challenges. How should small populations be managed? Should they be hunted? Should man–related disturbances be eliminated on sheep ranges? Should managers consider populations on separate mountain ranges as isolated? Should attempts be made to increase the number of sheep on small ranges by manipulating habitat variables? Should supplemental releases of nonrelated sheep be made into the small surviving populations? These are only a few of the critical questions asked by managers about small desert bighorn sheep populations.

Our objectives in this manuscript are to summarize the usefulness of small populations of desert bighorn sheep to the overall sheep population and to man, and to discuss what managers need to consider before altering sheep habitat. To exemplify certain points, we use data from small populations of desert bighorn sheep in western Arizona which we have studied from 1980 to 1985. Specifically, we will document the importance of a small relict population of sheep to surrounding mountain ranges, discuss the addition of water to their habitat as a possible detrimental alteration of bighorn sheep habitat, and illustrate how limited disturbance by man can alter bighorn behavior.

Study Area

The Little Harquahala Mountains, La Paz County, form the southern portion of the horseshoe-shaped Harquahala complex (Figure 1) and lie at the southwestern end of the Harquahala Mountains. The Harquahala complex includes the Little Harquahala, Granite Wash, and Harquahala Mountains. The Little Harquahala Mountains are 93.2 miles (150 km) west of Phoenix, Arizona, encompass 69.1 square miles (179 km^2) and support less than 30 desert bighorn sheep. Although the Little Harquahala Mountains are immediately adjacent to the Harquahala and Granite Wash Mountains, movement between ranges is restricted by roads, fences, railroads and agricultural activities.

Elevations in the Little Harquahalas range from 1,502 feet (458 m) to 3,084 feet (940 m) and topography varies from rolling hills to rugged cliffs. Average annual precipitation is 8.6 inches (21.8 cm) with April–June (spring) having the lowest average seasonal precipitation of 0.2 inches (0.49 cm). January–March (winter) had the highest seasonal average of 1.2 inches (3.0 cm), and July–September (summer) 0.6 inches (1.54 cm/month). Average seasonal temperature ranged from 56.4° Fahrenheit (14°C) in winter to 82.4° Fahrenheit (28°C) in summer. The Little Harquahala

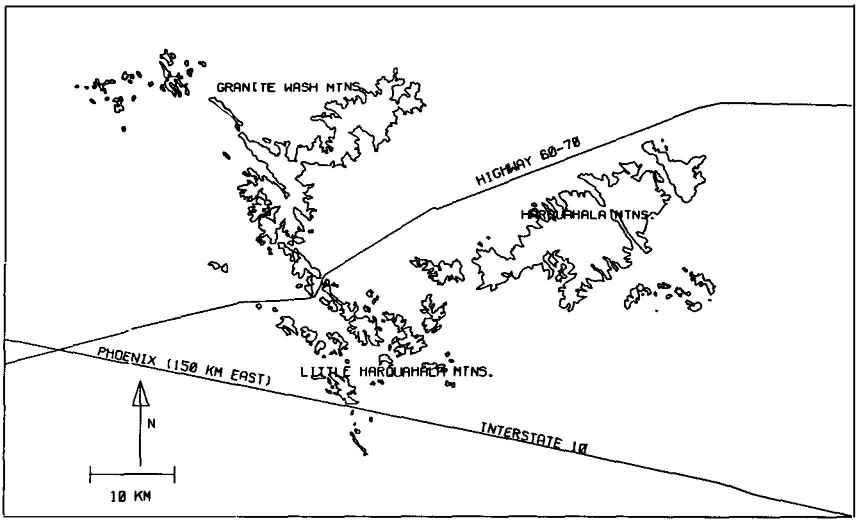

Figure 1. The Harquahala complex, Arizona.

Mountains lie entirely within the desert scrub formation. Creosotebush (*Larrea tridentata*)/bursage (*Ambrosia spp.*) and paloverde (*Cercidium spp.*)/cholla cactus (*Opuntia spp.*) are the two dominant communities (U.S. Department of the Interior 1974).

Livestock grazing, mining and recreational hunting are the present land–use practices. Although desert bighorn sheep are not hunted in the Little Harquahala Mountains, there is limited hunting for desert mule deer (*Odocoilious hemionus crooki*), lagomorphs and gamebirds (Krausman 1985).

Methods

Desert bighorn sheep were captured from a Bell Jet Ranger or a Hughes 500 helicopter using either M–99 (etorphine), administered with a Palmer Cap-Chur dart rifle (Krausman 1985), or a net gun (Krausman et al. 1984). Captured animals were fitted with color–coded radio collars and used in an ongoing project to determine the impacts of the Central Arizona water delivery project on desert ungulates (Krausman 1985).

Collared animals were systematically located during diurnal hours from 1980 to 1983 on ground or with a Cessna 172, 182 or Maule Model E–5 aircraft equipped with directional "H–antennae" mounted on each wing strut. Receiving and transmitting systems were provided by Telonics, Mesa, Arizona, and are described in detail by Krausman et al. (1984) and Krausman (1985). Located animals were plotted on U.S. Geological Survey 15–minute series topographic maps (scale 1:62,500) using the Universal Transverse Mercator (UTM) grid ticks.

Home range is defined as the area used by an individual in its normal activities of foraging, mating, caring for young (Burt 1943), resting and escaping predators. We calculated home ranges using the minimum convex polygon method (Southwood 1966). Home ranges were calculated seasonally for all sheep, with a minimum of 10 locations/season. Data from the radio collared sheep are used to discuss home range, disturbance and habitat alterations as related to surrounding sheep populations.

Results

Home Range of Ewes

Home ranges for 10 ewes were calculated from 1,199 radio telemetry locations (Table 1) collected from 1980 to 1984. Individuals were monitored an average of 19.6 months (range = 3–27 months). Ewes ranged throughout the Little Harquahala Mountains. The mean size of areas used by ewes varied from 6.0 square miles (15.5 km^2) in spring 1984 to 33.1 square miles (85.7 km^2) in fall 1980 (Table 2).

Home Range of Rams

Home ranges for five rams were calculated from 556 telemetry locations (Table 1). The rams were monitored an average of 18 months (range = 9–33 months). Males used the entire mountain range as exemplified by the movements of ram R5 (Figure 2). Mean home ranges of rams varied from 1.5 square miles (3.8 km^2) in winter 1983 to 30.7 square miles (79.6 km^2) in winter 1981 (Table 1).

Table 1. Number of locations of bighorn sheep by season in the Little Harquahala Mountains, Arizona, 1980–1984.

	Seasons[a]				Total locations
	Spring	Summer	Late summer	Winter	
Females					
F 5	31	31	16	24	101
F 13	54	86	72	54	266
F 52	35	47	39	43	164
F 64	0	0	0	18	18
F 85	11	0	0	0	11
F 86	22	37	38	24	121
F 88	36	43	35	24	138
F 89	0	30	34	26	90
F 91	22	42	44	29	137
F 93	36	40	43	34	153
Total	247	355	321	276	1,199
Males					
R 5	41	63	58	66	228
R 20	17	41	26	23	107
R 24	0	10	18	10	38
R 46	17	32	31	31	111
R 92	24	19	13	16	72
Total	99	165	146	146	556

[a]Seasons are: Spring (January–March); Summer (April–June); Late summer (July–September); and Winter (October–December).

Intermountain Movements by Ewes and Rams

Most sheep monitored in the Little Harquahala Mountains remained in the range. Only one of five rams and one of ten ewes left the Little Harquahala Mountains. The ram (R92) was captured in the Little Harquahala Mountains in December 1982. However, he moved into the Granite Wash Mountains during winter 1983, remained there through spring 1983, used both mountain ranges in summer and fall 1983, but returned in winter 1984 to the Granite Wash Mountains, where he remained through 1985 (Figure 3). The ewe (F13) only left the Little Harquahala Mountains one time. During spring 1982, she moved to the northwestern end of the Granite Wash Mountains and then returned to the Little Harquahala Mountains within 7 days (Figure 3). Movement away from the Little Harquahalas was always into the Granite Wash Mountains. However, other sheep we monitored in the Harquahala and the Granite Wash Mountains also used the Little Harquahala Mountains. One ewe (F2) moved from the Harquahala to the Little Harquahala Mountains in fall 1983. She remained in the Little Harquahala through winter 1984 but returned in spring 1984 to the Harquahalas. Another female (F4) was located in the Granite Wash Mountains from spring 1980 through the winter of 1982–83. In spring 1982, however, she moved into the Little Harquahala Mountains where she subsequently died.

Three males captured in the Harquahala Mountains made periodic trips to the Little Harquahala Mountains. Ram (R4) was captured in winter 1980 and remained in

Table 2. Home range of desert bighorn sheep in the Little Harquahala Mountains, Arizona, 1980–1984.

	Home range[a] by season[b]											
	Spring			Summer			Late summer			Winter		
	$\bar{X}$	Standard error	No.	$\bar{X}$	Standard error	No.	$\bar{X}$	Standard error	No.	$\bar{X}$	Standard error	No.
Males												
1980	0.0	0.00	0	9.4	0.00	1	32.8	0.00	1	41.0	0.00	1
1981	79.6	16.75	2	30.8	7.50	2	47.6	10.05	2	54.0	0.00	1
1982	10.9	0.00	1	33.0	6.00	2	74.4	40.44	3	15.7	2.32	3
1983	3.8	0.00	1	17.3	14.05	2	21.1	0.00	1	15.4	0.00	1
1984	14.1	0.00	1	6.7	0.65	2	32.8	6.20	2	68.2	20.65	2
Females												
1980	0.00	0.00	0	27.8	0.00	1	58.8	0.00	1	85.7	0.00	1
1981	63.0	0.00	1	29.5	0.00	1	46.6	18.05	2	47.9	1.59	3
1982	38.1	31.55	2	66.1	8.26	3	24.1	10.20	2	26.5	4.70	2
1983	36.6	7.12	3	56.3	10.46	7	32.3	7.43	7	18.3	2.84	8
1984	40.3	12.09	4	15.5	2.25	6	24.1	9.90	6	58.5	14.95	8

[a]In square kilometers.
[b]Seasons are: Spring (January–March); Summer (April–June), Late summer (July–September); and Winter (October–December).

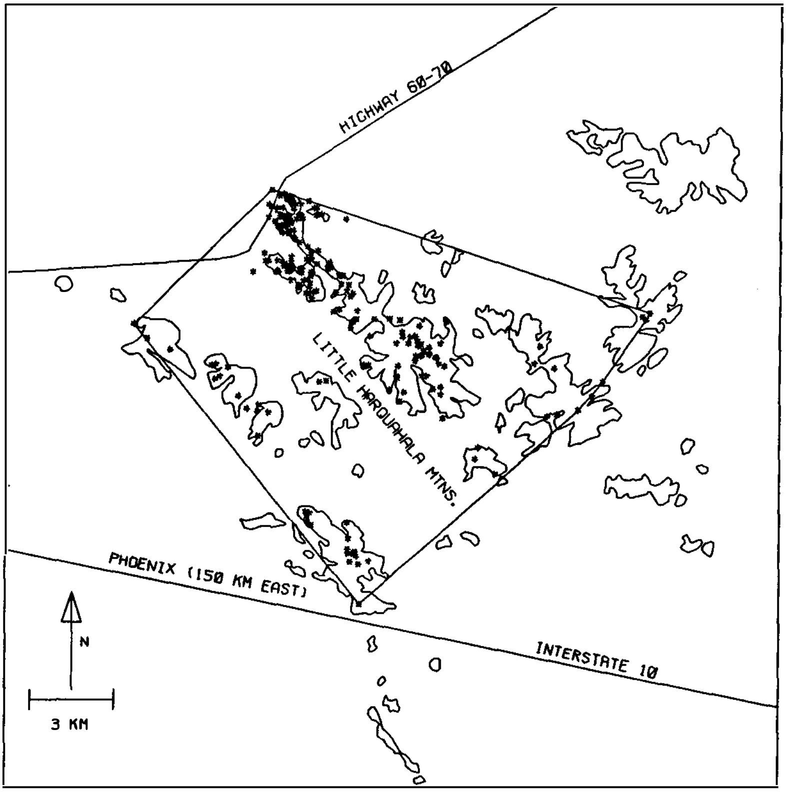

Figure 2. Home range (53.67 square miles: 139 km^2) of ram R5 between 1 January 1980 and 31 December 1982, in the Little Harquahala Mountains, Arizona.

the Harquahalas through spring 1981. In summer 1981, he made one trip to the Little Harquahalas and another the following summer. He remained in the Little Harquahalas through fall 1982 and returned to the Harquahala Mountains. Ram (R6) exhibited similar intermountain movements by making several short trips to the Little Harquahalas in the winter and spring of 1982. This ram also made frequent trips to the Big Horn Mountains to the east and, in 1981, had an annual home range of 128.6 square miles (333.1 km^2). The third ram (R81) had been in the Harquahala Mountains from fall 1981 to fall 1985; but in December 1985, he moved to the Little Harquahala Mountains for four weeks before returning to the Harquahala Mountains.

Movements Related to Disturbance

During the study, we had the opportunity to document the impact of vehicular disturbance on sheep in a limited area. In 1981, the Little Harquahala Mountains were bisected by a road leading to a gravel pit for canal construction. The road was extensively used in 1982. Prior to road development, three ewes were located in the southern portion of the range 24 percent of the time (38 of 160 locations) throughout 1980 and 1981. With the development and subsequent use of the road by large trucks

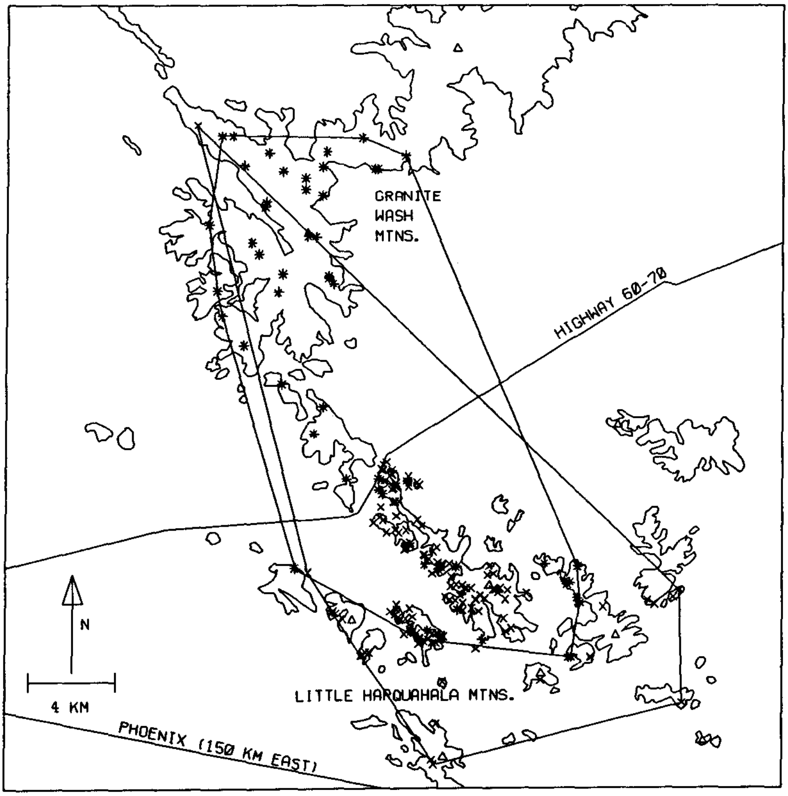

Figure 3. Intermountain movements of ram R92 (*) and ewe F13 (X) between 1 January 1982 and 31 December 1983, between the Little Harquahala Mountains and Granite Wash Mountains, Arizona.

for construction, only 2 (of 188) locations of sheep were made in the area bisected by the road for 1 percent of use. One ewe never returned and the other two only once each. In 1983, road traffic decreased and sheep occurrence increased slightly, but use of the area through 1985 has been sporadic and infrequent.

Discussion

Movements of undisturbed sheep in the Little Harquahala Mountains generally encompassed the entire range. However, the limited movement into other ranges and from other ranges may be important for the survival of desert bighorn sheep. Although there are no established guidelines relating the minimum number of animals required to maintain a viable population, it is recognized that large (100+), well–established populations are not faced with problems of inbreeding. Desert bighorn sheep are similar to many of the world's ungulate species that exist in relatively small populations in which some degree of inbreeding probably occurs. Inbred domestic animals are usually less fit than noninbred animals and are often more susceptible to various diseases and environmental stresses (Wright 1977, Lasley 1978). Limited data from natural wild populations (Greenwood et al. 1978, Parker 1979) suggest that inbreeding also affects wild populations. Ralls et al. (1979) documented that juvenile mortality of inbred young was higher than that of noninbred young in 15 of 16 species of captive ungulates. These data suggest that the limited movement of sheep from one range to another which reduces inbreeding would be advantageous to small sheep populations. Limited intermountain movements such as those we documented have also been reported by Monson (1964), Witham and Smith (1979), and Cochran and Smith (1983). Small populations of sheep should be managed to allow genetic interchange to occur, which will help safeguard the future of the species. In the Harquahala complex, the elimination of sheep in any of the mountain ranges would significantly reduce genetic exchange and increase the inbreeding potential.

Small populations of desert bighorn sheep may also be valuable in reintroduction programs. It is advantageous to reintroduce into habitats that closely resemble habitats of the translocation stock, enabling ecological rehabilitation (Geist 1975). Translocations into vacated historic range often fail when limiting factors have not been determined or removed. Areas inhabited by small populations may be better sites for reintroduction than are areas where sheep were extirpated, if the resident population is below carrying capacity. Often, it is assumed that small populations are below carrying capacity because of their low density, but this may not be the case. Many low-density populations may be in bounds of the available resources and therefore be at carrying capacity (Krausman et al. 1985).

Volunteers from private organizations such as the Arizona Bighorn Sheep Society, The Desert Bighorn Council, The Fraternity of the Desert Bighorn, and The Society for the Conservation of Bighorn Sheep donate thousands of dollars and hours of their time to improve sheep habitat by adding water to bighorn sheep range. In many cases, the addition of water may be advantageous if it has been demonstrated that water is a limiting factor. However, the addition of water on some ranges may not help sheep at all. In the Little Harquahala Mountains, sheep numbers are low but, we believe, within the limits of the resources. Although the range did not have permanent water until 1985, the population was able to survive (Krausman et al. 1985). The addition of water may attract more deer to the area and possibly burros. Hence, the range would be used by several species of ungulates instead of one and the limited forage would not be able to support them. Because sheep are poor competitors (Geist 1985), the addition of water would attract other ungulates and would not be desirable. We maintain that caution need be applied in placing sheep waters, to avoid increased competition and use of range resources by additional ungulate species.

Since desert bighorn sheep can be easily disturbed enough to alter their use of habitats, it is important that measures be taken to avoid such disturbance. Construction activity in the Little Harquahala Mountains that reduced sheep use of an area is only one of several examples where such disturbance altered sheep use of areas (Leslie and Douglas 1980, Campbell and Remington 1981). Other forms of recreational activity—such as hunting and hiking—can yield similar results. Geist (1975) outlined damage incurred from harassment: loss of habitat through loss of old rams that transmit home range knowledge to younger rams (when hunted) and thus the probable loss of small peripheral patches of habitat to the population; and preferential removal of calm, large–horned animals that are "less sensitive to harassment, more forgiving of disturbance and more likely to return to areas they saw companions killed in and saw hunters."

Geist (1975) argued that both nonconsumptive and consumptive uses of sheep can be incompatible for any given population. However, small populations should be more actively managed for nonconsumptive use. Most desert bighorn sheep reside on public land and are valued by the public for inspirational, aesthetic, photographic and scientific values (Grater 1959). In addition, the desert bighorn sheep is one of the few native North American ungulates capable of surviving in our harsh deserts. Every effort should be made to maintain the small, naturally existing populations of these wild sheep. They are indicators of the wilderness characteristics that still exist in the southwestern desert mountains (Cooperrider 1985). Translocated herds are an alternative to declining populations, but a naturally occurring population is one that has been able to survive man's activity and its continued survival should be attained through sound biology. An additional value of small populations of desert bighorn sheep is in their scientific study. By examining small populations, more complete demographic analysis of closely observed populations is possible, often availing applications that may be applied to larger populations.

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Modeling Demographics of Bighorn Sheep: Current Abilities and Missing Links

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Introduction

Understanding population dynamics of any wildlife resource is crucial for proper management (Smith and Fowler 1981). However, demographic data are often difficult or expensive to obtain, of questionable reliability, or both. Yet population modeling can help wildlife managers because it allows rapid analyses and syntheses of empirical observations. Perhaps more importantly, modeling "forces a distinction between what is known and what is not known" about a particular resource (Harris and Kochel 1981:222).

Modeling of population and habitat dynamics of bighorn sheep (*Ovis canadensis*) is in its infancy, particularly compared to efforts on North American cervids (e.g., Medin and Anderson 1979, Pojar 1981) and various marine mammals (e.g., Lett et al. 1981, Eberhardt 1981). Nevertheless, demographic data for bighorn sheep are sufficient for the development of simple models, which may provide useful insights into population responses to various management actions (Burgoyne 1981).

Since the late 1960s, the National Park Service and the Nevada Department of Wildlife (NDOW) have conducted research on desert bighorn sheep (*O. c. nelsoni*) in the River Mountains of southern Nevada. Work in the River Mountains has emphasized status and distribution (Cooper and McLean 1974, McQuivey and Leslie 1977), general ecology and behavior (Leslie 1977, 1978, Leslie and Douglas 1979), human disturbance (Leslie and Douglas 1980), population estimation (McQuivey 1978), and food habits (Kirkeeng 1985). Ground, fixed–wing and helicopter surveys, as well as random observations and summer waterhole counts, provide an unprecedented data base with which to examine herd productivity and general population characteristics of this unique desert ungulate.

Management of desert bighorn sheep in the River Mountains includes an aggressive translocation program designed to repopulate historic bighorn ranges in Nevada and throughout the Southwest. Since 1969, 324 sheep (234 since 1980) have been trapped and removed from the River Mountains, a level that exceeds very liberal harvesting schemes applied to other big game species. Such intensive management, plus the vulnerable nature of some populations of desert bighorn sheep (Graham 1980), has caused state and federal agencies to place a high priority on monitoring demographics as they relate to population vigor. Additionally, population changes of translocated sheep are of interest to measure success of relocation efforts. In response to those concerns, a population model was developed (Leslie 1980) to aid the management of translocation sources and to understand population growth after relocation.

In this paper, we describe our simulation model and discuss its current behavior, abilities and limitations. In the process, we present results of some simulations designed to aid in the management of the River Mountain herd. Our primary objective is to define areas where demographic insights are lacking—areas that inhibit our abilities to manage accurately some populations of desert bighorn sheep.

Methods

Study Area

The River Mountains (36° 00 N; 114° 50′ W) are typical of low–elevation ranges in the Mojave Desert (Bradley and Deacon 1965), and include 35 square miles (90 km^2) of rugged and weathered Tertiary volcanic rock (Longwell et al. 1965). The area is codominated by creosotebush (*Larrea divaricata*) and burrobush (*Ambrosia dumosa*); vegetation densities tend to be greatest in desert wash or valley communities. No elevational change in plant communities occurs in the River Mountains, which range from 1280–3790 feet (390–1155 m). Precipitation is sporadic and averages about 6 inches per year (150mm/yr). Temperatures frequently exceed 100° Fahrenheit (38°C) in summer but remain moderate during winter. Desert bighorn sheep are the only ungulates that regularly use the River Mountains (Leslie and Douglas 1979).

Model Description

Since 1979, we have been developing a discrete (time interval = 1 year) population model for desert bighorn sheep in the River Mountains (Leslie 1980, Leslie and Douglas 1981, 1982, Douglas and Leslie, 1984). The model currently incorporates 24 variables, 12 of which are dimensioned to permit inclusion of age–specific statistics in 10 age classes (Leslie 1980, Table 1). Based on input data, the program sequentially adds or subtracts individuals in various age classes to mimic both the annual cycle of mortality and natality of desert bighorn sheep and the management approach to the River Mountain herd (Figure 1). The model, written in Fortran, is straightforward and can be modified easily to suit a given management concern.

The program requires input data for a starting population (Figure 1) that includes: (1) numbers of ewes and rams in each of 10 age classes; (2) survival rates of ewes and rams in each of 10 age classes; (3) numbers of ewes and rams removed via annual harvest in addition to translocation removals; and (4) fecundity rates of sexually mature females in each of 10 age classes. The program is interactive and requires the user to answer four basic management questions before it can be run (Figure 1). First, the user must specify the numbers of years of simulation desired. Second, the user must provide information on annual fall precipitation, which is critical to lamb survival in the River Mountains (Douglas and Leslie 1986) and discussed in greater detail below. Two options for establishing fall precipitation are currently incorporated into the model: (1) values for each year of the simulation can be used directly; or (2) a random compiler within the program will generate annual levels within the range of observed fall precipitation in the River Mountains. Fall precipitation and density then are used in the model to set annual lamb survival

Table 1. Summary of 1969–84 translocation removals of desert bighorn sheep from the River Mountains, Nevada, through the cooperative efforts of the National Park Service and the Nevada Department of Wildlife.[a]

Year	Total	Rams	Ewes	Lambs	Relocation state
1969	10	2	5	3	Nevada
1973	10	1	5	4	Utah
1975	8	2	3	3	Nevada
1977	14	2	7	5	Nevada
1979	21	5	9	7	Nevada
1980	39	8	18	13	Nevada, Colorado
1982	69	7	40	22	Nevada
1983	31	31	0	0	Nevada
1984	95	25	51	19	Nevada
Totals	297	83	138	76	

[a]These data do not include 27 trapping and relocation mortalities, 16 of which resulted from an unfortunate vehicle fire. Direct trapping mortalities have been limited to 3.3 percent of the total animals translocated.

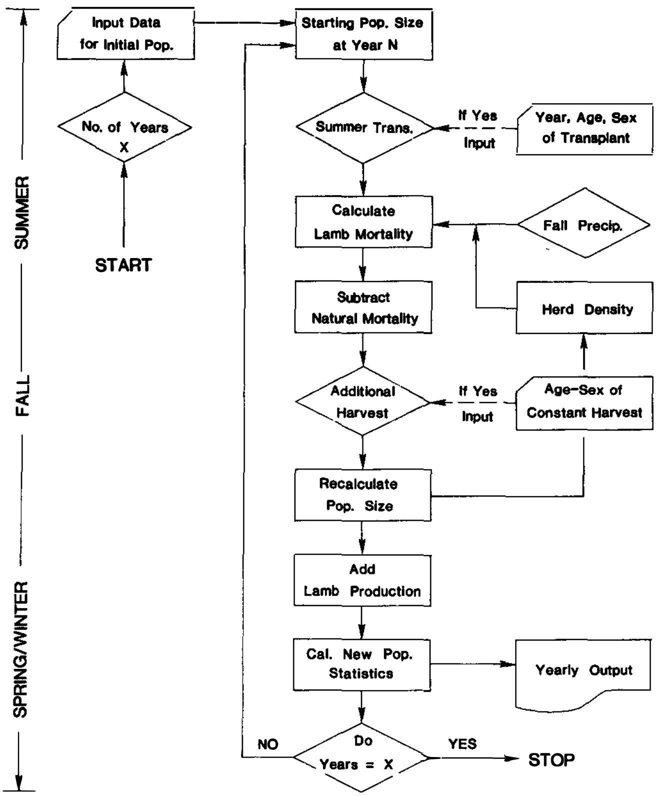

Figure 1. Flow chart of a discrete (time interval = 1 year) simulation model for desert bighorn sheep.

(Figure 1). Third, the user must provide input on specific translocation removals, i.e., the year of the removal in the simulated series and the numbers and ages of ewes and rams to be removed.

Printed output gives annual summaries of total population size, sex ratio, lamb survival, fall precipitation and population density, expressed as a percentage of an assumed carrying capacity (K) of 250 sheep. Outputs can be modified to include summaries of any of the 24 variables in the model.

Input Data

Basic life history characteristics that we have used to date are similar to those used by Buechner (1960) and Woodgerd (1964) but include data specific to desert races of bighorn sheep when available (Hansen 1967, McQuivey 1978, Leslie and Douglas 1979, Lenarz and Conley 1980, Berger 1982). They are: (1) sexually mature ewes produce one lamb per year; (2) sex ratio of lambs at birth is equal; (3) 50 percent of yearling ewes breed and produce a lamb as two–year–olds; and (4) longevity and survival of ewes are greater than that of rams.

Considerable research has addressed methods for determining survival of mountain sheep and on sampling and analytical biases of life tables (e.g., Bradley and Baker 1967, Murphy and Whitten 1976). Generally, mortality of mountain sheep (regardless of sex) is highest in the first year of life and lowest during intermediate ages (Shackleton 1985). Mortality increases again in the older age classes. Some data from desert bighorn sheep suggest a more uniform mortality rate for rams of all ages (McQuivey 1978, Leslie and Douglas 1979).

There is little consistency in the literature concerning survival rates of rams compared to ewes. Ewe survival was thought to be less than ram survival by Bradley and Baker (1967), Woodgerd (1964), and Hansen (1967, 1980). It was thought to be equal to ram survival by Lenarz and Conley (1980) and greater than ram survival by Leslie (1980). Varying adult sex ratios around parity suggest that all patterns occur in wild populations (assuming equal sex ratio at birth). Intersexual and interpopulational variations in survival are theoretically expected and probably depend on population quality (Geist 1971), environmental and habitat conditions, and management manipulations. Nevertheless, Geist (1971:300) reasoned that earlier determinations of ewe survival were underestimated because of difficulties in accurately aging ewes (Geist 1966).

Based on a reanalysis of life tables from the River Mountains (Leslie 1980) and examination of McQuivey's (1978) data for the statewide bighorn herd in Nevada, ram survival in our model has been fixed at 0.83 for two– to nine–year–olds and 0.40 for 10–year–old rams. The lower survival for old rams allowed some individuals to live to 12 years (McQuivey 1978, Leslie and Douglas 1979, Hansen 1980) but minimized an accumulation of individuals in the last age class. Ewe survival was initially set at 0.90 and 0.50 for two– to nine–year–olds and 10–year–olds, respectively. It was varied thereafter to find the level necessary to maintain a simulated population of about 250 sheep. Geist (1971) calculated an average annual survival of 0.88 for desert bighorn ewes from Hansen's (1967) data, which he considered to be an underestimate. McQuivey (1978) calculated an annual turnover rate of 17 percent for rams older than one year. Given our initial adult mortality fixed at 17 percent for rams and 10 percent for ewes, the turnover rate of two– to nine–year–old adults (assuming an equal sex ratio) was 13 percent.

Lamb survival in populations of mountain sheep is highly variable (Geist 1971), and changes in population size may be largely due to that variation (Hoef and Bayer 1983). In our model, lamb survival, unlike adult survival, varied each year of a simulation, depending on previous fall precipitation and herd density. Douglas and Leslie (1986) demonstrated that 87 percent of the variability in desert lamb survival (6–8 months of age) in the River Mountains could be accounted for by a positive effect of fall precipitation during gestation (52 percent) and a negative effect of herd density (35 percent). Therefore, we have incorporated the following regression into our model:

$$Y = 0.40X_1 - 128.92X_2 + 147.25,$$

where Y equals survival of lambs to 6–8 months of age (lambs/100 ewes); X_1 equals previous fall (Sept.–Dec.) precipitation (mm); and X_2 equals herd density, expressed as a proportion of an assumed K of 250. We have assumed that lamb mortality from 8–12 months of age is negligible. Natality and lamb survival in populations of Dall's sheep (*O. dalli dalli*) also are influenced by density and weather, primarily the negative effect of snow (Murphy and Whitten 1976, Nichols 1978).

Very little data exist on age–specific fecundity of mountain sheep, but variability probably occurs as a result of environmental conditions and population quality (Geist 1971). The maximum lamb/ewe ratio from fall helicopter surveys in the River Mountains was 80:100 in 1977. That ratio probably underestimated the actual birth rate for 1977 because early neonatal and summer mortality had already occurred. Counts were conducted late enough so that "long" yearling males (1.5–year–olds) were distinguishable from ewes. Lenarz and Conley (1980) used a birth rate of 0.80 for ewes three years of age or older. In our model, the birth rate was set liberally at 50 percent for yearlings and 91 percent for 2– to 10–year–olds. Although data were scant, that fecundity schedule appeared to follow observations of maximum lamb production in the River Mountains (Leslie and Douglas 1979).

Results and Discussion

Current Abilities

Model behavior. The driving force of our model is the lamb survival regression, which causes oscillations in the simulated population (Figure 2) that appear to be realistic based on empirical observations from the River Mountains (Leslie and Douglas 1979) and elsewhere in Nevada (McQuivey 1978). The synergistic effect of previous fall precipitation and herd density determines the magnitude of population change. For example, a density below 250 and favorable fall precipitation allow the modeled population to increase (Years 5–7, Figure 2). However, low density alone is not sufficient to allow the modeled population to increase (Years 3–5, Figure 2).

These results point to the importance of a density–independent factor in influencing lamb survival (Douglas and Leslie 1986), and concur with variability in lamb survival from field observations at low densities. Translocation removals since 1982 have reduced the River Mountain herd by 195 sheep (Table 1), or more than half the estimated K. Yet lamb survival has still varied from 15–52 lambs: 100 ewes (Figure 3). Also, age structures of rams and ewes never stabilize in these simulations because of population oscillations related to weather.

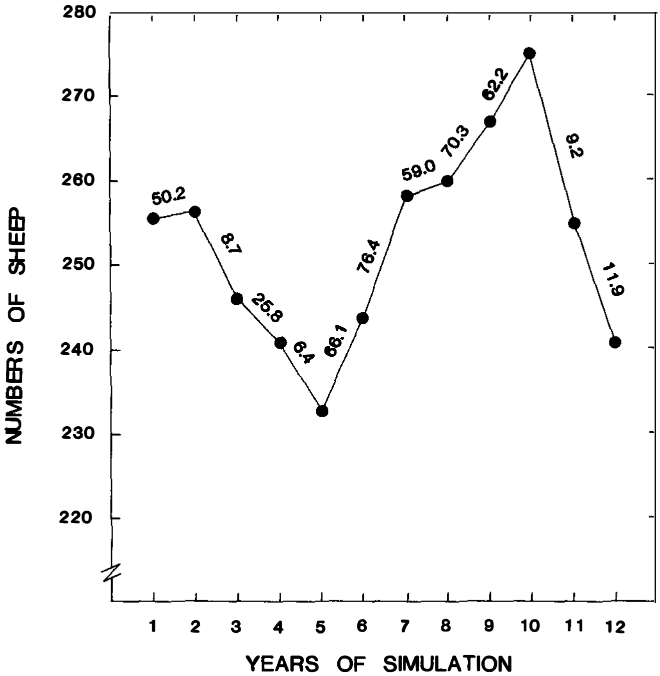

Figure 2. Fluctuations of a simulated population of desert bighorn sheep (ewe survival = 0.93; ram survival = 0.83), as influenced by previous fall precipitation (numbers along the line in mm) and herd density, assuming K = 250.

Adult survival. A single simulation operates on a fixed schedule of adult survival. Age and sex–specific survivals can be altered between simulations to examine their effects on population response by changing the initial input data. Given an assumed K of 250 and the empirical constraints on lamb survival, ewe survival has to be set at 0.93 and ram survival at 0.83 to maintain a modeled population around 250 individuals (Figure 2).

A constant survival rate of adult sheep in each year of a simulation, despite changes in density, may not be realistic. Presumably as density decreases, competition for food is relaxed, which may increase adult survival. Thus far, our model assumes that recruit survival is more dependent on density than is adult survival or fecundity (Caughley 1977:178–179). Simply stated, our modeled population responds to changes in density by increasing or decreasing only recruit survival.

Optimum Translocations. A variety of attempts has been made to ascertain the appropriate approach to translocating desert bighorn sheep from an established or "parent" population to an unoccupied but suitable habitat. Most conclusions rely on rather obvious demographic characteristics of ungulates in general, which reflects a limited understanding of bighorn in particular. Leslie (1980) reasoned that young females would maximize reproductive potential of a translocation but that a random selection of females for translocation would both maximize reproductive potential

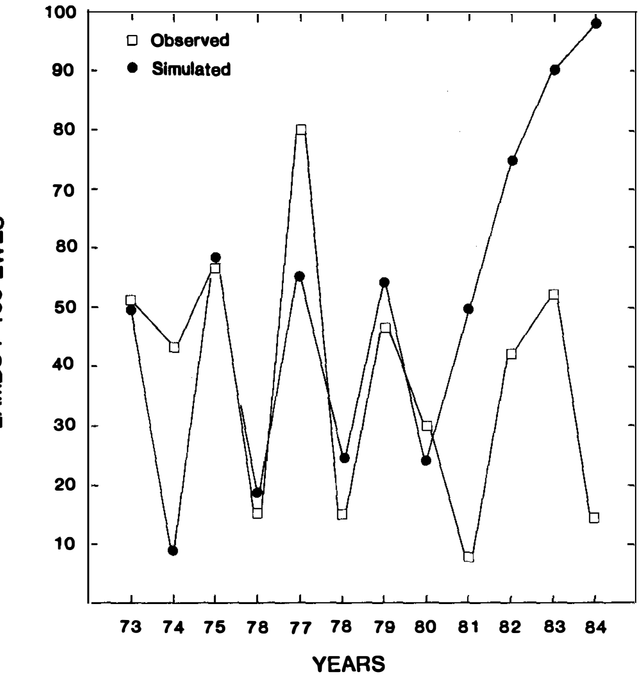

Figure 3. Observed fall lamb/ewe ratios of desert bighorn sheep in the River Mountains, Nevada, compared with simulated levels, given actual fall precipitation and translocation removals from 1973–84.

and ensure that a translocated group would harbor necessary learned behavior (Geist 1971). A removal of old females had the least impact on the "parent" population (Leslie 1980). Using a similar model, Lenarz and Conley (1980) concluded that a translocation of as many young, sexually mature ewes as possible would maximize translocation success. Further, there is no need to balance the sex ratio of a translocation as long as some reproductively active males are able to locate ewe bands during the rut.

Most authorities would agree that the greater the number of sheep translocated the greater the potential for success. Rowland and Schmidt (1981) reviewed the status of 13 translocations and concluded that a minimum of 20 individuals was necessary to ensure success. Wilson and Douglas (1982) proposed that a translocation should comprise a 3:1 ratio of ewes and rams and should be supplemented at approximately five–year intervals with rams from various populations to ensure genetic variability and thus minimize inbreeding depression.

Early attempts at translocation suffered from a lack of information on postrelease behavior and demography (Dodd 1983). Current research, however, should provide necessary insight into the characteristics of success and failure, to maximize the former (McQuivey and Pulliam 1980, Elenowitz 1982, 1984).

Effect of removal on a parent population. The extent to which individuals can be removed from an established population for translocation is a matter of harvesting theory and specific management objectives. Bighorn are typically harvested on a restricted trophy ram basis, which probably has limited demographic consequences to the hunted population (McQuivey 1978). Sheep in the River Mountains, however, are harvested for translocation in an aggressive manner (Table 1) that maximizes relocation efforts but could exceed the optimum yield for the "parent" population.

We have attempted to mimic the actual management of the River Mountain herd by conducting a series of simulations using the fixed schedule of adult survival (i.e., ewes = 0.93, rams = 0.83, K = 250), the lamb survival regression, observed levels of fall precipitation, and actual numbers of sheep removed from 1973–84 (Table 1). No age–specific data on females removed from 1973–84 were available, so we assumed that removals had been random with regard to age. Simulated lamb survival compared favorably to observed levels between 1973–80 but diverged thereafter (Figure 3). The model allows for very liberal recruitment between 1981–84 because of combined effect of relatively high fall precipitation (43–85 mm) and low population density due to translocation removals. Nevertheless, the trajectory of the modeled population between 1981–84 is downward and may indicate excessive harvest of the River Mountain herd (Figure 4), if the starting population of about 250 in 1973 is realistic. How does this scenario compare to field estimates of population size?

Despite intensive field investigations in the River Mountains, we must admit that our ability to estimate population size is limited. Confidence intervals around population estimates derived from fall helicopter surveys conducted by the NDOW are large (Figure 4). Furthermore, because the number of marked animals in the population was unknown, confidence intervals from 1979 assume that efficiency of fall helicopter surveys has remained unchanged.

The fall lamb/ewe ratio may be the most consistent and reliable population parameter collected annually in the River Mountains. Population estimates tend to mirror those ratios; i.e., a high ratio promotes population increase and, conversely, a low ratio causes the population to decrease. However, despite herd reductions of 139 animals between 1980–83 (Table 1), estimates indicated a 55 percent increase in population size. Furthermore, the lowest lamb/ewe ratio ever recorded in the River Mountains (8:100) occurred in 1981 (Figure 3), yet the estimates indicated a population increase (Figure 4). We cannot verify whether these represent a real increase or a by-product of increased survey efficiency. Our simulations represent our "best guess," but missing links prohibit an objective and accurate appraisal of the demographic consequences of current management of desert bighorn sheep in the River Mountains.

Missing Links

Our model depends on some extrapolated data that weaken its management utility. Survival of ewes is largely unknown. Also, we lack understanding of the annual dynamics of adult survival relative to herd density, precipitation, etc. Many of these influences can be examined mathematically with our model, but without empirical foundations, simulation results are of unknown or at least questionable value. Our inability to estimate population size with confidence further hampers an accurate appraisal.

At present, we have only a sketchy understanding of how bighorn/ habitat interactions operate to influence population vigor. Annual variability in lamb survival in the River Mountains is correlated with previous fall precipitation, which we believe

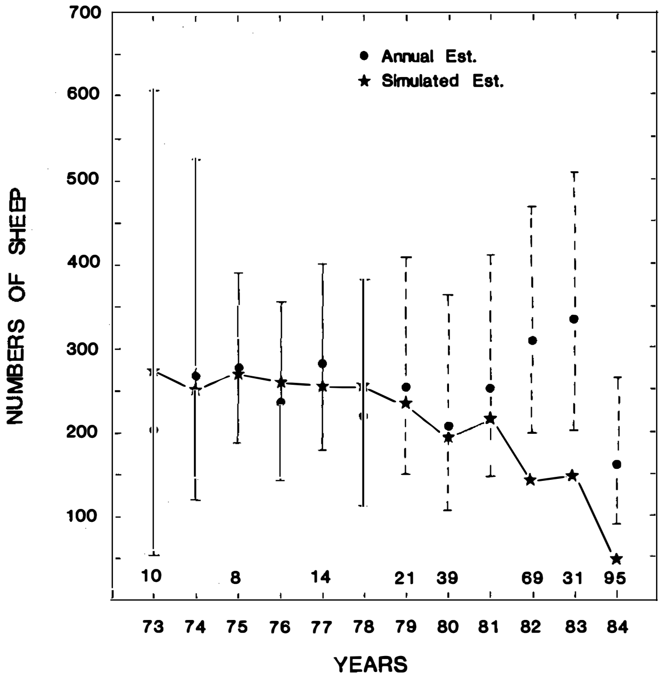

Figure 4. Lincoln index population estimates and 95–percent confidence intervals from NDOW fall helicopter surveys in the River Mountains, Nevada, compared with simulated levels, given fall precipitation and translocation removals (indicated above years) from 1973–84. Confidence intervals calculated following Overton (1971). The number of marked animals in the population was unknown from 1979–84. Therefore, dashed confidence intervals are approximations and assume unchanged survey efficiency (i.e., the proportion of the total population observed during each survey remained the same).

is an index of habitat conditions that are important to females during gestation (Douglas and Leslie 1986). With current data, however, this is the only correlation possible of such interactions. We do know that desert races of mountain sheep live in capricious environments and that under such conditions, wide changes in intra- and interseasonal carrying capacities can be expected. Caughley (1977) warned that management for a sustained harvest is difficult in such habitats, unless K can be ascertained and the population tracked with certainty. Unfortunately, we lack such information for desert bighorn sheep.

The number of marked sheep in the River Mountains was greatest from 1975 to 1977, and considerable effort was placed on estimating population size during that period (McQuivey 1978, Leslie and Douglas 1979). The population size appeared to fluctuate around 250 sheep. Mindful that confidence intervals around those estimates were large (Figure 4), we set the average carrying capacity at 250 in our simulations. Although this level is based on the best data available, we must acknowledge that our understanding of carrying capacity is incomplete and that our simulations greatly simplify what is theoretically a very dynamic process. Nevertheless, the effect of density on lamb survival is a numerical response and, assuming that we can establish trends, the effect would be replicated regardless of where K was set.

The Future

Different management philosophies and priorities of state and federal agencies influence the River Mountain herd (Douglas and Leslie 1984). Successful relocations have occurred, and bighorn sheep now reside in habitats that have been void of the species for decades. However, care must be taken to ensure survival of "parent" populations. Although models are useful in examining population responses to various management schemes or to changing demographic parameters, we must not fail to comprehend the adequacy of both the model and the input data. To improve our ability to model population dynamics of bighorn sheep, future research needs to concentrate on aspects of adult survival, fecundity and carrying capacity.

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Response of Desert Bighorn Sheep to Human Harassment: Management Implications

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Introduction

The effects of human disturbance on wildlife populations is an area of concern to wildlife managers and land managers. In light of increasing potential for disturbances associated with an expanding human population, information on the effects of human disturbance is needed to predict impacts on wildlife populations. Despite the extreme need for such information, adequate data for such management problems are lacking.

Geist (1975a), Miller and Gunn (1979) and Shank (1979) have pointed out the deficiency of systematic studies with respect to harassment for virtually all wildlife species, citing inappropriate research design as a major drawback to the study of harassment. Because behavioral data are readily obtainable, most studies have focused on overt behavioral response, while few have concentrated on equally important physiological and demographical impacts. Much of the information now available is anecdotal or has come tangentially to studies with other primary objectives. A large portion of the information now available on how human disturbance affects mountain sheep is no exception. This is unfortunate since mountain sheep populations have been greatly reduced since the arrival of European man (Buechner 1960) and must be carefully managed to maintain viable populations.

A majority of studies that have examined human disturbance on mountain sheep have focused on behavioral responses. Severity of behavioral response for various disturbance distances, approach positions, seasons, disturbance types, etc., has been determined in a few areas (Hicks and Elder 1979, Wehausen 1980, 1983, Hamilton 1982, Holl and Bleich 1982, Krausman and Hervert 1983). Heart–rate telemetry studies have been conducted to determine what types of harassment stimuli elicit increases in cardiac response and how these increases relate to behavioral activities and energy expenditure (McArthur et al. 1979, 1982). However, most of these studies have been conducted in wildlife refuges or other areas where bighorn are not hunted or otherwise protected from other obviously negative experiences. Response by these animals to various human disturbances may not be the same as that of animals exposed to more negative encounters, such as hunting. It has been generally noted that hunted bighorn react more severely than do unhunted bighorn (Hansen 1970, Geist 1971, Horesji 1976). Care must be taken when extrapolating conclusions from relatively undisturbed areas to disturbed areas, and vice versa. Despite many recent advances in understanding of how bighorn populations are affected by human disturbance, there are many areas in which our knowledge is deficient regarding the influence of human disturbance.

Disturbance history of an animal population is an important component in the suite of factors that determines how animals will respond to human disturbance (Shank 1979, Berger et al. 1983). However, systematic comparison of behavior in response to human disturbances in areas of contrasting disturbance regimes is rare. An opportunity to study desert bighorn sheep (*Ovis canadensis nelsoni*) under such conditions existed in southeastern Utah. Bighorn behavioral response to deliberate human harassment was compared between Red Canyon, an area that receives relatively high levels of human disturbance, and White Canyon, an area that receives relatively low levels of human disturbance, to determine if behavior differed with respect to severity of immediate response, distance fled, activity budgets and group wariness.

Description of Study Area

Desert canyons and mesas of southeastern Utah provide large acreages of habitat for desert bighorn sheep. Stable populations of desert bighorn live along the Colorado River and Lake Powell as well as in the rugged canyons that drain into both. The area is administered by the U.S. Bureau of Land Management and National Park Service (for complete description of the area, see King 1985). The Red Canyon and White Canyon areas in the southeastern corner of Utah provided a suitable place to compare bighorn behavior with respect to contrasting disturbance histories. The two areas are not identical, but have similar topographic and vegetation characteristics. Both areas are extremely rugged and characterized by steep broken terrain. There are locations with high visibility as well as locations with low visibility due to dense vegetation and broken terrain. The adjacent areas are separated by the Wingate Mesa, a large mesa that is approximately 24 miles (39 km) long and 7000 feet (2134 m) high. Annual average group size in the two areas is virtually the same. Red Canyon average group size is 7.5 ($n = 134$, $r = 1$–23) compared to average group size of 7.4 ($n = 139$, $r = 1$–20) for White Canyon. Reproductive rates and herd composition of both areas are also comparable.

Several human activities occur in both areas. Cattle are grazed on both areas during winter. Helicopter surveys are conducted in both by the Utah Division of Wildlife Resources. All parts of both canyons have been sampled for the past 15 years under this program. Bighorn are exposed to water traffic in both areas, as rafters float the Colorado River and boaters explore the many side canyons of Lake Powell. Also, during the uranium boom of the 1950s and 1960s, extensive mineral exploration and mining occurred in both areas (Wilson 1968). However, due to the unfavorable market for uranium the past several years, mining was virtually nonexistent during the course of the study. A little mineral exploration occurred in both areas, but disturbance was minimal.

Although Red and White Canyons received relatively little overland vehicular traffic, differences in traffic levels between the two areas are apparent. Utah Highway 95 roughly bisects the White Canyon study area, and although many vehicles travel this highway, habitat actually occupied by desert bighorn in Red Canyon likely receives more vehicular traffic than does the bighorn habitat in White Canyon. Roads in the White Canyon area through desert bighorn habitat are very rugged and generally accessible only with "off-road vehicles," whereas three improved roads in the Red Canyon area are maintained by San Juan County to allow better access into the area, specifically to Lake Powell. This is evident by the average number of vehicles encountered by the authors per visit into the two areas. Average number of vehicles encountered per visit in the Red Canyon area was 1.7 ($n = 142$, $r = 0$–30), whereas average number of vehicles encountered per trip in the White Canyon area was 0.3

($n = 156$, $r = 0$–4). Most human activity in the area occurs during spring and fall, when weather conditions are favorable for recreational activities.

Hunting pressure in the two areas differs considerably. Red Canyon has been a popular area for bighorn hunters since 1967, with the exception of 1973 and 1974 when no legal hunts were held. White Canyon has received little hunting pressure during that time. This is primarily due to habitat use patterns by mature rams in both areas. Hunting season takes place immediately prior to the breeding season, so ewes and rams are segregated, as are many other large ungulate species (Geist and Petocz 1977, Franklin and Lieb 1980, King and Smith 1980, Bowyer 1984). Mature rams are not generally found in close proximity to ewe groups in the White Canyon area during the hunting season. But in Red Canyon during the last several days of the general hunting season, younger rams move into ewe groups and initial rutting activity begins. As a result, several rams have been killed in the company of ewes and lambs in the Red Canyon area.

Since the inception of the desert bighorn hunt in Utah in 1967, approximately 55 rams have been killed in the Red Canyon area. In contrast, only eight rams have been killed in the White Canyon area, six of which were killed prior to or during 1970. During the 1981, 1982 and 1983 desert bighorn hunts, an average of 105 hunter-days per season (number of hunters and their non-hunting companions times the number of days in the field) was spent by hunters in the Red Canyon area compared to an average of only 5 hunter-days per season in the White Canyon area.

Differences between areas with respect to vehicular traffic and hunting pressure, though not great, are significant enough to permit the prediction that behavioral differences should occur between Red and White Canyon bighorn when exposed to harassing stimuli. Red Canyon was designated as the disturbed site based on the relatively high vehicular traffic and heavy hunting pressure; the White Canyon area was designated as the undisturbed site based on lower levels of vehicular traffic and hunting pressure. Given these assumptions, it was predicted that Red Canyon animals would be more wary and respond more severely than White Canyon bighorn when subjected to harassment trials.

Methods

As part of a long-term study on the ecology of desert bighorn sheep in southeastern Utah by Utah State University, the Bureau of Land Management and the Utah Division of Wildlife Resources, 9 desert bighorn were collared in the Red Canyon area and 10 were radio-collared in the White Canyon area from 1981–83 (King and Workman 1982, 1983). To facilitate efficient data collection, these animals and their associates were used to evaluate the effects of harassment on bighorn because they could be located quickly and observed for extended periods of time.

To compare behavioral responses of disturbed bighorn (Red Canyon animals) and relatively undisturbed bighorn (White Canyon animals), it was necessary to present harassment stimuli (hikers and vehicles) and to monitor bighorn response. When possible, the subject animals were located and observed from great distances so they were not aware of the researcher's presence. Once initial behavior was recorded, bighorn were approached on foot or by vehicle until they became aware of the harassing stimulus, at which time the researcher held his position. Desert bighorn reaction, based on how the majority of the harassed group reacted, was recorded as:

(1) nonflight response, when bighorn interrupted behavior with alarm and attention behaviors but remained in the presence of the disturbance; or (2) flight response, when bighorn vacated the area either by walking flight or running flight.

Distances fled by harassed bighorn were estimated visually or by plotting flight routes on 15° quad topographic maps. Flight responses were considered terminated when the majority of group initiated and maintained a behavior other than flight (e.g., feeding, lying, social behavior, etc.) or until the group was no longer visible.

In order to evaluate changes in activity budgets as a result of human disturbance, bighorn behavior was monitored after the initial harassment and while individuals remained in the presence of the harassing stimuli. Desert bighorn in both areas were also observed under unharassed conditions (bighorn not in presence of any human disturbance) so comparisons could also be made between areas under those conditions. Once a bighorn group was located, a focal animal (Altmann 1974) was selected and observed for a 15–minute period during which actual time engaged in all behavioral categories was recorded. At the end of the 15–minute period, a new focal animal was selected and the process was repeated.

Group wariness was monitored to determine comparative wariness of Red and White Canyon bighorn by scanning individual group members at five–minute intervals after the initial harassment and recording the number of animals at attention or engaged in flight behavior as opposed to nonflight behavior.

Immediate behavioral response to harassment was analyzed by Chi–square analysis (Fienberg 1977). A t–test based on the arcsin transformation (Sokal and Rohlf 1969) was used to test the equality of proportions when significance was found during Chi–square analysis. Distance fled in response to harassment and activity budgets based on actual time spent in various behaviors were analyzed by two–way analysis of variance for unbalanced designs (Bryce 1970) and differences between means were compared by Fisher's LSD procedures (Steel and Torrie 1980). Differences in group wariness between areas and through time were determined using binomial Chi–square analysis (Cochran and Cox 1957). The 0.05 level was selected as the level of statistical significance.

Results

Immediate Behavioral Response

Bighorn were deliberately harassed on several occasions in both the Red Canyon ($n = 108$) and White Canyon ($n = 118$) areas. Immediate behavioral response by desert bighorn sheep to human harassment differed between the areas ($X^2 = 31.7$, $df = 1$, $P<0.001$). Red Canyon bighorn were more reactive than White Canyon bighorn as evidenced by the significantly greater proportion (Red Canyon 83 percent, White Canyon 47 percent) of harassment trials that resulted in flight ($t = 6.2$, $P<0.001$) and by the significantly lower proportion (Red Canyon 17 percent, White Canyon 53 percent) of trials that resulted in nonflight responses ($t = 6.2$, $P<0.001$) relative to White Canyon bighorn (Figure 1).

Distance Fled

Average distance fled by harassed desert bighorn was compared between Red and White Canyon areas for trials that resulted in flight responses (walking or running

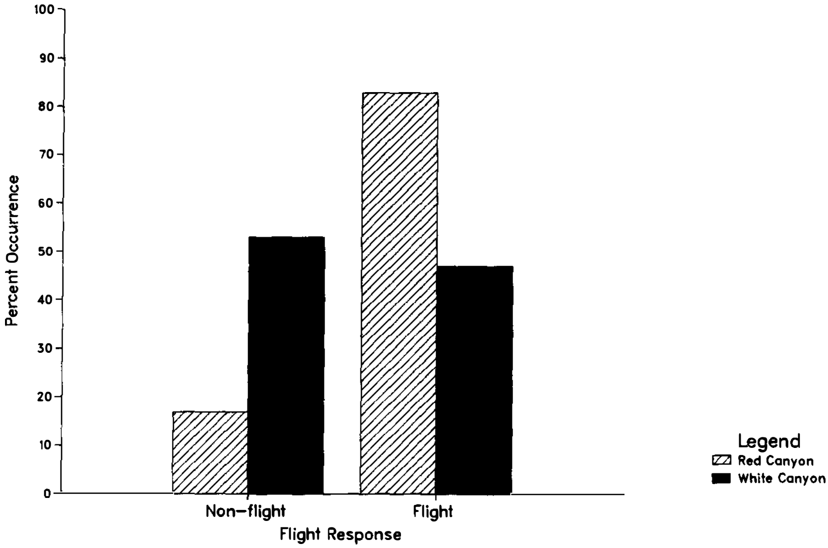

Figure 1. Flight responses of desert bighorn sheep as a result of human harassment in the Red Canyon and White Canyon areas of southeastern Utah.

flight). Red Canyon bighorn fled significantly farther ($F=21.5$, $P<0.001$) than did White Canyon bighorn after harassment (Figure 2). Average distance fled by Red Canyon bighorn was 3563 feet (1086 m), compared to 1296 feet (395 m) for White Canyon bighorn.

Group Wariness

Significant differences in group wariness (proportion of animals per group engaged in attention and/or flight behaviors at five-minute intervals after harassment) between Red Canyon and White Canyon bighorn were determined through time (Figure 3) by binomial Chi-square analysis. For both ram and ewe group types, Red Canyon bighorn were more wary than White Canyon bighorn (ram groups $X^2=91.5$, $P<0.005$; ewe groups $X^2=569.5$, $P<0.005$), although the proportion of animals exhibiting wariness behavior decreased through time in both areas (ram groups $X^2=101.0$, $P<0.005$; ewe groups $X^2=593.0$, $P<0.005$). Initially, a greater proportion of Red Canyon rams and ewes exibited attention or flight behavior than did White Canyon rams and ewes. However, through time, a significantly higher proportion of Red Canyon rams and ewes remained at attention than did White Canyon rams and ewes (area by time interaction–rams $X^2=23.1$, $P<0.05$; area by time interaction–ewes $X^2=143.4$, $P<0.005$).

For mixed groups, a significantly greater proportion of Red Canyon bighorn exhibited attention or flight behaviors than did White Canyon bighorn ($X^2=178.1$, $P<0.005$), and significantly more bighorn were engaged in wariness activities immediately after harassment compared to several minutes after the disturbance in both Red and White Canyon areas ($X^2=509.4$, $P<0.005$). However, there was no signif-

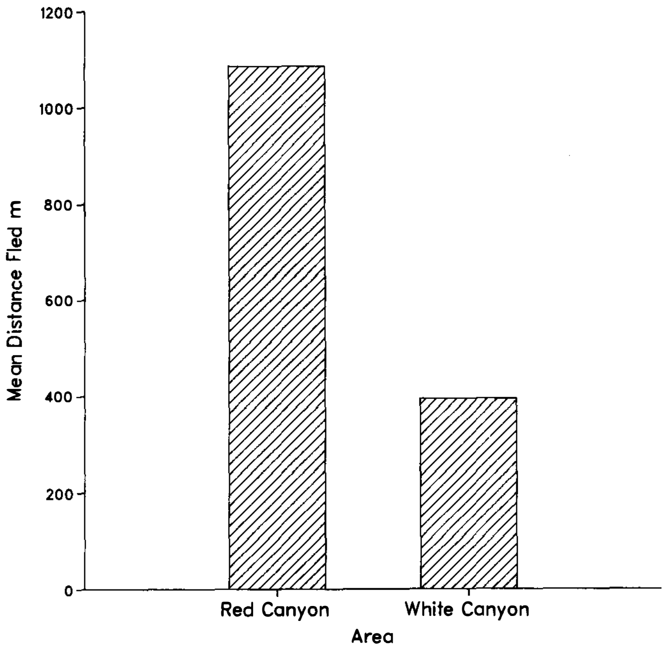

Figure 2. Average distance fled by desert bighorn sheep as a result of human harassment in the Red Canyon and White Canyon areas of southeastern Utah.

icant interaction between area and time for mixed groups, indicating that group wariness was consistently greater in Red Canyon groups than in White Canyon groups at all five–minute intervals after harassment ($X^2 = 14.9$, $P > 0.10$).

Activity Budget

Activity budgets of desert bighorn sheep based on actual time engaged in various behaviors were compared between Red and White Canyon areas under harassed (bighorn in the prolonged presence of hikers and/or vehicles) and unharassed conditions. Throughout the year, there were no notable differences in the amount of time spent by Red and White Canyon bighorn in various behaviors under unharassed conditions. However, under harassed conditions there were significant differences between the two areas with respect to attention and feeding behaviors (Table 1).

During spring and summer, Red Canyon bighorn spent significantly more time at attention than did White Canyon bighorn under harassed conditions. And during summer, harassed Red Canyon bighorn spent significantly less time feeding than did harassed White Canyon animals. Also, under unharassed conditions, they fed significantly more than White Canyon bighorn did, but it is not known if the increased feeding during unharassed conditions was compensatory for decreased feeding during harassed conditions.

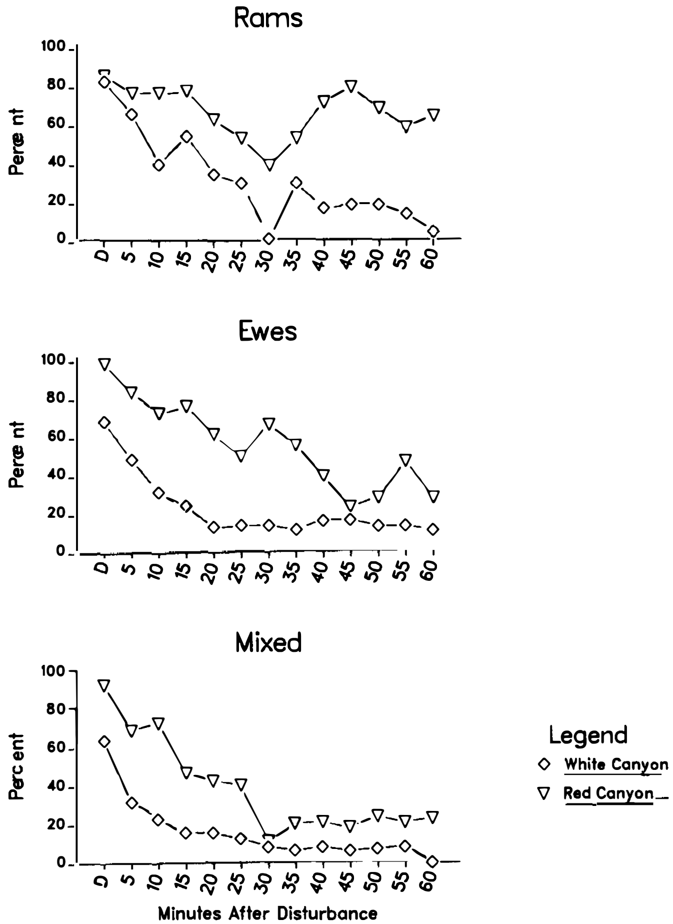

Figure 3. Comparative wariness of ram, ewe and mixed desert bighorn sheep groups of Red Canyon and White Canyon, Utah, during continuous disturbance.

Discussion

Sound management of desert bighorn sheep populations is an important goal of wildlife and land management agencies in the western United States. As has been pointed out in a recent series of papers on the adaptiveness of desert bighorn sheep to their environments (Bailey 1980, McCutchen 1981, Hansen 1982), desert bighorn sheep have generally not shown resilience to interaction with humans. In order to maintain viable desert bighorn populations, wildlife and land managers need to understand the effects of human disturbance so those impacts can be incorporated in planning efforts. The information provided by this study—that behavioral differences are clearly evident as a consequence of contrasting disturbance histories—

Table 1. Average time spent by desert bighorn sheep in attention and feeding behaviors per 15-minute observation period under harassed and unharassed conditions.

Season	N	Attention (minutes)	Feeding (minutes)
Winter			
Red Canyon/unharassed	40	0.9	8.1
White Canyon/unharassed	17	0.0	6.5
Red Canyon/harassed	54	4.1	6.2
White Canyon/harassed	41	4.1	4.4
Spring			
Red Canyon/unharassed	43	1.2	4.7
White Canyon/unharassed	21	1.1	6.9
Red Canyon/harassed	42	6.8[b]	2.7
White Canyon/harassed	55	3.9	4.5
Summer			
Red Canyon/unharassed	16	0.9	8.0[c]
White Canyon/unharassed	72	0.2	5.3
Red Canyon/harassed	54	6.3[b]	3.0[b]
White Canyon/harassed	62	3.5	5.7
Fall			
Red Canyon/unharassed	15	0.2	7.5
White Canyon/unharassed[a]			
Red Canyon/harassed	30	2.6	5.3
White Canyon/harassed	42	2.7	7.1

[a]No observations of unharassed White Canyon bighorn were made, so no statistical comparisons made during fall.
[b]Significant differences ($P<0.05$) between Red Canyon and White Canyon bighorn under harassed conditions.
[c]Significant differences ($P<0.05$) between Red Canyon and White Canyon bighorn under unharassed conditions.

should be of use in formulation of management plans for desert bighorn in southeastern Utah as well as other areas.

Results of the study indicate that desert bighorn historically exposed to higher levels of human disturbance are more sensitive to human encounters than are bighorn in relatively undisturbed areas. Bighorn that have experienced more negative encounters with humans responded more severely, fled farther and exhibited wariness for longer periods of time. Although exact energy expenditures for the above activities are not known, it can be reasonably assumed that the disparity in behavior indicates that Red Canyon bighorn spent more time in energy costly behaviors when confronted by humans than did White Canyon bighorn, which were exposed to fewer negative experiences.

Efficient use by bighorn of their habitat requires a high degree of awareness. They are highly sensitized to stimuli indicating the presence of food, conspecifics, predators, etc. However, if the bighorn are continually aroused, as from human disturbance, the added costs of excitement and escape override long-term energy conservation adaptations that bighorn possess. Thus, energy necessary for maintenance, growth and reproduction is unavailable.

Harassment in any season can have negative impacts on desert bighorn, depending on the intensity of the disturbance. However, there are times when the effects of harassment will likely be more severe. Spring harassment can be particularly harmful to pregnant or lactating ewes in terms of energy costs. Rapid growth by lambs and lactation by ewes demand high amounts of energy (Moen 1981). Energy spent in excitement or flight would subtract from the total needed to maintain adequate milk production and growth. During the course of the study, desert bighorn ewes with lams were harassed on several occasions. Response was generally greater than in other seasons in both areas, though the response by Red Canyon animals was greater than that of White Canyon bighorn. Running flight by ewes with lambs was the most common response, the distance fled by ewes with one–to two–week–old lambs often exceeded several miles. Extreme energy expenditure in cases like these cannot be beneficial for small lambs.

Summer can also be a critical season for desert bighorn in southeastern Utah as well. Response to harassment and distances fled are comparable to those for spring, but unlike in spring when forage is relatively nutritious, summer forage is at its lowest nutrient levels (Hull 1984). Bighorn flight from harassing stimuli could be particularly severe if energy expended could not be recovered from nutrients available in their diet. Measures should be taken to minimize major disturbances during spring and summer that would cause lactating ewes and young lambs to expend large amounts of energy to excitement or flight.

White Canyon bighorn can be expected to continue to be tolerant of people as long as they are not actively hunted. If hunting pressure increases in the White Canyon area, bighorn behavior will likely begin to resemble that of Red Canyon animals. Differences in behavior between hunted and unhunted animals have been noted for a variety of ungulate species (Geist 1971, Dorrance et al. 1975, Horesji 1976, Schultz and Bailey 1978, Berger et al. 1983). These differences are particularly evident when comparing relatively tame behavior exhibited by protected wildlife in national parks to wary behavior of nearby animals that are regularly hunted.

Red Canyon bighorn have experienced considerably more negative interactions with people and are more sensitive to human activities than are White Canyon bighorn. It can be expected that, if hunting patterns continue *status quo*, Red Canyon bighorn will continue to react severely to human presence. This response can also be expected when hikers, miners, geologists, ranchers, researchers and other humans encounter Red Canyon bighorn because, like other ungulates, bighorn are not capable of differentiating between hunters and nonhunters and react the same towards both groups (Horesji 1976). Based on this premise, Geist (1971, 1975b) suggested that hunting—a consumptive use—was not compatible with nonconsumptive uses, such as photography, wildlife observation and development.

The issue of incompatability of consumptive and nonconsumptive activities has significant implications for the management desert bighorn sheep throughout the western United States. Much of desert bighorn habitat is public domain and subject to multiple use by the public. Therefore, varied interests including mining, livestock operations, hunting and other recreation, etc., compete for available land. Wildlife and land managers will have to cooperate to make management decisions that will take action to ensure interests of desert bighorn are considered. These decisions may mean significant trade-offs between agencies to guarantee that bighorn populations remain stable. To maintain bighorn populations, it may be necessary that land management agencies will have to withdraw crucial bighorn habitats as potential development sites. Or, wildlife management agencies may have to eliminate hunting and initiate complete protection of desert bighorn in areas destined for development and intense disturbance.

Present levels of human activity in desert bighorn habitat in the Red and White Canyon areas are relatively low. Encounters between desert bighorn and humans are generally infrequent and occur primarily during spring and fall seasons. The level of disturbance in the area is probably not severe enough to impact bighorn at the population level. However, disturbance to bighorn populations by people will undoubtedly continue as demands increase for recreation in remote areas. The potential for human interaction with desert bighorn in southeastern Utah is also on the rise because of the area's increasing popularity with recreationists. If the potentially negative impacts of these encounters are to be buffered, comprehensive management plans must be developed that address all aspects of human disturbance. This will require extensive research on how bighorn respond to harassment physiologically and demographically as well as behaviorally. Until such supplemental data are available desert bighorn sheep should be managed conservatively.

Summary

Behavioral response of desert bighorn sheep to human disturbance was evaluated in southeastern Utah from 1981 to 1983. Bighorn response was compared between two areas with contrasting disturbance histories. Red Canyon bighorn have been exposed to greater levels of hunting pressure and vehicular traffic than have White Canyon bighorn. To determine if differences in behavioral response to human disturbances existed between Red Canyon and White Canyon bighorn, groups of bighorn were deliberately harassed by vehicles and hikers. Immediate response and distance fled by bighorn were recorded during harassment trials. When bighorn remained in the presence of the harassing stimuli, actual time spent by bighorn in various behaviors was recorded to determine group wariness and activity budgets under harassed conditions. Bighorn were also observed under unharassed conditions to compare behavior under those two circumstances.

Eighty-three percent of harassment trials illicited flight responses from Red Canyon bighorn compared to 46 percent for White Canyon bighorn. Average distance fled as a result of harassment was approximately 2.75 times greater for Red Canyon bighorn than White Canyon bighorn. Group wariness was exhibited at more intense levels by Red Canyon bighorn than White Canyon bighorn when they remained in the presence of harassing stimuli. Activity budgets of unharassed bighorn were similar between areas. However, activity budgets of harassed animals differed significantly between areas particularly with respect to attention and feeding behaviors. Under harassed conditions, Red Canyon bighorn were at attention longer and fed less than did White Canyon bighorn.

Behavioral response of desert bighorn to encounters with humans were more severe and thus more energy costly for animals that had been historically exposed to relatively high levels of human disturbance. Wildlife and land managers should include evaluation of past disturbance history in bighorn habitat and plan to minimize potentially harassing human activities in crucial habitat particularly if bighorn have been exposed to high levels of human disturbance. Further research is needed to determine physiological and demographical impacts of human disturbance on desert bighorn sheep. Until such data are available, desert bighorn populations should be managed conservatively.

Acknowledgments

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Management Challenges and Innovative Responses: Case Histories

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Introductory Statement

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Wildlife professionals receive extensive advice about what they should and should not be doing. Perhaps the current round was initiated about 10 years ago with Caughley's (1976) remark that wildlife management had made no qualitative advance in theory or practice since Leopold (1933). That stimulation was followed by such comments as those by Romesburg (1981), who argued that much of wildlife management was based on an indefensible data base. Bailey (1982) felt that management had been demeaned by the heavy emphasis on science, and claimed that management was as demanding of intellectual skills and innovative thinking as was research. Then, McNab (1983) encouraged us to conduct management by establishing hypotheses to test, as an objective way of improving our efforts.

While all of this enters the literature and discussion, the conservation dollar is in short supply. In fact, I had an opportunity in 1976 to question wildlife officials in the states and provinces that have elk about whether they thought more funding was needed for elk research, management, and habitat acquisition and management (Peek et al. 1982). To a person, the response was that more dollars were certainly needed, but that it was very unlikely that they would materialize. Things have not gotten any better in the ensuing 10 years and they likely won't in the next decade either: a more rigorous management effort means a more costly one.

So the wildlife manager is faced with several alternatives: make do with what funding is available and muddle along as best we can; attempt to locate other sources of funding by innovative methods, such as auctioning off bighorn sheep hunting permits; attempt to combine forces with others and address opportunities on a cooperative basis, pooling what resources are available; cut back to the most essential activities. There are plenty of other examples of alternatives.

Those of us who have observed resource management in action over a period of years are aware that the need for different resource professionals to cooperate more effectively with each other has been evident for a long, long time. Now, we are placed under more pressures to use the conservation dollar more effectively than ever, to integrate resource management, as Cutler (1982) pointed out.

But opportunities go unnoticed when concern centers on more dollars and the lack of support that appears to prevail. In fact, there are examples where people have found ways to work together more effectively in today's climate to improve resource management. This session presents examples of such innovative activities. At a time when dollars for conservation are dwindling, people are indeed finding that some of the time–tried means of achieving goals are useful. Combining forces with others—once perceived as being inalterably in conflict with one's own goals—is now being pursued. Old–fashioned innovation stemming from use of the collective brawn and brain of folks who find it opportunistic to work with each other is now occuring. Now, we find mining companies working with wildlife agencies, federal range managers and state wildlife officials coordinating plans effectively, native Americans and other subsistence hunters working with wildlife biologists, the U.S. Department of Defense working with state and federal wildlife groups, and private resource management organizations becoming increasingly important.

Much of this must be attributed to the wealth of federal legislation that developed in the early 1970s and now requires specific consideration of wildlife on federal lands and elsewhere. This legislation set a pattern that has encouraged cooperative arrangements in many ways. In some cases, coordination between competing uses was mandated by law and implemented on that basis. But in other cases, an effort to avoid federal intervention fostered cooperation between organizations at other levels.

The climate in which wildlife management exists will not become more relaxed in the future. We should expect to justify our activities more adequately. We will need to bring a more scientific and objective approach to our management. But when we promote more cooperative approaches to management which help to foster understanding of our problems and involve more people besides those traditionally involved, we likely make the task of providing effectively for wildlife easier in the long run.

So I submit that innovation includes efforts to cooperate with others in pursuing wildlife management. I suggest that a more rigorous approach to wildlife management involves working more effectively with others. And I further argue that this does not necessarily take more dollars, only those time–tried human virtues of good will, respect for the other person's views and a willingness to learn together. The wildlife resource stands to benefit immensely, if not the most, from these efforts.

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The Impacts of Phosphate Mining on Big Game in Idaho: A Cooperative Approach to Conflict Resolution

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Introduction

Wildlife habitat in southeastern Idaho is abundant, productive and capable of supporting high populations of mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*) and moose (*Alces alces*). Unfortunately, from a wildlife viewpoint, some of the world's richest known phosphate reserves are also located in this area, generating a concern that the development of these reserves could severely impact the quality and quantity of big game populations and their habitat. Complicating the potential problem of phosphate–mining impacts on Idaho's wildlife resources is the imbalance in consumption of refined phosphate products by the United States and the worldwide availability of this resource. The United States now consumes over 75 percent of all processed phosphate products in the world, but possesses only 14 percent of the reserves. Particularly disconcerting to the Idaho Department of Fish and Game was the knowledge that over 35 percent of this country's known phosphate reserves lies to the east of Soda Springs.

In addition to elemental phosphorus, phosphate is an essential fertilizer component critical to our agriculture industry. Based on current projections, the world population is expected to double by the year 2000. With few additional lands available for conversion to agriculture, increased food production must be met through increased crop yield, i.e., more fertilization. This situation, unfortunately for the sportsmen of Idaho, will dictate the continued and expanded development of Idaho's phosphate reserves.

Despite the obvious need for more information on the potential impacts on Idaho's big game populations, a study to investigate the impacts of mining on big game evolved out of controversy. By the summer of 1974, the magnitude of the projected growth of the phosphate industry in southeastern Idaho was apparent. The Secretary of the Interior and the Secretary of Agriculture jointly determined that the projected development of phosphate reserves was a "significant Federal action" under the National Environmental Policy Act of 1969. A draft Environmental Impact Statement (EIS) was initiated by a Task Force made up of several federal resource agencies. However, then–Governor Cecil D. Andrus challenged the draft EIS for its "severe weakness" in not adequately involving state agencies, including the Idaho Department of Fish and Game. The Department, in response to the governor's position, released a series of five news releases intended to communicate to the people of Idaho its concern related to the potential impacts of phosphate mining on the wildlife and fishery resources in southeastern Idaho.

The Idaho Mining Association followed suit with their own series of news releases that charged the Department with intentionally inflaming, emotionalizing and exaggerating the potential impact of phosphate mining. The Association further charged the Department with intentionally orchestrating public sentiment in Idaho against mining in general. The undercurrent of the mining industry's position questioned the Department's ethics and insinuated that its position was less than objective.

Response to the press campaign created a highly polarized political situation, with conservationists and their concern for the richness of the wildlife resources on one side and the mining community and their concerns for the development of phosphate resources and jobs on the other. The result was a battle with no middle ground and a total breakdown of communication, respect and regard for each other's position. It became apparent that the driving force behind this polarized atmosphere was an absence of knowledge about phosphate mining impacts on big game populations and their habitats in southeastern Idaho. In the absence of information and understanding, the Department, which is mandated by state law to "manage, protect and perpetuate" Idaho's wildlife resources, opted to take a broad–based position to protect these values, rather than a narrow base for which it might be sorry later.

Early in the EIS process, the Department recognized the need for an improved information base about phosphate mining impacts, but questioned the commitment of sportsmen's dollars to a situation in which others would profit and/or in which the Department did not play a direct role in the decision-making process. Therefore, in 1976, the Department proposed a cooperative study to broaden the information base, with support for the study being generated equally from state, federal and private mining resources. With an emphasis on objectivity, the intent of this approach was to establish one study to meet the individual needs of all cooperators. The objective of the study was not to stop mining, but to strengthen the data base on mule deer, elk, moose and their habitats within the phosphate impact area, and to suggest methods to minimize mining impacts on these resources. The ultimate goal of the study was to build an information base that could be included in the decision-making and planning processes of all cooperators and to allow simultaneous perpetuation of wildlife resources and development of phosphate.

The study was conducted on a 946–square mile (2450–sq. km) area in southeastern Idaho, between Soda Springs and the Wyoming border. This area included 15 of the 16 current and submitted mine plans, including 83 different federal phosphate leases that covered over 43,000 acres (17,400 ha). A two-phase study was designed to evaluate the impacts of phosphate mining on big game. The first phase, or baseline data phase, was designed to provide an ecological description of unmined portions of the study area to serve as a basis for decisions to minimize future phosphate mining impacts on big game populations and their habitat. In addition, these data served as a foundation for the second phase, or mining–impact phase of the study.

Implemented in 1976, this effort evolved into a multisupport program, with active involvement from phosphate mining companies, including the J. R. Simplot Company, Monsanto Chemical Intermediate Company, FMC Corp., Conda Partnership, and to a lesser extent Alumet. Three federal agencies were involved—the U.S. Forest Service, Fish and Wildlife Service, and Bureau of Land Management—as was the Idaho Department of Fish and Game. Research funded by the Department was supported through Federal Aid to Wildlife Restoration Project W-160-R.

Baseline Data Phase

Helicopter Inventories

The baseline phase (Kuck 1984a) was initially directed towards traditional wildlife management concerns, particularly winter range. Winter habitat was considered especially important because of the severe winters with deep snows. A series of six intensive helicopter inventories over four winters was conducted to determine big game population sizes, composition, winter distribution and physical characteristics of winter habitat. Highest counts for each species were 763 elk, 3,205 mule deer and 343 moose. Comparison of counts with data from the late 1960s and early 1970s suggested that mule deer populations had declined substantially, elk populations had remained stable and moose numbers had increased.

Winter distribution patterns appeared to be dictated by each species' ability to negotiate deep or crusted snows (Kelsall 1969, Gilbert et al. 1970). Mule deer—the smallest and most sensitive to snow depths—were concentrated at low elevations around the periphery of the study area. Elk, in contrast, were able to utilize numerous windswept ridges in the interior of the area. This differs from elk winter habitat observed in most parts of the northern Rockies (Peek 1982). These ridges are generally swept bare by prevailing westerly winds. Because of their larger size and tolerance of deeper snows and colder temperatures, elk were able to utilize fully these higher elevation steppe-grassland areas. Moose were most tolerant of snow, and were usually found on northern and eastern exposures, in aspen and conifer stands.

Winter distribution and habitat use varied substantially between the three big game species, and appeared to be an ecological strategy to minimize interspecific competition.

Telemetry Studies

In order to strengthen initial findings, a radio–telemetry study was initiated in 1977 (Ackerman et al. 1983). Radio collars were placed on 41 female elk, 52 mule deer and 20 moose. A total of 6,619 aerial locations were made on those animals over four and a half years. Winter habitat–use patterns from telemetry were similar to those found by aerial surveys, although changing use patterns through the winter and differences between years of varying snow conditions were more pronounced. Summer habitat use by elk and deer differed substantially from winter ranges, but less so for moose. Likewise, migratory patterns and home range use varied substantially between species.

Mule deer were highly migratory, and most moved 10–20 miles (16–32 km) to summer range. Three narrow migration corridors used by this deer herd were identified. The deer left winter ranges in late April. Instrumented animals showed a strong tendency to use the same rather–small summer home range each year. Aspen and conifer types at higher elevation were predominantly used in summer. Deer returned to larger winter range in late November but individuals often used different winter ranges from year to year.

In contrast, elk were more nomadic than migratory, using large, overlapping areas winter and summer. This differs markedly from long migrations observed elsewhere (Knight 1970, Craighead et al. 1972). Use of small calving areas was highly traditional and predictable. Later in summer, wandering use of larger areas was observed. Elk used aspen types in early summer, especially when calving, but switched to conifer types in later summer. Winter ranges were typically adjacent to or overlapped summer ranges, and elk often used different small wintering areas over the course of a winter, or in different years.

Moose were also somewhat nomadic, rather than migratory. Winter and summer ranges were almost identical. Summer habitat, like winter, was in high elevation aspen and conifer types. Cooler conifer types were used more in late summer. Long migrations were not observed here, as they were in other areas (Knowlton 1960, Ritchie 1978).

Mining–Impact Phase

The baseline information set the foundation for the mining–impact phase (Kuck 1984b) of the study. With increased understanding of populations and habitat relationships on unmined portions of the study area, potential impacts of mines could be objectively assessed.

Mining Impacts on Big Game Habitat

A primary concern was the loss of quality big game habitat. Surface phosphate mining has occurred in southeastern Idaho since 1945. In 1983, 5 million tons of ore worth $130 million were taken from 7 mines, with a predicted 10 million tons to be taken from 14 mines by the year 2000 (USDI and USDA 1976). Pattern–recognition concepts were used to develop a habitat–evaluation model for big game on the study area (Williams et al. 1978, Evans 1983). Five models for elk and mule deer, on both winter and summer range, and for moose on year-round range were developed, tested and validated. They were found to predict total populations on the study area within 5 percent of that projected from helicopter inventories.

These models were then used to estimate impacts of current and future phosphate–mining activities. Habitat potential for each mine was estimated at 10–year intervals, from 1950 to 2010. Results suggested that areas that will be mined (2 percent of the study area) are high quality habitat, but that mining-related habitat losses (4 to 6 percent of habitat potential) are still relatively small. Unexpectedly, a different source of habitat loss was found to be much more important, especially to mule deer. Natural succession, from aspen to conifer–dominated vegetation types, that resulted from widespread burning at the turn of the century, followed by fire suppression, was predicted to cause a much larger decline in habitat potential on summer range.

Mining Impacts on Habitat Use

Direct loss of habitat to surface mines is compounded by possible displacement of animals from habitat adjacent to mining activities. This could result from increased noise, human activity, equipment operation, lights, dust or increased recreational access. Ward (1976) found decreased elk use near logging operations, and Perry and Overly (1976) found vehicle traffic reduced elk use near roads. In an attempt to quantify seasonal displacement, big game use near two existing mines was documented using pellet–group transects. Eighty transects, each consisting of twenty 0.01-acre (0.004 ha) circular plots, were placed near mines. Forty transects each were on winter and summer range. The 40 transects at each area were divided into five vegetation types and four distance intervals less than 1 mile (1.61 km) from the mines. Forty additional transects were established as controls greater than 1 mile from mines.

Limitations of the pellet-group technique for discerning habitat use were recognized (Collins and Urness 1979), and other problems occurred. Unexpected intense use by domestic sheep precluded analysis of mule deer pellet data. High variation in number of pellet groups observed between transects further obscured results.

Elk were shown to use most vegetation types near mines less than those greater than 1 mile away. However, in winter, the importance of certain windswept grassy ridges apparently outweighed the factor of nearness to the mine, and the vegetation types close to mines were more heavily used than those in the control areas. Likewise, in summer, some portions of the aspen and aspen/conifer type were used more than control areas. Moose used areas near mines less than control areas in winter, but no difference could be detected on summer range.

Although some decline in use near mines was observed, there was still a reasonably high level of acceptance of mining activities. It should be noted, however, that these mines had been in operation for over 10 years, and temporary or local displacement could already have occurred. A detailed study before and after mine development would have been more instructive.

Impacts of Simulated Disturbance on Elk Calves

To assess better the impacts of mining disturbance, a more direct method of detecting disturbance was sought. An attempt to use implanted heart–rate transmitters to indicate stress in deer failed for technical reasons. Therefore, an effort was made to disturb animals intentionally, then look for differences in behavior between disturbed and undisturbed animals. A controlled experiment to ascertain disturbance impacts on elk calves was initiated in 1981 (Kuck et al. 1985). The highly traditional use of specific calving areas by cow elk had suggested that these were physiologically important areas. In 1981, 13 elk calves were radio-collared on two similar, adjacent calving areas. Five calves on the south area were controls, and not disturbed. Both groups were relocated aerially every second day to evaluate impacts of the disturbance. Disturbed calves were found to have moved twice as far, used eight times as large home areas, and made four times greater elevational changes. Some disturbed calves were forced off traditional calving habitat into atypical areas, either by the simulated disturbance or by helicopter capture operations.

In 1982, the experiment was repeated on 12 more calves, using a disturbance more typical of mining activities. Five calves in the disturbance group were exposed to recorded mining noise using portable backpack tape player and loudspeakers. The mine noise was played continuously along a four–mile (6.486–km) transect through the "disturbed" area, at a volume of 100 dBA. Simulation sessions were run from 9 June to 16 July.

As was found the previous year, disturbed calves moved 1.5 times as far as did undisturbed calves, used six times as large areas, and made three times greater elevational changes. Disturbed calves and their mothers used higher elevations, steeper slopes and more northerly aspects. They used the aspen type relatively less. This use of types other than the warm, southerly aspen stands was expected to have important energetic consequences. However, despite the intense level of disturbance, no abandonment of calves was observed in either group. Further, these animals were monitored through the following winters and no calf mortality was observed in either group, even in the severe winter of 1981–82.

Impacts on Mule Deer Migration

An initial cause for concern was the potential for strip mines along ridge tops to act as barriers to migration. Animals could conceivably be trapped on summer range behind these long mines. Ungulate movements have previously been found to be affected by interstate highways, railroads and pipelines (Gilbert et al. 1971, Klein 1971, Ward et al. 1973, Cameron and Whitten 1980, Hanna 1982). Elk and moose migrated long distances elsewhere in eastern Idaho but only mule deer exhibited long migrations here. Emphasis, therefore, was shifted toward impacts on deer, particularly during fall migration, when heavy snows might require deer to move rapidly down from high elevations, across a series of ridges to winter range.

One mine of particular concern was the Maybe Canyon Mine. This is a steep-walled, open pit almost 5 miles (8.045 km) long, with only one short break, situated on a ridge perpendicular to an important deer migration route. Since 1978, 23 radio-collared deer (some individuals for five consecutive years) were monitored as they migrated past this mine. In most winters, no difference could be detected in the time deer needed to pass the Maybe Canyon Mine. Deer passing through the mine and those traveling further south both took one to six days. However, in 1978, two deer passing through the mine took 11 and 27 days to get through. In 1981, one radio-collared doe and several others died behind the mine.

Data collected from 1978–83 substantiated original concerns that, in harsh winters, deer could be seriously delayed and some mortality could occur. In milder winters, however, deer demonstrated some ability to adapt and successfully negotiated the mines. Fortunately, since the beginning of this study, the phosphate industry has agreed to increase backfilling of pits as development proceeds. The Maybe Canyon Mine has also submitted a revised plan to fill part of the pit currently blocking this important migration route.

Twenty-one deer were monitored during spring migration from 1979 to 1981. There was no indication that deer movements were hindered by mining activities during spring migration. Since the deer are not under the same pressure to arrive as in fall, their spring migration is not believed to be seriously affected by mining activities.

Illegal Harvest

Although this study was not specifically designed to document illegal harvest and crippling loss, the apparent impacts of those factors are substantial. A total of 113 radio–collared females were monitored from January 1977 to July 1981. When an animal died, cause of death was determined if possible. In some cases, illegal harvest was assumed, based on circumstantial evidence. Presumed illegal kill and crippling loss accounted for a high proportion of deaths among doe deer (47 percent), cow elk (55 percent) and cow moose (86 percent). Apparently because of limited hunting pressure on each female segment, legal harvest was light. Natural mortality, largely related to winter condition, was higher among deer (41 percent) than elk (27 percent) or moose (14 percent).

Although sample sizes were small, illegal harvest clearly was a major problem on the study area. A combination of human population growth and increases in secondary roads results in extensive backwoods travel in four-wheel drive vehicles, with potential for easy, undetected illegal harvest.

Conclusions

Results of this study indicate that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges or for increased mortality associated with industrial development. Most of the impacts here, and others not studied, are believed to have some negative effect on productivity or population numbers. While not proven, it is probable that, without careful management the cumulative effect of these impacts will be reduction in big game populations. Because only 2 percent of the study area will actually be mined, there are many management alternatives for the remaining 98 percent.

Only general results and conclusions have been presented here. More–detailed information is reported in Kuck (1984a, 1984b), and can be obtained from the author.

Specific recommendations have been made (Kuck 1984b) to: (1) minimize loss of habitat at mine sites; (2) minimize disruption of mule deer migration corridors; (3) protect critical big game habitats, such as winter range and elk calving areas; (4) reduce illegal harvest by minimizing encounters between big game and potential violators; and (5) implement an off–site aspen management program to compensate for habitat losses due to mining.

This cooperative approach to research has not eliminated the impacts on wildlife but has led to an improved information base and clarified perceptions of mining impacts. Equally important, the cooperative approach has led to improved communications and increased respect among opposing resource user groups. The situation now exists for opposing views to be aired in an atmosphere of cooperation rather than confrontation. The long–term value of the cooperative approach will be measured by the extent of implementation of its results into mine planning.

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Combining Agency Goals to Meet Wildlife Needs and Manage Oil and Gas Resources in Alaska

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Introduction

Historical Background

The U.S. Bureau of Land Management (BLM) in Alaska recently completed an intensive effort to combine the goals of BLM, U.S. Fish and Wildlife Service, the State of Alaska, and the North Slope Borough to attain mutually acceptable decisions for managing certain oil and gas resources, biological values and subsistence opportunities in northern Alaska. The area in question was the Teshekpuk Lake Special Area within the 23–million acre (56.83–million ha) National Petroleum Reserve in Alaska (Figure 1).

The National Petroleum Reserve was originally set aside in 1923 as Naval Petroleum Reserve Number 4. It was placed under the jurisdiction of the U.S. Navy for the purpose of finding and producing oil for the Navy. The Naval Petroleum Reserves Production Act of 1976—PL 94-258—changed the name of the Reserve and awarded management to the Secretary of the Interior. The Act recognized both oil and gas potential in the Reserve and high wildlife values associated with the Teshekpuk Lake area.

The Secretary of the Interior in 1977 designated three special areas within the Reserve because of significant subsistence, recreational, and fish and wildlife values. These special areas were the Teshekpuk Lake, Utukok Uplands and Colville River Special Areas (Figure 1). Section 104 of the Act specifically provided that any oil and gas exploration within the Teshekpuk Lake Special Area and any other areas designated by the Secretary, "shall be conducted in a manner which will assure the maximum protection of such surface values to the extent consistent with the requirements of this act for the exploration of the reserve." Conversely, the Act also required an expeditious program of competitive oil and gas leasing. BLM responded by developing an environmental impact statement (EIS) that was completed in 1983 (U.S. Bureau of Land Management 1983a).

To protect the wildlife resources while allowing oil and gas leasing, the EIS, through its Record of Decision (U.S. Bureau of Land Management 1983b), adopted stipulations to protect wildlife values and deleted leasing in parts of the Teshekpuk Lake Special Area. Oil industry interest has been concentrating in northern Alaska since the huge oil and gas discovery was made at Prudhoe Bay in the late 1960s. More–recent offshore discoveries nearby also indicate high potential along the northern coastal area of Alaska. The Teshekpuk Lake Special Area received the highest number of industry nominations for future oil and gas leasing in the reserve, because of the westward progression of oil and gas development. Notably, Prudhoe Bay was developed first, then the Kuparuk oil field was developed farther west. The Teshekpuk Lake Special Area is less than 75 miles (46.6 km) west of Kuparuk.

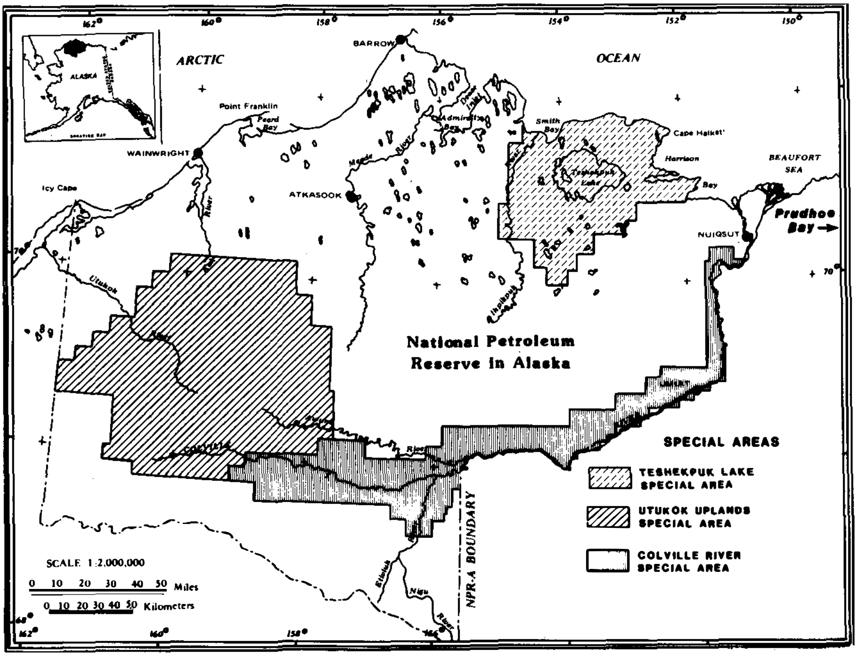

Figure 1. The National Petroleum Reserve in Alaska.

After the final EIS was published and leasing schedules were proposed, an unexpectedly high degree of apprehension was expressed by the public on decisions involving the Teshekpuk Lake Special Area. One of the biggest concerns was for waterfowl, particularly Pacific black brant (*Branta bernicla nigricans*). This concern was expressed nationwide, but especially by people along the western coastal states. The concern centered on possible habitat loss due to oil and gas development, which could accelerate the decline of populations that are already low. To give appropriate attention in response to this concern, BLM elected to reconsider the decisions about the special area, and developed a new approach to a study process. Thus, BLM initiated the Teshekpuk Lake Special Area Study in 1984. The focus was to consider leasing where there is recognized potential for oil and gas, yet not compromise biological values or subsistence uses. The special study was undertaken to protect wildlife values beyond the level afforded by the EIS, which dealt with the entire reserve and had less–specific analysis than could be accomplished in a special study. Furthermore, this special study effort was intended not only to invite public and agency comment, but to go beyond this standard and secure working involvement of key land and resource managers and owners. In the past, other agencies have always been invited to review and comment (consistent with the National Environmental Policy Act) and, on occasion, involved in helping to write descriptions of the environment. However, this study effort is the first time other agencies have been involved in the planning process to the extent of participating actively in developing alternatives and recommendations, and participating in the decision–making process itself.

The U.S. Fish and Wildlife Service was a key agency because of its responsibility for migratory waterfowl welfare and harvest regulation. The state was equally important, as the land manager and owner and custodian of wildlife in Alaska. The North Slope Borough, with a recently completed land–use plan corresponding to its coastal zone management responsibilities for the area, was also a key manager, as well as landowner.

BLM secured active participation in the development of the study by means of memoranda of understanding in which the agencies formally agreed to active involvement. In 1984, a memorandum was signed by the U.S. Fish and Wildlife Service and a separate one was signed with the state (U.S. Fish and Wildlife Service and State of Alaska 1984). A verbal commitment to participate was obtained from the North Slope Borough. Several public meetings were held to encourage the public and industry to comment and provide information.

The U.S. Fish and Wildlife Service and the State of Alaska were enthusiastic about being brought into BLM's decision–making process. The North Slope Borough was also highly interested. Representatives of the petroleum industry were involved in early stages of the study, but it was mandatory to exclude them from part of the process, which involved use of proprietary information.

Industry officials protested that, without their representation, the process was weighted on the environmental side. However, they did acknowledge that BLM is a multiple–use agency with personnel trained specifically in the collection and analysis of mineral information and in management of mineral as well as biological resources.

The study was designed to map (as specifically as possible), analyze and weigh surface resource values in relation to potential subsurface values. This allowed for the best–possible decisions for management of all values within the Teshekpuk Lake Special Area, consistent with congressional intent.

The Area

The Teshekpuk Lake Special Area contains a total of approximately 1,735,000 acres (4,287,185 ha), which is approximately 10 percent of the Alaskan Arctic coastal plain. About 32 percent of the area is water—primarily shallow lakes. Approximately 10,000 acres (24,710 ha) of the area are privately owned by Native allotment holders and corporations, with the remaining 1,725,000 acres (4,262,475 ha) under the management of BLM (Mellor et al. 1985).

The priority species within this study were (1) waterbirds, particularly Pacific black brant, and (2) caribou (*Rangifer tarandus*). Other goose species specifically evaluated were white-fronted goose (*Anser albifrons*), Canada goose (*Branta canadensis*), and snow goose (*Anser caerulescens*). Populations of these four goose species are depleted and decreasing worldwide. The Teshekpuk Lake Special Area has long been considered to be one of the most productive, diverse and sensitive wetland ecosystems in Arctic Alaska. Compared with the rest of the National Petroleum Reserve, the area has approximately six times the average density of geese, five times the average of tundra swans, three times the average of shorebirds, and twice the average of ducks and loons (U.S. Geological Survey 1979). This special area has greater concentrations of molting geese than any other area in North America and eastern Siberia. In particular, more than 20 percent of the world's population of Pacific black brant use the Teshekpuk Lake Special Area during the critical molting stage of their yearly life cycle (Derksen 1978). With such a large seasonal concentration of black brant, as well as thousands of other waterfowl and shorebirds, unwise management of oil and gas development activities could result in significant impacts. The area also has crucial habitat for a caribou herd of approximately 11,000 to 12,000 animals that are year-round occupants (Reynolds 1982). In addition, the special area is used as a subsistence hunting and fishing area by the residents within the region, mainly from the villages of Barrow and Nuiqsut.

BLM set up a unique four–phase process designed not only to involve the major parties, but field, middle and top agency levels as well.

Four–phase Study

The first three phases of the study provided for multiagency participation that consisted of: field–level evaluations by staff specialists, recommendations and alternatives by managers, consultation and deliberation of agency chief executives with the BLM State Director, and the State Director's decision. In the fourth phase, BLM used the State Director's decision to develop an implementation plan.

Phase I—Habitat and Mineral Evaluations

Habitat evaluation. In the Habitat Evaluation (Mellor et al. 1985), all sensitive or crucial biological values were described and geographically delineated, and criteria were developed for use in avoiding impacts. The Habitat Evaluation also delineated crucial goose (particularly black brant) molting, nesting and staging habitat. And it described fisheries resources and crucial caribou habitat, such as calving grounds and insect–relief areas, and discussed important subsistence uses.

Separate zones requiring different levels of protection were displayed on maps. The higher the biological value of a zone, the greater the need for protection. These zones were based mostly on seasonal population densities and sensitivity to oil and gas development for species of high interest. The focus on zones facilitated comparisons of risk that would be expected to occur from possible oil and gas development. This provided for understanding of where protection and conflict resolution would be needed most, because the higher the biological value, the greater the potential for conflicts.

Mineral evaluation. The Mineral Evaluation was designed to ensure that the decisions being made were based on the latest and best mineral information possible. This made it necessary to use confidential information obtained from private companies. Therefore, two documents were required—one public (Mellor and Menge 1985a) and one confidential (Mellor and Menge 1985b)—because BLM is prohibited by law from divulging proprietary information. The public document only provided a general evaluation of different oil and gas potential, but the confidential document displayed specific oil and gas prospects.

This evaluation provided three kinds of information to the decision makers: (1) the oil and gas potential of the study area; (2) surface impacts associated with petroleum development; and (3) information on economic trends and marketability. It also discussed: the location, size and development potential of oil and gas prospects; the facilities and equipment necessary to develop oil and gas; the lack of available gravel for construction and the alternative use of sand; the use of technology to reduce impacts; recent energy developments and impacts in the area; and evaluations of energy economics.

Phase II—Recommendations and Alternatives

This was an analysis of the Habitat and Mineral Evaluations. During this phase, a task group of seasoned managers from the BLM, U.S. Fish and Wildlife Service, and the State of Alaska deliberated four days to weigh mineral and biological values. This multiagency task group was provided with specific confidential oil and gas information, and the participants signed statements to maintain data confidentiality.

The goal was to reach consensus on a range of alternatives, recommendations and protection criteria that optimized the exploration and development of petroleum resources, while providing appropriate consideration for and protection of crucial biological values and subsistence opportunities.

A facilitator led the task group in analyzing the areas of conflict. Each manager on the task group, as a representative of a different agency, carried his own idea of the perceived importance of biological versus mineral values, based on his agency's charter. Maps from the Habitat and Mineral Evaluations were overlaid. Those areas within high oil and gas potential overlying high biological values displayed areas of concern and conflict, requiring the most resolution. There was little overlap of significantly high values, since the oil and gas values were low compared with biological values.

Phase II was highly successful, as consensus was reached on a range of alternatives, recommendations and protective criteria to be considered in the next phase. These alternatives, recommendations and criteria were described and presented in a document, the *Teshekpuk Lake Special Area Study Phase II Recommendations and Alternatives* (October 3, 1985).

Phase III—State Director's Decision

As part of this phase, a panel including the BLM State Director and other agency chief executives from the North Slope Borough, U.S. Fish and Wildlife Service, and State of Alaska attended a public meeting in Anchorage. The objective was to obtain testimony from the public and industry, then use it to temper agency concerns when providing consultation to the State Director during final Phase III discussions. Following the public meeting, the panel reconvened and reached a consensus on the recommendations and protective criteria. The chief executives, however, were split on the choice of any one alternative, but consensus was reached that a decision should come from within the range of alternatives.

Ultimately, the State Director had to resolve the debated positions that favored different alternatives, and arrive at a reasonable decision based on his own best judgment. That proposed decision (Penfold 1986) follows.

Leasing. One and one-half townships will be offered for lease in upcoming lease sales for the National Petroleum Reserve in Alaska. Other areas will not be reconsidered for leasing for approximately seven years unless the following criteria are met:

- studies show the areas are no longer critical to the life cycle of caribou, black brant and national species of special interest as listed by the U.S. Fish and Wildlife Service; or,

- analogous situations have demonstrated a high degree of compatibility with calving caribou, molting black brant and national species of special interest as listed by the U.S. Fish and Wildlife Service; or
- new or improved resource estimates or Department of the Interior directives establish that potential oil and gas values outweigh potential environmental losses.

Habitat protection. Any use–authorization permits will include rigorous stipulations to protect species of special interest and their habitats. Any major action (i.e., pipelines, powerlines, oil production facilities, etc.) is outside the scope of this study and would require an EIS.

BLM will initiate cooperative efforts with the Federal Aviation Administration to identify a pilot alert on aeronautical charts to minimize use of flight altitudes below 4,000 feet (1,219.2 m) over crucial black brant molting and staging areas during sensitive seasons.

The Teshekpuk Lake region was designated as a special area by the Secretary of the Interior. Although this designation may have greater emphasis than an Area of Critical Environmental Concern (ACEC), BLM will initiate a process to determine the appropriateness of an ACEC designation to increase the public and agency awareness of the special values in the area.

Development of studies. BLM will cooperatively pursue studies that would provide better future resource estimates and management. BLM will encourage continued mineral and biological data collecting efforts (i.e., winter seismic exploration and independent biological investigations).

Coordinated management. BLM will initiate discussions to align management objectives and coordinate management practices with those of the Arctic Slope Regional Corporation. To achieve this goal, BLM will initiate efforts with the Corporation to investigate the mutual advantages of exchange, acquisition or memorandum of understanding for Cape Halkett lands.

Phase IV—Habitat Management Plan

A habitat management plan is not a decision document, rather BLM's formal action plan for carrying out specific projects and activities to benefit wildlife species and their habitats. The process of preparing a habitat management plan to carry out the State Director's decisions (Phase III) on the Teshekpuk Lake Special Area is now in progress.

The Habitat Management Plan has two parts. The first is the general framework reflecting the State Director's decisions; it directs or shapes all future work designs. This part has been completed (Mellor and Silva 1986). The second part is dynamic, designed for flexibility to allow timely responses to issues and needs. It is strictly activity–and–project oriented and will be continually updated and expanded through individual projects and activities. These will be added to the appendix as studies and new information reveal opportunities or needs for habitat improvement or maintenance.

Conclusion

The innovative approach of directly involving major interested agencies and landowners was generally successful. BLM would have preferred to have achieved a 100–percent agreement on what to lease. This did not occur. Nevertheless, this approach was remarkable because it conclusively demonstrated the value of specific information for achieving participant consensus, because it promoted interagency trust, because it validated the use of development phases that involve various agency levels, and because it promoted a decision which was, by consensus, reasonable.

Early in Phase I, when the special area was considered as a whole, there was strong agreement between the U.S. Fish and Wildlife Service and the State of Alaska that no leasing should be allowed. However, when specific species and specific habitats were considered, a comparison of habitat importance inevitably occurred. This automatically resulted in prioritization and assignment of areas of importance. Perceptions changed as the participants were led to consider parts of the whole and to prioritize areas of importance. At this point, there was less opposition to leasing in areas of lowest priority. Conversely, there was increasingly determined opposition to leasing within the area of highest priority for wildlife.

With each degree of specificity, discussions became less abstract and participants became more sure of their positions. Furthermore, the more specifically the Phase I, II and III discussions were oriented, the more closely participants approached consensus. Conversely, the more abstract the discussions, the more strongly polarized the participants became. This emphasizes the importance of specific, accurate information for mineral and biological values. It also shows the need to lead participants into considering the merits of specific parts, rather than debating the abstract, less–meaningful whole.

The concept of securing cooperative participation was productive because the agencies had a document–developing role and shared responsibilities, all of which served to foster perseverance.

Although the goal of achieving consensus about which areas to lease was not reached for all the public interests represented, the study did achieve consensus on recommendations for protection of biological values and on the range of leasing alternatives to be considered by the BLM State Director. But perhaps the greatest value of this study came from making agency participants aware of BLM's decision–making process and multiple–use management doctrine. Consensus was that it was a good process that would be highly desirable for use in future planning efforts.

Ultimately, the State Director had to resolve the debated positions that favored different alternatives, and he arrived at a reasonable decision, as acknowledged by *all* participants. He directed what area to lease, gave specific measures to protect habitat, outlined necessary study parameters, and implied general and particular coordination needs.

Colville River Special Area Study

Due to the special area designations described by the Secretary of the Interior (1977), BLM has programmed separate special studies for Teshekpuk Lake, Colville River and Utukok Uplands. These efforts will be an integral part of continued specific planning and management for the entire National Petroleum Reserve in Alaska in the 1990s. The special study will facilitate energy transportation through, and possible oil and gas development within, the Colville River Special Area. However, the primary goal is to sustain a secure upward peregrine falcon population trend and accomplish recovery, then to delist the species, consistent with the intent of the Endangered Species Act.

The Colville River Special Area Study will be BLM's second special study and a sequel to the process presently under way for the Teshekpuk Lake Special Area. The Colville effort will follow similar intensity of effort and time frames. Both are guided by the same legislative mandates, although the Endangered Species Act has direct bearing on the Colville Special Study because of the Arctic subspecies of peregrine falcon (*Falco peregrinus tundrius*) that uses the special area.

The Colville River has the largest concentration of nesting pairs of the Arctic subspecies of peregrine falcon in the world. This subspecies is officially listed as threatened. Presently, BLM is adhering to general stipulations outlined in the Peregrine Falcon Recovery Plan (U.S. Fish and Wildlife Service 1983) that the U.S. Fish and Wildlife Service, BLM, and other federal and state agencies helped develop for protection of the Alaskan peregrine falcon populations. These stipulations presently appear to be adequate.

The priority species for the Colville River Special Study Area are peregrine falcon, moose (*Alces alces*), fish, caribou, and grizzly bear (*Ursus arctos*). There are also important paleontological and archeological values, and such important uses as recreation and subsistence.

There are high value prospects for oil and gas along the Colville River. Considering the mineral, biological and other values, BLM feels resolution of potential conflicts requires another special study effort.

The Colville River Special Area Study will consist of four phases similar to those of the Teshekpuk Lake Special Area Study. Within each of the four phases, BLM will actively seek public, state and local government, and other federal agency participation and consultation. Memoranda of understanding will again be used to secure active involvement of key land and species managers.

The analysis of habitat and mineral values, combined with economic considerations, should indicate future possibilities for gravel and petroleum development and important potential transportation corridor needs, along with necessary protection criteria for peregrine falcon, fish, wildlife, archeological, recreational, paleontological and subsistence values.

The Colville River Special Area Study is scheduled for completion in 1987. It will involve consideration of the area for possible nomination as the nation's second Birds of Prey National Area.

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Legislation, Litigation and Allocation: A Case History of Subsistence Hunting in Alaska

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Alaska's rich wildlife resources have played an important role in the state's history. Native Indian and Eskimo settlements developed in places where reliable supplies of wild resources supplied nutritional needs (Nelson 1973). Wildlife species, including both terrestrial and marine large mammals, were important components of the diet for Alaska's first inhabitants, whose welfare was directly tied to wildlife abundance (Burch 1980). Carcasses of many species provided not only food but also clothing, fuel, tools, transportation, weapons and articles for trade and barter. Customs and traditions in pursuing, capturing and processing wildlife became important components of native cultural development (VanStone 1974, McKennan 1981).

Incentives for early European exploration and settlement were largely economic, with trade in wildlife products an important contributing element (Black 1984, Webb 1985). Pelts of sea otters, fur seals, marten, fox, lynx and beaver were among the state's first exports. Native people found Europeans eager to trade for pelts, and systems to regulate such trade were quickly developed (Hosley 1981). The second (1821) and third (1844) charters of the Russian American Company mandated that natives wishing to trade furs could sell them only to the Company at fixed rates.

During the gold rush era of the late 1800s and early 1900s, large numbers of prospectors penetrated Alaska's bush. Mining operations were dormant in winter and miners turned to trapping as a source of income. Market hunting occurred on a large scale near settlements and was the main source of fresh meat for miners, their families and those who worked in related fields (Lutz 1956). Populations of Dall's sheep, moose and caribou provided most of the meat, and herds declined in some areas as the human population grew. Trappers and market hunters also routinely shot and poisoned predators including brown bears and wolves (Peterson and Woolington 1982). In the sense that subsistence means living off the land, Alaska's nonnative population practiced this lifestyle more widely during the gold rush era than at any subsequent time.

Recreational hunters were first attracted to Alaska in significant numbers in the 1920s to hunt moose, Dall's sheep and brown bears. Areas such as the Kenai peninsula (moose) and the Alaska Mountain Range (sheep) became world famous to sportsman who read well–publicized accounts of successful hunts in books and sporting journals (Mason 1968). Guiding and outfitting operations developed to accommodate recreational hunters who became important contributors to the state's economy following World War II. As transportation systems expanded, the human population grew. Big game populations also increased during the 1950s and early 1960s, and many state residents participated in hunting as a source of food and as a form of recreation.

During the 1970s Alaska's human population increased greatly as a result of oil exploration and development. Moose and caribou populations across a broad area of the state declined in response to hunting, predation, severe winters and reduced forage, the latter a legacy from the high populations of the previous decade (Rausch and Hinman 1975). Rural residents living a subsistence lifestyle found it increasingly difficult to meet their needs as game populations declined. In some areas, local residents felt that they were competing with mobile urban hunters and nonresident trophy hunters for limited wildlife resources (Wolfe and Walker 1985). This set the stage for legislative, judicial and regulatory conflicts over subsistence hunting.

The purpose of this paper is to review some of the legislation that has governed subsistence hunting in Alaska, to summarize some of the recent court decisions dealing with subsistence and to discuss Alaska's recent experience in allocating wildlife resources among subsistence users as mandated by statutes and legal opinions. Kelso (1982) discussed in detail several factors involved in formulating Alaska's subsistence–management policies, including cultural and sociological research, cooperation between managers and users, education, and involvement of users in the regulatory process. Case (1984) provided an extensive summary of laws dealing with subsistence and numerous related matters of importance to Alaska natives.

Legislation

Subsistence uses of Alaska's wildlife resources have a long history of statutory treatment. Prior to Alaska's statehood in 1959, the United States Congress enacted much legislation according special preference for subsistence in the territory of Alaska. In 1870, Congress imposed seasons and bag limits on the commercial taking of fur seals on the Pribilof Islands, but provided that natives could take seals for food, clothing and building of boats during the closed season, subject to regulations prescribed by the Secretary of the Treasury. Alaska's first game law—passed by Congress in 1902—included a provision for taking game for subsistence by natives, miners, explorers or travelers. Such game could not be shipped or sold. A subsequent act in 1908 preserved this subsistence exemption.

In 1916, the United States and Great Britain signed a treaty pertaining to conservation of certain migratory birds shared by the U.S. and Canada. The Migratory Bird Treaty Act of 1918 implemented the treaty's provisions in the U.S. and provided for the taking of certain migratory nongame birds and their eggs throughout the year by Alaska natives.

The Alaska Game Commission was created in 1925 by Congress to regulate, in consultation with the Secretary of Agriculture, the taking of game in the territory. That legislation provided that the Secretary's regulations may not restrict the emergency taking of wildlife for food unless the affected species were in danger of extinction. Congress amended this act in 1940 and expanded the emergency subsistence provision to create a much broader exception. The phrase ". . . when in absolute need of food and other food is not available" was changed to ". . . when . . . in need of food and other sufficient food is not available."

Other early legislation included the Reindeer Industry Act of 1937 that explicitly addressed native subsistence, and a 1941 act that prohibited the taking of walruses, but exempted certain uses of walrus meat, skins and ivory for subsistence.

In the early 1970s, a period of both state and federal legislative history began that saw many important, far-reaching statutes enacted. The Alaska Native Claims Settlement Act included a section that has been interpreted by some as extinguishing native subsistence rights. The Marine Mammals Protection Act of 1972 expressly allowed natives to take marine mammals for nonwasteful subsistence or native handicrafts. Subsistence exemptions for natives and nonnative residents of native villages were part of the 1973 Endangered Species Act. The 1978 Fish and Wildlife Improvement Act contained provisions to assure the taking of migratory birds and their eggs by the indigenous inhabitants of Alaska.

Prior to 1978, State of Alaska statutes—dating from statehood and establishing authority to regulate wildlife harvests—contained no specific provisions for subsistence. In 1978, the State Legislature expressed its intent to establish subsistence as a priority use of fish and game resources, consistent with the principle of sustained yield. Subsistence was defined as the customary and traditional use of wild, renewable resources for food, shelter, fuel, clothing, tools or transportation. The terms "customary" and "traditional" were left undefined, and the act made no reference to natives or to rural residents. The act directed that, whenever it is necessary to restrict taking of wildlife, subsistence shall be the priority use. If further restrictions are necessary, they must be based on customary and direct dependence on the resource as the mainstay of one's livelihood, local residency and availability of alternative resources.

Similar language was included in Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980, but subsistence was defined as the customary and traditional use of wild renewable resources by rural Alaska residents. *Rural residency* thus distinguished the state and federal definitions. ANILCA pertained to federal lands and required the Secretary of the Interior to certify that the 1978 state law and resulting subsistence regulations were in compliance with Title VIII, ANILCA. Compliance was certified in 1982, based on Interior's finding that Alaska had a law of general applicability that provided for a rural subsistence priority, and that the state had a regional advisory council system whose regulatory proposals were considered by the Alaska Board of Game. Left to the state was the task of defining such terms as "rural," "customary and traditional," and "nonwasteful levels of taking."

Litigation

In February 1985, the Alaska Supreme Court struck down a Board of Fisheries regulation designed to identify eligibility for subsistence fishing in the Cook Inlet region of Alaska—the case of *Madison et al. vs. Alaska Department of Fish and Game*. The court's ruling had important implications for management of game despite the central issue of fisheries management. The court determined that subsistence uses, according to the 1978 state statute, could not be identified on a rural basis or in terms of uses by a community or area. According to the *Madison* decision, subsistence hunting must be authorized on populations of wildlife used historically for food and other uses, unless such hunting would jeopardize sustained yield. If subsistence hunting must be restricted to protect sustained yield, then nonsubsistence uses (nonresident hunting) must be eliminated first. If further restrictions are necessary to decide which subsistence hunters may hunt, the court ruled that the three criteria (customary and direct dependence as the mainstay of one's livelihood, local residency and availability of alternative resources) listed in the 1978 state statute must be implemented to distinguish among users. The court labelled these as "Tier II" criteria. Thus, hunting regulations may not restrict subsistence hunting at all in areas where nonsubsistence (recreational) hunting is permitted. If recreational hunting is prohibited, subsistence hunting still cannot be restricted unless it interferes with sustained yield. At that point, the three distinguishing Tier II criteria (dependence, residency and alternatives) form the basis of the restrictions.

Shortly after the *Madison* decision, the Alaska State Court of Appeals decided *State of Alaska vs. Eluska,* wherein a "subsistence defense" to violations of hunting regulations was created. The Board of Game created no special subsistence regulations following the 1978 state statute, and the court ruled that individuals engaged in subsistence hunting outside existing seasons and bag limits could claim there were no applicable regulations. Because, with few exceptions, the Board of Game historically accommodated subsistence hunting within the general hunting regulations, *Eluska* was interpreted by the state's chief prosecutor to mean that practically no closed season or bag limit violations could be prosecuted.

Subsequent to these decisions, Alaska's hunting regulations were revised in time for the 1985 seasons. *Madison* required elimination of all random lottery hunts or unlimited participation registration hunts, and *Eluska* required separate sets of subsistence and general hunting regulations. Out-of-state hunters were excluded from participating in the hunts defined in the subsistence regulations. Many hunts were converted from open lotteries to drawings with points awarded on the basis of the three distinguishing Tier II criteria. These changes spawned a group of legal challenges on various constitutional grounds. All suits are currently pending.

In January 1986, the U.S. District Court in Alaska ruled that natives could harvest waterfowl during any season, according to provisions of the 1925 Alaska Game Act. At issue was spring hunting in the Yukon–Kuskokwim Delta area where three species of geese and one of brant have suffered major declines over the last 20 years. Hunting waterfowl during spring is potentially illegal under terms of the Migratory Bird Treaty Act (MBTA), but the court ruled that the 1925 statute replaced the MBTA as a source of authority for issuing regulations in Alaska. The court found that a 1944 U.S. Fish and Wildlife Service regulation excluding migratory birds from the subsistence provision in the 1925 Game Act was contrary to law. The court further found that the Statehood Act did not transfer to Alaska authority over migratory birds.

A pending suit brought in November 1984 and amended in July 1985—*Bobby vs. State of Alaska*—is a class action that raises several potentially precedential issues. Plaintiffs claim that calendar-based closed seasons and bag limits are incompatible with native subsistence-based socioeconomic systems and are generally inappropriate. They also claim that subsistence protection should be granted on a community (rather than an individual) basis. The state's revised regulations following *Madison* and *Eluska* were challenged as diluting the subsistence preference and as racially discriminatory. The suit seeks injunctive relief by declaring the state out of compliance with ANILCA and ordering it to comply independent of what the state's statutes authorize. This argues for federal preemption, but not for its generally envisioned consequence, namely federal takeover of subsistence management.

Allocation

Hunting seasons for big game begin as early as August 10 in Alaska, and many seasons are over by late September. Board of Game meetings on regulatory changes for such seasons are typically held in March, with the intervening months available to publish and distribute the regulations as well as provide for administration of permit hunts. In 1985, the Board met in emergency session in mid–June to adopt separate subsistence regulations as required by ***Eluska*** and to modify hunting regulations according to principles articulated in *Madison*. This required examining existing regulations to determine if they prohibited subsistence hunting for any Alaskans, failed to provide the same legal subsistence hunting opportunities to all Alaskans or otherwise significantly impaired subsistence uses. If significant impairment could not be avoided by restructuring the regulations (e.g., reducing nonsubsistence uses), then the Board was required to prohibit nonresident hunting and determine if it was necessary to restrict subsistence uses further to protect sustained yield. If so, Tier II standards were applied.

The Board considered such things as season length and timing, bag limits, sex restrictions, antler and horn size restrictions, harvest success criteria, and historical patterns of regulatory changes, in evaluating whether subsistence uses were significantly impaired. Division of Game staff from the Department of Fish and Game assembled this information for each separate hunt on populations of all big game species throughout the state. Included were species used traditionally for food such as black–tailed deer, moose and caribou, species traditionally eaten but hunted also for trophy value such as mountain goats and Dall's sheep, species seldom eaten but hunted mainly as trophies such as brown bears, and species such as bison and musk–oxen introduced to the state by man in recent times and therefore lacking traditional patterns of subsistence use. The Division of Subsistence, Department of Fish and Game, provided data on local use patterns for certain species in several areas of the state, but the data were generally sparse.

The most difficult chores the Board faced were applying the Tier II criteria in the absence of public testimony and adapting the permit–application process to the short time until hunting seasons opened. For hunts determined to be at Tier II, i.e., nonresident hunting was prohibited and subsistence hunting had to be limited in order to avoid overharvests, a system of assigning hunting permits had to be devised. An affidavit application was designed to provide information used to rank applicants on the basis of customary and direct dependence, local residency and availability of alternate resources. These factors were weighted equally and a point score was assigned to each application. Permits were awarded to applicants with the highest scores.

Of the three Tier II criteria, local residency was the most verifiable and objective. The Board ultimately settled on a zone approach, based on maximum points for residency in the immediate area of the hunt as opposed to adjacent areas or adjacent game management units. Certain hunts, e.g., those involving migratory caribou herds, had very large local residency zones, while others for small, resident populations of game had very small local zones.

Points for customary and direct dependence on the resource were awarded through evaluation of historical use patterns and the importance of the specific wildlife resource in relation to other components of an individual's economic situation. For each year applicants had harvested an animal from the population, they were entitled to one point, up to a maximum of 10 years. Applicants also rated their direct dependence on the resource as great, moderate or slight, and were awarded points accordingly. Simple, objective, verifiable factors to measure dependence were very difficult to devise.

Two measures of alternate resources adopted by the Board were financial circumstances of the applicant and availability of other fish and game resources. Timing of resource availability (e.g., migratory fish stocks available at a different time of year than during hunting season) and problems of transportation complicated assessment of alternate fish and game resources. Nonwild resources, accepted by the Board as alternates, were complicated by unknown variables, including differences in cost of living and the applicant's other financial liabilities and assets. A straightforward, simple measure, such as annual income, was therefore insufficient. Applicants answered "yes" or "no" to the question: "Is your household's income large enough to purchase food and other items as reasonable alternatives to taking wild fish and game?"

A total of 54 Tier II hunts was authorized statewide in 1985. Although about 45,000 applicants applied for the random lottery hunts prior to the Tier II regulations, only about 9,000 Tier II applications were filed. This resulted from widespread public confusion, dissatisfaction with the new system and problems compounded by short deadlines. The application process was particularly difficult in remote areas. Administrative costs to the Department of Fish and Game were high, particularly since about $200,000 in application fees were lost in transition to the new system.

Fifty-three Tier II hunts for five species of big game were held in 1985. A total of 4,535 permits were awarded with caribou (55 percent) and moose (33 percent) comprising most of the total. Three game management units surrounding Anchorage, Alaska's largest population center, accounted for 30 of the 53 hunts. Only 10 hunts occurred in areas not connected by roads to large population centers. About 40 percent of the permits were awarded to residents of Anchorage and the adjacent Matanuska–Susitna valley.

In general, Tier II hunts that were previously on a random lottery basis changed the allocation of permits from a random chance system to one based on individual and household characteristics. Hunts previously administered as registration permits or permits issued on the basis of residency or dependency saw little change in permit allocation. Under the new system, nonresident hunters generally had reduced opportunities to participate, but could still hunt for all species in certain areas of the state. A large number of non–Tier II hunts, with unlimited participation by residents and nonresidents alike, occurred in 1985.

Discussion

Alaska's recent experiences in struggling with the difficult question of subsistence hunting are deeply rooted in legislation, court decisions and regulatory processes of resource allocation. These three basic components have each contributed to the present system designed to give priority to subsistence uses of wildlife resources, and each will play an important role in future direction. As with many case histories in natural resource management, conflicts have developed between resource users, leading to litigation, efforts to change legislation or special interest lobbying to modify existing regulations. At present, Alaska is experiencing all of these attempted remedies. Their success or failure will play an important role in determining the future of subsistence hunting in Alaska.

Since statehood, Alaska's hunting regulations have given certain priorities to subsistence users by allowing late seasons in rural areas to facilitate meat storage, providing a low–cost hunting license for low–income residents, creating areas where access was limited for nonlocal residents, authorizing antlerless hunts for moose and caribou, and other modifications to the regulations. The *Eluska* decision forced the state to change its long–standing practice of accommodating subsistence hunting within a general framework of recreational hunting regulations. Critics maintain that creation of a separate set of subsistence hunting regulations still fails to address the problem of providing adequate opportunity for subsistence hunting. In some cases where traditional use patterns and the lack of meat–storage facilities necessitate yearlong hunting, some advocates insist that closed seasons are inappropriate. Furthermore, the traditional wildlife establishment's concept of an individual bag limit may also be inappropriate when one hunter provides meat for an entire household or family of nonhunters. At present, there are some wildlife populations in Alaska that can provide sustained yields with yearlong seasons and very liberal bag limits. The Western Arctic Caribou Herd currently has no closed season on bulls, a 10–month open season on cows and a 5–per–day bag limit with certain restrictions on transporting caribou out of local areas. Such examples, however, are exceptional; most moose and caribou populations in the state require conservative seasons and bag limits, and many cannot provide sufficient yields to satisfy demand by both subsistence and recreational hunters. Yearlong seasons and unrestricted bag limits would probably expand subsistence harvests greatly, thereby reducing long–term sustained yields for the very few moose and caribou populations that could withstand such liberal regulations at present.

These considerations highlight the need for management–oriented data, both biological and sociological, in order to manage big game populations in Alaska effectively. Wildlife population census data necessary to compute yields are difficult and expensive to obtain; estimates of yields based on population estimates of low accuracy and precision must be conservative. In addition, yield theory is poorly developed for subarctic ecosystems where wild predators compete with humans for sustenance.

Although great advances have occurred in recent years, the task of documenting local use patterns of subsistence users and determining their requirements is enormous. Funding constraints will likely impede the rate at which these data accumulate in the future. An additional problem concerns the method of collecting such data, i.e., interviews with subsistence users. Users may bias their responses if they believe it is in their best interest to do so.

After passage of the 1978 subsistence law many recreational hunters objected to the concept of a subsistence priority. In 1982, a ballot initiative to repeal the subsistence priority failed by a wide margin in a bitter battle pitting recreational and subsistence hunting interests against each other. Thus, the public's desire to ensure a priority for subsistence was reaffirmed, but many issues involving implementation were left unresolved. The state's efforts at implementation between 1978 and 1985 were clearly deemed inadequate by the *Madison* and *Eluska* decisions. Subsequent attempts to comply with court rulings created a high level of public dissatisfaction and renewed attempts to change the state statute.

A bill designed to return to pre-*Madison* conditions by amending the 1978 statutory definition of subsistence uses passed the State House of Representatives by a narrow margin in 1985, but failed to move through the State Senate. Urban hunters who felt disenfranchised by the regulatory changes that followed *Madison* and *Eluska* did not favor that bill, but pushed instead for Senate approval of legislation that would put urban and rural hunters on a more equitable basis. If passed, pending Senate legislation and the existing House bill would require conference committee action to resolve substantial differences. However, no matter what form the state legislation finally takes, it must conform to the requirements of ANILCA to comply with this preemptive federal legislation. ANILCA clearly defines subsistence uses as rural in nature; Alaska's subsistence law currently does not and future amendments may not define them as rural. The U.S. Department of the Interior has given notice that Alaska must now demonstrate compliance with ANILCA by June 1, 1986. Still unclear is whether a finding of noncompliance would result in federal management of hunting on federal lands or court–imposed state management employing ANILCA standards.

It is likely that the Alaska Board of Game will continue to struggle with the present system of assessing Tier II criteria. Crude, subjective measures of customary and direct dependence and availability of alternate resources are inadequate. But precise, objective measures tailored to specific hunts are difficult to construct and administer. For example, possible indicators of customary and direct dependence relate to the degree of past reliance on game populations in a given geographic area, as well as the importance of such resources to an individual's livelihood. Indicators such as the percentage of game in the diet, history of hunting in the area, size of the local community (e.g., the smaller the community, the greater the dependency), number of years the resource has been used, and quantity of the resource harvested may all be useful. However, an objective, verifiable system to measure these has not been developed. Additional problems occur in areas where English is not the primary language.

Finally, the subsistence hunting issue raises some difficult questions for wildlife decision makers accustomed to traditional North American management schemes centered around recreational hunting. Alien to this traditional system are concepts of community subsistence needs (as opposed to those of the individual), yearlong open seasons, unrestricted bag limits, subsistence hunting of species previously managed mainly for their trophy value, and spring hunting of waterfowl. Alaska's attempts to accommodate these concepts are still in their infancy, but will mature in the coming years as the legislative, judicial and regulatory processes provide additional direction.

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A Solution to Desertification and Associated Threats to Wildlife and Man

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The Problem

That land deterioration, or "desertification" as it is called in its extreme, is the most serious problem facing the world today is almost too obvious to need statement. Some 850 million people are now adversely affected by it (Tolba 1984).

As wildlifers know, disappearing wildlife and plant populations are some of the earliest signs of desertification. Unfortunately, most people do not heed these signs until those farming and ranching the land disappear and eventually the villages, towns and cities they support.

Because mankind has not yet understood the desertification process and its causes, many tragic mistakes have been made and continue to be made, exacerbating the situation. The early civilizations in the arid and semiarid areas that today lie under desert sands are testimony to the past mistakes. In Africa, the looming environmental disaster indicates that mistakes continue to be made, while in China and many other parts of the world deserts continue to expand at an alarming rate.

In America, the same mistakes are leading to tragic results. In central New Mexico, there is a large basin drained by the Rio Puerco which, as recently as the turn of the century, was known as the "bread basket" of New Mexico (Sheridan 1981). Today, it is a desolate valley, slashed with gullies, deserted villages and irrigation works. Overflying it, one is impressed with the scale of the efforts to halt the desertification in the hundreds of thousands of acres of failed reseedings, contour ridging and other measures.

Before any problem can be solved, it must first be recognized. Following recognition, it is then most helpful to learn what the causes of the problem are. However, in the world's developed countries, there is little acknowledgement that desertification is a serious problem outside the Third World, despite evidence to the contrary (Sheridan 1981). There is a widespread belief in the developed countries, including America, that we have solutions for desertification in the Third World (and for declining land productivity in the United States) if only people would apply them.

An inspection of the many hundreds of reports and papers dealing with the massive environmental disaster building up in Africa will indicate that the causes are "well–known". Timberlake (1985) outlined and summarized many of these "known" causes. In Table 1, I have listed the major known causes for Africa's deteriorating environment. Alongside these, I have given the comparable situation in the State of Texas. I use Texas as my American example since its environment is not as harsh as much of Africa, it does not have the poverty or high population and, for the most part, the land is privately owned. Almost any American state west of the Mississippi could have been selected.

When seen in this manner, the two situations reflect as opposites. What we see as

Table 1. Major causes for desertification in Africa and the State of Texas.

Causes of environmental deterioration	
Africa	Texas
High rural populations	Very low rural population
Overstocking	Little or no overstocking
Too much tree cutting	Relatively little tree cutting
Bad run of droughts	No run of droughts
Cultivating unsuitable soils (steep slopes, etc.)	No necessity to cultivate steep slopes, etc.
Low general education of farmers	Thousands of graduates owning and operating land
Poverty	Extreme wealth
Communal tenure of land	Private tenure of land
Shifting agriculture	Stable agriculture
Insufficient fertilizers, herbicides, machinery, etc.	Massive availability of fertilizers, herbicides, machinery, etc.
Poor and somewhat corrupt administrations	Large bureaucracy with low level of corruption
No extension services	Large universities and extension services

causing desertification in Africa does not appear to exist in Texas. From this, then, it is logical to reason that desertification is not a problem in Texas. Unfortunately, this is not the case. In 1977, the western half of Texas was already being described as suffering from moderate to severe desertification (Dregne 1977). In 1985, approximately 100 farming families a week were leaving the land. On August 15, 1985, the *Austin American Statesman* carried five different articles connected to serious environmental degradation in the state and the proliferation of ghost towns. The published U.S. Department of Agriculture stocking rates for livestock at the turn of the century around San Angelo, Texas, look like science fiction compared with today's official stocking rates. Since 1900, stocking rates have dropped an average of 1.5 animal units per section per year (Bently 1902, Merrill 1959).

Clearly, we do not understand what is causing desertification and the consequent loss of plant and animal life. Thus, it is no surprise that our costly and well-meaning efforts to halt it are consistently failing. In 1985, a significant statement was issued at the end of an International Arid Lands Conference sponsored by the University of Arizona, UNESCO, the U.S. Agency for International Development and the American Association for the Advancement of Science, among others. The statement (Stiles 1985) read in part: "An International committee of 13 arid lands scientists from nine nations have urged their colleagues to determine why years of effort to improve life in the world's dry regions have failed. Scientists must clearly tell global political leaders why those efforts failed, they said . . . It has become gravely evident that with a few exceptions, the welfare of the people occupying many of the arid lands and the health of the underlying resources of air, water, soil and biota are continuing to degrade . . . It is not a simple matter of additional funds or of new technology or of further research along conventional lines. The central challenge is to translate our accumulated experience into approaches that see people in their environment whole, and to embody that view pervasively in new activity and policy."

A Solution to Desertification

A potential solution to this worldwide problem originated in work begun in Africa 30 years ago—to halt the decline of large wildlife populations. It has steadily progressed through its development stages and made increasingly deep inroads into mankind's agricultural practices as the prime cause of land and wildlife deterioration. Known as Holistic Resource Management (HRM) today, the work has been refined into a planning and management model that incorporates a holistic view of human, financial and biological resources. The HRM model is used by resource managers (including farmers and ranchers) to guide them in their management to ensure that it is economically and ecologically sound.

The first step in using the model is to decide on a goal. The ecosystem is then evaluated to see how it must function to achieve that goal. Next, the model is used to decide which of the tools available to mankind should be applied toward achieving that goal. And finally, a number of guidelines in the model help the manager determine how best to use those tools to achieve his goal in the most economically and ecologically sound manner.

The Goal

Unlike resource management to date, HRM cannot be applied without a clear goal. The goal is always expressed in three parts. First, there is the "quality of life" sought by the people from the environment under management. This is followed by the "production" desired from the ecosystem to attain that quality of life. This takes many forms, from profit through aesthetic qualities, recreation, culture, timber, wildlife, livestock, crops and other descriptions of a form of product. Finally, there is the "landscape description," which is a futuristic description of the ecosystem that will produce and sustain that production.

The Ecosystem

Anywhere in the world, a goal defined as indicated will rest on the ecosystem and no other base or foundation. The ecosystem is conceptualized as four blocks which are: water cycle; mineral cycle; succession; and energy flow. Although they are, in reality, one entity—the ecosystem—they are broken out in this manner to aid in the practical application of the tools that will be used to take us to the required landscape goal.

The Tools

Three broad categories of tools are available to mankind to manipulate the ecosystem blocks to the desired goal. These are: "money and man–hours of labor"; a group of tools that are applied directly to the ecosystem through money and/or man–hours of labor—"fire, rest, grazing, animal impact, wildlife and technology"; and finally, human creativity. There are no other tools available to mankind.

The Guidelines

We can have the finest tools in the world, but without an understanding of how to use them, we are prone to drastic mistakes. The guidelines are a fast–developing part of the model that guide us on the application of any of the tools to the ecosystem blocks.

Once the goal is established, the resources involved (biological, financial and human) are continuously monitored. A control process is linked to this to ensure that no major deviation takes place except through natural catastrophe or human error, in which case a replan procedure is initiated.

The Missing Keys

Although the process of applying the HRM model has proven successful in practice, it has generated considerable controversy over the years of its development. This reception is understandable because some of the knowledge on which the model is based goes against long–held beliefs. Historically, acceptance of new knowledge has been particularly difficult when the new knowledge has conflicted with what people "knew" to be true and not merely what they "thought" was true (Beveridge 1957, Boorstin 1983).

There were four major discoveries that had to be made in connection with environmental deterioration and with resource management before the desertification problem could be understood and before the HRM model could be devised. One of these discoveries made some form of holistic modeling imperative for sound resource management. We refer to these four discoveries, made over the last 60 years, as the four "missing keys."

Holism

The concept of holism was first expounded by Jan Smuts 60 years ago (Smuts 1973). Although Smuts provided the basic ideas, it has taken us a long time to absorb the knowledge and realize its importance in practical application. Elsewhere (Savory 1985a, 1985b, 1986a), I have given explanations of Holistic Resource Management and spelled out how very different it is from interdisciplinary management. For many years, I made the mistake of using the two terms interchangeably, thinking they were but two faces of one coin. I now realize that they are totally different concepts.

Basically, many people had appreciated that the single–discipline approach to resource management was not succeeding. Advances to the integrated approach—the multidisciplinary approach and then the interdisciplinary approach—were little more successful (Naveh 1983). In all of these approaches to resource management, we essentially looked at the management of total resources from the points of view of our various specialties. However, where the whole was made up of interrelationships greater than the sum of the parts, we only studied perceived parts in all of our disciplines *and never the whole* from which the disciplines were derived.

We use the HRM model to look at the knowledge available in all of our disciplines from a "holistic point of view." We subject the knowledge to testing through the model and then apply the knowledge as long as it passes the tests and leads us towards achievement of our goal. This application of knowledge is then "holistically sound," to the best of our current knowledge.

It is apparent that the most difficult aspect of HRM, based on my own experience and that of other scientists, is the transition from interdisciplinary thinking to holistic thinking, which involves a complete paradigm shift.

Brittle and Nonbrittle Environments

The next essential discovery without which we could not understand the desertification process was that we have two broadly distinct terrestrial environments that are not distinguished by the amount of rainfall they receive. We had always known that we had jungles, forests, savannahs, grasslands and true deserts, depending on rainfall. We had always known that the areas that were arid and semiarid were desertifying worst. We had always known that if we rested any of these environments from overuse in any form they would "improve." If an overgrazed grassland was rested, it would again have vitality—a complexity of species and stability. Our first inkling that this was not the case in all environments occurred in Zimbabwe in the early 60s, when livestock there was almost totally removed from deteriorating national land, followed by 50,000 or so head of game dying of malnutrition and related factors. The area, contrary to all beliefs at the time, did not "recover" with the removal of the animals as it was supposed to do (Savory 1969).

The things that we "knew" for thousands of years did not explain situations such as the lack of anticipated recovery mentioned above and:

1. Many of the areas of the world desertifying seriously were high rainfall areas with 50 or more inches of rain. Other areas not desertifying badly after hundreds of years of "abuse" were only 20–inch rainfall areas.
2. All of our many efforts at reclamation were consistently failing, no matter how many millions of dollars we spent on stock reductions, wildlife culling, reseeding, brush clearing, soil contouring, etc. All of these measures should have contributed to improvement and success according to our knowledge and research, but they did not. This is now starting to be acknowledged publicly for the first time (Stiles 1985).
3. Many of our "wild" areas and national parks were developing obvious management problems when "left to nature." Where we had "culled" game populations to reduce riparian damage, such damage persisted.

We have had to introduce new terms to explain the new discovery: "nonbrittle environment" and "brittle environment" (not to be confused with fragile environment—a fragile environment can be either brittle or nonbrittle).

The degree of "brittleness" of an environment runs on a continuum from very brittle to completely nonbrittle. The more brittle the environment, the greater the speed of the desertification process under current agricultural, wildlife and range management practices.

In Table 2, I have taken the two extremes of very brittle and nonbrittle environment and listed the major differences discovered to date. In this, a grassland is used as the example, since grasses provide most of the soil–stabilizing influence in arid areas where problems are greatest.

The Role of the Herding Ungulate in Brittle Environments

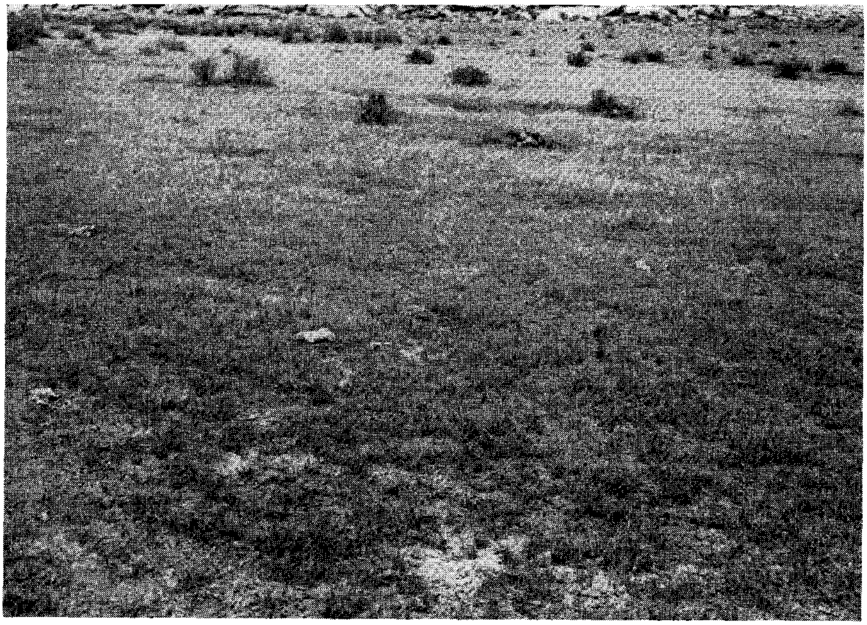
The third of the discoveries is closely linked to the one just covered, but it was actually discovered before the different forms of environment were clearly observed and understood. It has to do with the physical impact (trampling, dunging, urinating, rubbing, etc.) of large herbivores in the ecosystem. This is more than the mere trampling, etc., and involves the behavior of the animals and their relationship to their predators as well as their home range or territorial movement and the evolution of whole communities of soil, animal and plant life.

Table 2. Differences between nonbrittle and brittle grasslands.

Grassland characteristics	
Nonbrittle	Brittle
Reliable precipitation	Unreliable precipitation
Reliable growing seasons	Unreliable growing seasons
Erect–type grasses of unclumped form	Erect grasses of a strongly clumped nature
Plants closely spaced as a function of the climate	Plant spacings tend to be wide and more a function of large animal numbers and behavior than climate
Decay of old material rapid and largely biological	Decay of old material slow and largely chemical (oxidation)
Breakdown of old material starts near the base of leaves and stems and takes place largely on the ground	Breakdown of old material largely a weathering process starting at the unprotected grass tips
Old plant material held by close plant spacing regardless of the presence of animals	Old plant material easily eroded as animal impact decreases and plant spacing increases
If rested from any form of physical disturbance, can develop great species diversity and stability	If rested from any form of physical disturbance, species diversity and stability decreases
Dependent on climate for diversity and stability	Dependent on disturbance for diversity and stability
Heavy overgrazing produces tight plant cover in a near monoculture (small bare areas may develop near points of extreme concentration)	Heavy overgrazing produces bare ground between plants, but plant spacing is controlled mainly by animal impact rather than overgrazing.

We have now been able to link this with brittle environments and finally understand the essential connection between the animal impact and behavior now lacking in the worst of the desertifying lands. We can now see how some of our early civilizations initiated the destruction of the agricultural base they depended on by their mere presence disturbing the habitual movement patterns of the wildlife populations on the water catchments controlling their fate. When these civilizations introduced livestock to these same areas, they did not replicate the effects of the wildlife populations.

What took us a long time to discover, even after we understood the importance of animal impact in brittle environments, was that inadequate animal impact combined with overgrazing has a very adverse effect on the ecosystem—much more adverse, in fact, than does overgrazing on its own. Animal impact tends to offset to a high degree the adverse effects of any overgrazing taking place at the same time. I have tried to depict that in the accompanying photographs, which show the effects of 50 years of severe overgrazing alongside 50 years of nondisturbance in a brittle grassland area of New Mexico. As shown, 50 years of heavy overgrazing combined with adequate animal impact in one scene has led to a living grassland of small closely spaced young plants. The average space between grass plants is about one to two inches. Just across the fence, as seen in the other photo, 50 years of no grazing at all on Chaco Canyon National Monument land has led to serious destruction of the grassland, with very large spaces between old remnant grass plants. I'm not praising the results of 50 years of overgrazing, I'm merely here trying to point out the far



Fifty years of overgrazing with heavy concentrations of livestock on this tribal land in New Mexico has resulted in a short, dense, green and actively growing, grassland, although most plants are severely overgrazed. Photo by Allan Savory.

greater damage from 50 years of nondisturbance in a brittle environment.

This discovery, which caused such controversy in the 1960s that no reputable journal would publish the findings, has now been supported by some excellent work done in East Africa (McNaughton 1984).

Overgrazing Related to Time Not Numbers

The fourth of the discoveries required to solve the problem of desertification was provided by the French scientist, Andre Voisin (1961), who discovered that "overgrazing" by livestock was a function of "time" and not "numbers."

Controlling "time" is easy with livestock, since we can herd them, fence them in and move them at will, to control the amount of time plants are exposed to them. More complex is controlling time with wildlife species that are not self-regulating and are dependent on predation and natural catastrophe to control numbers. We are in our infancy in learning how best to regulate "time" in wildlife management, but at least we now know what we have to achieve. We also know that it cannot be achieved by controlling numbers alone (Savory 1986b).

Whenever animals are on the land, whether by design or accident, there is always a "time dimension" involved. This time dimension affects both the overgrazing of plants and the animals' physical impact on the plants and soils. The very worst combination for most brittle environment grasslands is to subject them to overgrazing of the plants simultaneously with low animal impact as mentioned above. Unfortunately, this was by accident the very underlying basis of most of our modern range

Fifty years of no grazing at all in the Chaco Canyon National Monument has resulted in the disappearance of grasses but for a few moribund remnants. Erosion is severe and gullying extreme despite considerable expenditure on gully control. None of the plants shown are green and growing, although they are within 100 yards of the vegetation in the other scene, photographed on the same day. Photo by Allan Savory.

management—we reduced livestock numbers and scattered them thinly on the land in our efforts to avoid overgrazing and overtrampling, but in fact continued to overgraze and overtrample because we did not control the time. Most importantly, we deprived the land of the beneficial form of animal impact that was necessary to sustain its health. This, at last, begins to account for how we have managed to cause more damage to our brittle environment rangelands in a century than nomadic people had done in a few millenia (Savory 1985a).

Conclusion

It is clear from the failure of our efforts in many countries to halt the desertification process—deserts are now advancing at a rate of nearly 15,000,000 acres a year worldwide (Worrall 1984)—that something was missing in our knowledge of the problem. Four discoveries have been made that have filled that vital gap in mankind's knowledge and enabled us to design a simple holistic model to manage resources successfully in a sustained and economic manner. Excellent results have now been achieved in many situations, and we have witnessed positive grassland improvement, even in severe drought and under increased livestock stocking rates while protected plots in the same seasons have deteriorated (Cardon 1983, Savory 1984).

The fate of all wildlife is bound to mankind's agricultural practices, which have had the greatest single impact on the environment. Even those wildlife populations thought to be secure in protected national parks are not secure in many regions of the world for the simple reason that a hungry man knows no boundaries.

HRM offers great hope for all resource management situations. The Center for Holistic Resource Management, a nonprofit membership organization located in Albuquerque, New Mexico, was formed by a group of resource managers, researchers, ranchers, farmers and environmentalists, to provide training and dissemination of knowledge on HRM. Working in an international collaborative effort, the Center now also acts as a focal point for the rapid increase in knowledge that is taking place through practical application of the HRM Model.

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Natural Resources Management in Support of National Defense

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Introduction

The uninformed may be shocked by the size of the real property holdings of the U.S. Department of Defense (DoD). About 24 million acres (Army 11.5 million; Air Force 9.2 million; Navy and Marines 3.6 million) of public lands in the United States are under military stewardship.[1] About 2 million acres are used outside of the United States. The civil works projects of the U.S. Army Corps of Engineers occupy another 9 million acres of land and waters in the U.S. Additionally, DoD controls millions of square miles of air space over the U.S. and waters of the Atlantic, Gulf of Mexico and Pacific. The natural resources under the influence of DoD are substantial, and frequently challenge scientists and managers.

Varying in size from a few acres to over a million acres, the 900 DoD installations in the United States contain every conceivable landform and type of habitat. Even the small parcels, such as radar sites and storage bunkers, may contain significant wildlife, habitat or cultural resources. The Navy's Indian Island (2,700 acres), for example, near the entrance to Puget Sound, contains a marsh, bird sanctuary, heron rookery, healthy deer herd, nesting eagles and miles of beaches teeming with clams.

Many installations include tracts of wilderness. Under the umbrella of safety and security, lands have recuperated from abuse or overuse that occurred prior to DoD management. Because the military typically needs relatively isolated and undeveloped areas and because urban sprawl and development frequently surround DoD property, wildlife and endangered or threatened species may be driven to the only remaining area that is suitable habitat for them. Thus, DoD has valuable natural resources to care for at some locations. Unfortunately, this is not a well–known military mission, and there are precious few staff and funds to do that job.

A good example is the Marine Corps Base Camp Pendleton, located between San Diego and Los Angeles. Its western perimeter is 18 miles of relatively undeveloped Pacific coastline. Once owned by a cattle rancher, this property now contains facilities to house and support the work of 34,740 Marines. The total workforce is about 38,000. There's a 3,600-acre state park and a few thousand acres leased to vegetable farmers. The rest of the 186,000-acre base supports amphibious landing, helicopter and mechanized infantry training, artillery and bombing practice, and other essential military operations. To enhance the quality of life at Camp Pendleton, its natural resources are carefully managed. As the last relatively undeveloped area between two metropolitan sprawls, Camp Pendleton provides sanctuary for two endangered species and several other candidates for endangered species listing. It may be the most significant wintering area for birds on the west coast of southern California.

[1] Department of Defense, List of All Military Installations (Excluding Reserve Centers and Minor Properties), Part of the FY87 Base Structure Report.

There are over 200 nesting sites for California least terns on Pendleton's beaches. The base is one of only 18 California nesting areas for the endangered light-footed clapper rail, and contains about 20 percent of California's nesting least Bell's vireos. Due to the successful management of the vireos' habitat by the Marine Corps, the Department of the Interior has determined that it is not necessary to designate critical habitat for the birds at Camp Pendleton. An intensive field study in the 1970s by Peter Bloom of California State University concluded that the base has one of the highest densities of raptor nesting in North America. An average of 630 active nests of 13 raptor species occur on Camp Pendleton.[2]

Mission Support

Many challenges are brought about by the necessity to comply with environmental protection laws, good management practices and good neighbor policies while supporting the military mission. Without concerted effort and cooperation among DoD, other federal and state agencies, and the public, performance of the DoD mission could result in conflicts as we strive toward the national goal of maintaining a healthy and productive environment for present and future generations of Americans. The following are a few examples of how DoD works toward this goal.

Forest Management

Forested DoD lands have great potential for multiple use. There are many examples of successful integration of commercial harvesting, realistic training and recreation in the forests. The job of forest management is not a new one for the military. In 1828, 30,000 acres of forested land on Santa Rosa Island near Pensacola, Florida, was the first federal land set aside for forest management. The predominant species, live oak, was managed for years as a renewable supply of timber for shipbuilding. During the Civil War, saw mills were operated by engineer units all over the South. The wood was used for trench and tunnel construction, corduroy roads, abatises and bridges. The Army's formal management of forests began in 1903, when the first forest–management plan was approved by the Secretary of War for the Military Academy at West Point, New York. During World War I, many American forestry units worked for General Pershing, procuring wood for military use.

The Clark–McNary Act of 1924 established forested military reservations as national forest units. Forts Benning, Jackson and McClellan were under this program, jointly managed by the U.S. Forest Service and the War Department. The program was discontinued in 1927 at the request of the Forest Service.

About 80 percent of DoD's present forested land was acquired during World War II, and had previously been used for agriculture or timber harvesting. By 1960, nearly all DoD installations with significant forested land had forest–management plans. At that time, funding for forest management was dependent on appropriations from Congress, and typically received very low priority in competition for funds. Beginning in 1961, Congress annually included a provision in the DoD Appropriations Act that allowed reimbursement of expenses for forest management from sales proceeds. With this change, forest management in DoD achieved stability and im-

[2]Telephone interview with Marlo Acock, Natural Resources Manager, Marine Corps Headquarters, January 30, 1986.

petus. In 1977, this reimbursement authority was made permanent. The law was amended in 1981 to provide for host states to receive 25 percent of installations' net proceeds, and amended again in 1984 to provide host states with 40 percent of net proceeds.

Currently, nearly 200 DoD installations manage about 2.3 million acres of forested lands to support various military uses, provide good wildlife habitat and support a variety of outdoor recreation opportunities as well as for commercial harvesting. During 1985, over $15 million worth of forest products were sold, and all expenses of the program were paid from the sales proceeds. About $2 million were distributed to host states to be spent on schools and roads, and the U.S. Treasury received over $1 million.

Beach Management

The beaches at Tyndall Air Force Base, Florida, are now part of the protected Coastal Barrier Resources System. For years, Tyndall's beaches were host to recreational off–road vehicle traffic, naval hovercraft testing and military–training exercises. These beaches were also nesting grounds for endangered sea turtles and several state–protected birds. In 1982, Air Force wildlife managers noted that the intense beach activity not only prevented full nesting potential from being reached, but nests and hatchlings were being destroyed. The matter was taken directly to the base commander. In 1983, a retired U.S. Fish and Wildlife Service enforcement official was hired temporarily to patrol the beaches and enforce natural resource–protection regulations. Meanwhile, a request to establish a permanent position to do this job was processed. The retiree did such a good job that the commander rehired him the next year. The request for the permanent wildlife biologist/wildlife enforcement position was approved by Tyndall's headquarters and was filled in December 1984. Probably as a direct result of those enhanced enforcement efforts, 1985 saw the nesting rate of sea turtles jump from 6-8 nests to 15 nests. The vehicle traffic on the beaches decreased substantially and dunes began to reseed. Sea oats became abundant. The residents of Mexico Beach, adjacent to Tyndall, saw the change at Tyndall and petitioned their county sheriff to shut down their beach to vehicle traffic. Also, the Navy has agreed to modify its hovercraft activity to avoid jeopardizing sea turtle nesting activities and disturbing dunes.[3]

Rangeland Management

A decade ago, Avon Park Bombing Range, 106,000 acres of sandhills and wetlands in central Florida, was used intensively for cattle grazing—without any management plan to protect or sustain the natural resources. Pastures were not allowed to rest nor were they fertilized. Wetlands were drained to produce more pastureland. Forestry activities were haphazard. The leasing ranchers were not anxious to have any restrictions or changes imposed on them and they expressed their concerns even to the Air Force Secretariat. However, an Air Force natural resource–management plan was implemented which included over $100,000 worth of land improvements and the hiring of a professional range conservationist. The U.S. Soil Conservation Service assisted the Air Force in the development of improvements and the manage-

[3]Telephone interview with Major Joe Ward, Natural Resources Manager, Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, January 7, 1986.

ment plan to sustain the productivity of natural resources and enable multiple use of the property. Wetlands are now periodically drawn down and flooded. Forests are managed for a sustained commercial yield as well as better wildlife habitat. A wildlife–management plan was implemented, including specific protection for endangered and threatened species. About 3,000 people now participate in hunting and other outdoor recreation opportunities at Avon Park each year.[4] Avon Park won the Air Force's Natural Resources Conservation Award in 1983 for its vast improvements and excellent integrated management program.

Cemetery Management

Few people realize that, unlike most other national cemeteries, the best known one—Arlington National Cemetery—is managed by the Army, but with direct funding from Congress. The pomp, ritual and high visibility of ceremonies at Arlington Cemetery present constant challenges to Erik Dihle, the head of the horticulture division employed by the Army to take care of Arlington as well as the Soldiers' Home and Airman's National Cemetery in Washington, D.C. Arlington National Cemetery contains about 9,000 trees, some of which are hundreds of years old. The landscape is dotted with magnolia, weeping cherry, hickory, cedar, maple, elm and crabapple, but about one-fourth of the trees are oak. Many were part of the Custis-Lee estate when it was confiscated by the U.S. government in 1864 (Flood 1981). Among them are one of the largest post oaks in Washington—the Arlington oak—and one of the largest white oaks. The white oak is at President Taft's grave and is about 350 years old and has a diameter of about six feet.[5]

Prestigious Arlington Cemetery attracts millions of tourists each year—primarily to visit the grave of John F. Kennedy and the Tomb of the Unknown Soldier or to attend ceremonies on Memorial Day. It is a very active place, and maintenance of 500 acres of the Cemetery must be squeezed in between ceremonies and respectful burials. Compaction is a problem because of the heavy vehicles used around the grounds. New burials, among the 190,000 marble headstones already there, sometimes disturb the roots of those trees that are hundreds of years old. However, weeds are controlled, 3,000 shrubs and hedges are kept neat, trees are pruned, planted, sprayed and fed, grasses are mowed or hand-trimmed, and leaves are collected. About 300 truckloads of leaves are hauled away each year by a contractor, but about 2 percent are collected by the grounds staff, mixed with sewage sludge and used as a topdressing (Hrehocik 1984). Under conscientious Army management, Arlington National Cemetery will continue to be a source of pride for all citizens.

Training Activities

The Army's training mission sometimes creates special environmental and land–management problems. Each new or improved vehicle or tactic may make new demands on the natural resources exposed to it. Some Army installations enjoy climates that enable quick recovery of affected resources; others do not.

Fort Benning, Georgia, is one with a helpful climate but, even there, constant care

[4]Telephone interview with Major Joe Ward, Natural Resources Manager, Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, January 7, 1986.

[5]Telephone interview with Erik Dihle, Horticulturist, Arlington National Cemetery, Washington, DC, January 31, 1986.

and adjustments must be made. Infantry training has occurred at Fort Benning since 1918, but it is also the home of about 600 nesting trees for the endangered red–cockaded woodpecker. Buffer zones are maintained around these trees and all forestry activities, as well as training activities, are planned so as to avoid adverse impacts on the birds and their habitat.

Fort Carson, Colorado, is an example of an installation that does not have a climate favorable to quick recovery of natural resources affected by military–training activities. With only about 12 inches of precipitation per year, protection of vegetative cover and trees is essential to control erosion. Also, to support realistic training, natural resources must remain healthy. Mechanized infantry–training activities have been conducted at Fort Carson since 1940, and intensively used areas now exhibit environmental damage. Trees that took hundreds of years to grow can be wiped out in seconds by military vehicles or can die in a few months because of compacted soil or root damage due to close calls with mechanized vehicles.

In 1976, the Army proposed to acquire more land to use for mechanized infantry training at Fort Carson. This was necessary for two reasons. First, more land was needed to train infantrymen to use new equipment and tanks that move faster and shoot farther. Second, additional land was needed in order to stop training on some areas of Fort Carson and start repairing them. Development had occurred all around Fort Carson, so acquisition of new lands and public tolerance of noisy military activities contiguous to Fort Carson itself were precluded. Finally, after completing an environmental impact statement and having innumerable public and Congressional hearings on the proposal, about $30 million was appropriated for the acquisition of 244,000 acres. The newly acquired land, called the Pinon Canyon Maneuver Site, is 155 miles from Fort Carson in the southeastern corner of Colorado. For training exercises, mechanized equipment is moved by train, and troops and other equipment by roads. Prior to the initiation of the Maneuver Site to Army mechanized infantry training in the summer of 1985, $6 million was spent on seeding, land treatment and erosion–control projects, as well as studies used to develop the management plan. The objective of the natural resource–management plan is to provide for long–term accomplishment of the military mission by maintaining the healthy natural resource base necessary to accomplish it. Those things are certainly not mutually exclusive, but do come at a cost. The Pinon Canyon Maneuver Site will be used in accordance with the natural resource–management plan, which calls for use of only three of five parcels at a time while the other two are repaired and rested. The environmental impact statement is also being used and evaluated constantly as a tool to manage carefully and monitor the new training site.[6]

Navy Goats

San Clemente Island, California, is managed by the Navy for numerous operations, including Marine assault landings, ship–to–shore bombardment, carrier landing practice, and research and development. San Clemente, about 64 miles west of San Diego, is the southernmost of the California Channel Islands and is almost 4 miles wide and 21 miles long at its greatest points.

The island is home to five protected species of plants, two birds and one lizard.

[6]Telephone interview with Tom Warren, Environmental and Natural Resources Manager, Fort Carson, Colorado, January 29, 1986.

Also living on the island are wild goats that were originally introduced by fishermen as a source of meat and milk. By the mid 1970s, the goats had grown to a population that interfered with Navy operations, such as by eating Navy housing and running across active runways. In 1972, the Navy began a sport-hunter program which, over a period of six years, removed approximately 4,000 goats. In 1979, the U.S. Fish and Wildlife Service asked the Navy to remove all of the feral goats because they were a threat to the protected and endangered species. The goats eat the plants and destroy the vegetation that supports the birds and lizard. The Navy hired a cowboy who, using dogs, was able to round up over 12,000 goats in 1979 and 1980.

Next, the Navy formulated a plan that called for aerial shooting of the remaining goats. However, before the Navy could implement this plan, the Fund for Animals, headed by Cleveland Amory, filed suit and was successful in obtaining a temporary restraining order from the federal district court in Los Angeles. The hearing included a media event consisting of actress Cindy Williams carrying a baby goat into the courtroom. The Navy negotiated a settlement with the Fund for Animals, which called for live–trapping of the goats. It required the Navy to hire Jim Clapp, who invented a special trap dubbed the Clapp trap. Clapp's associates became known as the "Clapp family trappers." During the next two years, the trappers captured over 4,000 goats. The animals were removed from the Island by Navy barge and trucked to various Fund ranches for adoption.

In late 1981, the Navy and Mr. Clapp agreed that all goats that could be caught had been, and the Navy once again prepared to shoot the remaining goats. The Fund for Animals again asked for a restraining order, but it was denied by the court. A September 1981 census showed approximately 500 goats remaining on the island. The shoot did not begin until August 1982 and, after killing 640 goats, the contractor ran out of ammunition. At this point, although further court action was unsuccessful, political and public pressure caused the Navy to stop the shooting program.

In July 1983, the Fund began an aerial net-trapping program and successfully removed 321 animals. In September 1983, a survey showed about 1,000 goats still on the island. The Navy asked the U.S. Fish and Wildlife Service regional office to approve a plan to maintain a population limit of 500 goats. In December 1983, the U.S. Fish and Wildlife Service responded with a request for all goats to be removed from the island.

In July 1984, the Navy once again contracted with the Fund for Animals and 602 goats were trapped and removed. At this point, the Navy again planned to shoot the remaining animals, estimated to be less than 1,500. But the shoot was stopped moments before it was to start in January 1985 when political pressure was brought to bear. So again, the Navy contracted with the Fund and, during 1985, over 1,500 goats were removed from the island.

From 1972 through 1985, the Navy spent in excess of $750,000 removing over 23,000 goats from San Clemente. The Fund for Animals has spent several hundred thousand dollars. At last estimate, approximately 500 feral goats still live on San Clemente and the Navy is still trying to accomplish the Fish and Wildlife Service mandate.[7] The irony of the Navy's dilemma with goat management on San Clemente

[7]Personal interview with Richard Cornelius, Attorney, Office of Navy General Counsel, Washington, D.C. January 27, 1986.

Island has ceased to be humorous to most people concerned with fiscal and natural resource management and public relations.

Conclusion

Among the hundreds of DoD installations in the United States, there are innumerable examples of special natural resource–management challenges that are met daily by a staff of about 300 professionals (excluding Army Civil Works). Obviously, that is not enough expertise to manage properly the resources on 24 million acres of public lands subjected to military activities. Successes can be attributed to a general spirit of cooperation from commanders, the military families who live on these bases, civilian employees, host states' natural resource managers, scientists at universities, and specialists and officials in other federal agencies. The job gets done through formal and informal agreements, contracts for services, helpful citizens and a small but dedicated group of scientists employed by the Defense Department.

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Idaho's Cooperative Sikes Act Wildlife Management Program

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Introduction

The Idaho Cooperative Wildlife Management Program is a cooperative effort between the U.S. Bureau of Land Management (BLM), the Idaho Department of Fish and Game (IDFG), the Intermountain Forest and Range Experiment Station, and private landowners. Its purpose is to protect and enhance wildlife habitat on isolated tracts of public land in southcentral Idaho.

The Problem

The Snake River Plain of southcentral Idaho has historically been one of the most productive ring-necked pheasant (*Phasianus colchicus*) areas in the western states. Croplands, ditches, fence rows and waste areas on farms of the region provided excellent feeding, nesting, brooding, escape and winter habitat for the pheasants, as well as for other upland wildlife. The edge effect created by dense native sagebrush stands adjacent to the farms added to this mosaic and also provided valuable winter, escape, and brooding habitat.

In the past 20 years, however, this region has experienced a steady decline in pheasant numbers. This decline is primarily a result of winter and nesting habitat loss due to agricultural land-use changes that have occurred over this same period. Other upland wildlife species have also been impacted. Significant land-use changes include: (1) greatly increased use of sprinkler irrigation, eliminating the need for irrigation ditches and permitting much more land (i.e., "waste areas") to be cultivated; (2) clean farming practices such as burning fence rows, ditch banks, stubble fields and other unfarmed areas; (3) fall disking of grain stubble and row-crop residues; (4) the continuing trend toward larger, more-intensively managed farms; and (5) conversion of more native rangeland to private agriculture and monotypic crested wheatgrass stands for grazing purposes. These same circumstances have been associated with pheasant population declines in other states (Olsen 1977, Nish 1973, Snyder 1973, 1982, Baxter and Wolfe 1973, Kebbe 1973, Trautman 1982, Weigand 1973).

As pheasant and other upland wildlife habitat declined, BLM and IDFG biologists recognized that the isolated tracts of public land still remaining in these large agricultural areas would become increasingly valuable. Many of these sites were already popular hunting areas during the pheasant season. Managing them to reach their full potential for pheasant and other wildlife habitat would require a broad comprehensive plan. The amended Sikes Act provided the legislative incentive to carry this planning and subsequent management out on a cooperative basis. The rest of this paper describes the organization, implementation and current status of the Idaho Cooperative Wildlife Management Program since its inception.

Program Description

Legislative Background

The original Sikes Act (P.L. 93-452) was passed by the U.S. Congress in 1960. It directed the U.S. Department of the Interior's Fish and Wildlife Service and the Department of Defense to cooperate in developing and implementing fish and wildlife conservation programs on military reservations.

In 1974, the Act was amended and called for state and federal cooperation in coordinating the planning, development and maintenance of comprehensive conservation and rehabilitation programs for fish and wildlife on other federally administered lands. The development of cooperative agreements between state wildlife and federal agencies for carrying out these comprehensive plans was also authorized.

The Cooperative Wildlife Management Program was started in 1975, with the signing of the Sikes Act Comprehensive Plan for National Resource Lands in Idaho by the State Director for the BLM, and the Director of the IDFG. This agreement was followed by completion and signing of the Cooperative Wildlife Habitat Management Plans for the Boise, Burley and Shoshone BLM Districts between 1976 and 1978. A master Sikes Act Cooperative Agreement was also signed in 1977 by the directors of both agencies, and identified the various jobs and responsibilities for the program. These signings provided for over 27,000 acres (10,931 ha) of public land to be managed cooperatively for the improvement of wildlife habitat. Since then, approximately 4,000 additional acres (1,619 ha) have been added to the program, bringing the total to 31,548 acres (12,772 ha) of public land.

The Wildlife Tracts

As stated earlier, the aforementioned acreage is located on the Snake River Plain of southcentral Idaho. This BLM land is comprised of 269 tracts that range from 14 to 920 acres (6–372 ha) in size. These parcels are generally surrounded by highly developed agricultural land and/or land with high potential for future development (Figure 1).

Annual precipitation in the region averages 8–12 inches (20–30 cm), with 50 percent of the moisture occurring as snow from November through February. The growing season averages approximately 120 frost–free days. Summers are generally warm and dry.

Due to the dry climate, habitats on most of the tracts are arid shrub–grass or grass types. Some parcels do contain wetland and riparian areas, usually as a result of agricultural water developments and/or runoff. In the past, a number of the areas have been burned, trespass farmed and/or overgrazed. Dominant plant species include: big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*) and Great Basin wildrye (*Elymus cinereus*). In addition to pheasants, other wildlife species found on the tracts include: gray partridge (*Perdix perdix*), California quail (*Lophortyx californicus*), sage grouse (*Centrocercus urophasianus*), mourning dove (*Zenaida macroura*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), coyote (*Canis latrans*), and a variety of waterfowl, raptors, songbirds and small mammals. Several tracts are also used by elk (*Cervus elaphus*) as part of their winter range.

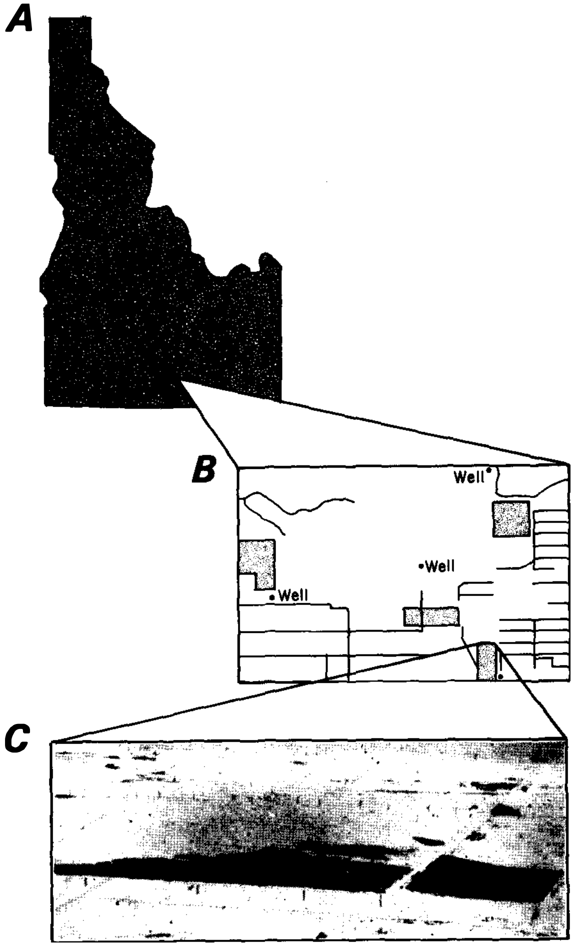

Figure 1. (A) Location of the Idaho Cooperative Wildlife Management Program. (B) Map illustrating the wildlife tracts. (C) Aerial photograph of a sagebrush (*Artemesia tridentata*) covered wildlife tract during winter. IDFG photo.

The Cooperative Habitat Management Plans

Following the signing of the 1975 Sikes Act Comprehensive Plan for Idaho, personnel from the Boise, Burley and Shoshone BLM Districts and IDFG Region IV began to develop the Cooperative Habitat Management Plans (HMPs) for each BLM district. These plans identified the wildlife problems, and set forth the objectives, management methods and responsibilities for implementing the program. The major objectives outlined in the plans include:

1. provide for the protection and enhancement of wildlife habitat on the tracts, with special emphasis on wintering and nesting habitat for pheasants;
2. increase populations of pheasants and other upland game, passerine birds and raptor prey species within the wildlife tracts habitat areas;

3. provide yearlong water sources for wildlife on selected tracts;
4. provide and identify areas for public recreation; and
5. protect the wildlife tracts from all unauthorized uses, including grazing, agricultural trespass and fire.

To meet the objectives, management methods discussed in the HMPs focused on habitat development. Improvements described include fencing, water development, dryland rehabilitation and cooperative farming techniques. The responsibilities for carrying out these developments were outlined in the Sikes Act agreement as follows.

The Bureau of Land Management will:

- Designate and furnish public lands for conducting habitat improvement activities.
- Obtain protective withdrawals for the designated lands.
- Assist in the development of the HMPs and the Sikes Act agreements.
- Review and assist with any cooperative wildlife farm plans recommended by IDFG.
- Contract with IDFG for wildlife studies and habitat development work, including vegetative plantings, fencing and irrigation system construction.

The Idaho Department of Fish and Game will:

- Supervise all habitat work involving the implementation of the HMPs.
- Establish studies to evaluate the wildlife response to the work set forth in the HMPs, and provide this information to the BLM.
- Enforce laws applicable to the areas.
- Coordinate the development of any cooperative wildlife habitat farm plans.
- Monitor all of the cooperative wildlife tracts and agreements.

The Sikes Act Agreement in the Boise BLM District's HMP also included the Intermountain Forest and Range Experiment Station (IFRES) as a third cooperating agency. Its role has been to assist in establishing and evaluating vegetative plantings for the selection of species adapted to the region and useful for habitat enhancement. Because many of the tracts in poor condition have required dryland plantings, the IFRES's role has been a key one in the success of the program (U.S. Bureau of Land Management 1976, 1977, 1978).

Program Implementation

As the HMPs were completed for each BLM district, the habitat–improvement work was started and continues at this time. The combination of low precipitation, past land abuses, diverse habitats and species occurrence, and isolation from other public ground has required flexible and innovative management of the tracts. Basically, this management has been accomplished by separating the tracts according to their condition and habitat potential. Much of this work was done during the initial tract inventories. Conditions have generally been visually determined by the amount of suitable cover (habitat) available to wildlife on the individual tracts, rather than strictly using the area's ecological condition as criteria. While this method is more subjective, it has allowed managers to prioritize better the tracts needing improvements. It has also helped biologists avoid conflicts in managing the areas for pheasants, versus managing them for other wildlife species. Many of the tracts identified are obviously in poor ecological condition due to past abuses. However, these areas were set aside on the basis of wildlife that were found to be using them. Examples are tracts where runoff irrigation is raising "weeds" important to pheasants, and disturbed areas that are providing habitat for the burrowing owl (*Athene cunicularia*).

Using the above criteria, approximately 66 percent of the tracts were in poor habitat condition at the outset of the program. Eleven percent had been subject to agricultural trespass (Figure 2), making them candidates for cooperative agreements. This latter management alternative was considered as a means of increasing the amount of nesting habitat for pheasants.

Tracts in good habitat condition have generally been managed using such protectionary measures as fencing, fire control and increased monitoring. Most of these tracts contain good stands of native shrub cover and are used extensively by wildlife, particularly in the winter season when the neighboring farm ground is bare. In addition, 36 water developments (guzzlers, check dams and ponds) and 78 nest structures have been completed on these areas. Tracts that were in poor condition have

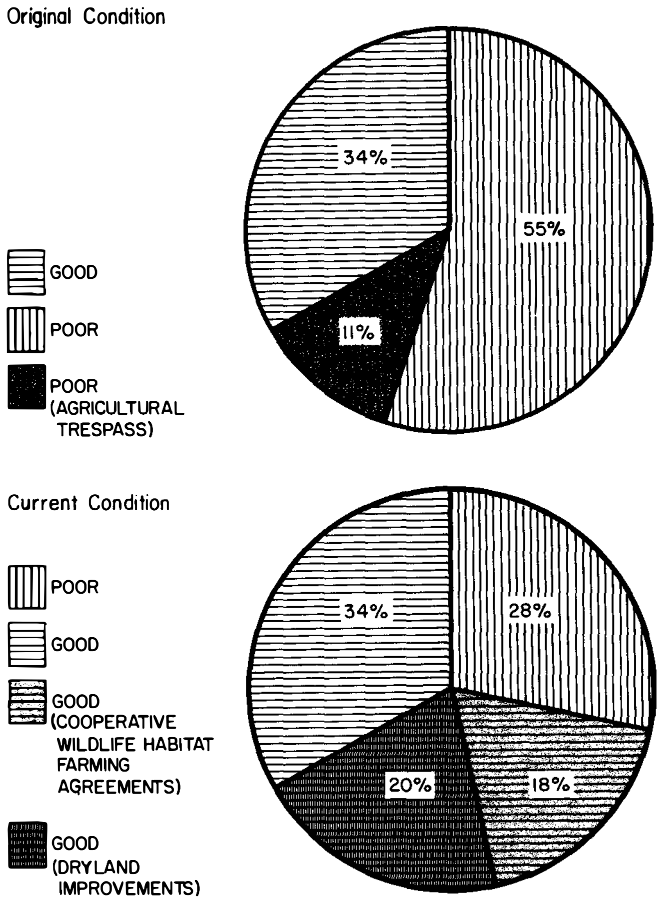

Figure 2. Results of habitat improvements, Idaho Cooperative Wildlife Management Program, 1977–85.

also been managed using protectionary measures to prevent further abuse. Many of these have been rehabilitated as well, using dryland seedings and cooperative agreements. Most of the dryland work has been contracted by the BLM, either through IDFG, IFRES or private companies. To date, over 2,700 acres (1,093 ha) have been dryland rehabilitated for wildlife. This work has ranged from total reseedings of annual grasslands to interseeding shrubs in existing monotypic crested wheatgrass seedings. The aim has been to provide a diversity of cover on these habitat islands. Species seeded include big sagebrush, rabbitbrush, four-wing saltbush (*Atriplex canescens*) and Great Basin wildrye. IDFG is now taking a greater role in assisting the BLM with these developments. In conjunction with this work, 71 miles (114 km) of protective fencing have been completed. Approximately 28 percent of the parcels are still slated for rehabilitation work within the next few years. (Figure 2).

Probably the most–innovative phase of the program has been the development of the cooperative wildlife habitat farming agreements. Primarily IDFG's responsibility, these agreements have been a major factor in: (1) achieving increases in the amount of pheasant–nesting habitat; (2) solving trespass and access problems in a cost–effective, long–term manner; (3) increasing the amount of land open to recreation; and (4) providing potential economic gains to the cooperative farmer.

There are currently 50 cooperative agreements involving almost 3,000 acres (1,215 ha) of the wildlife tracts (Table 1). IDFG personnel negotiate these agreements by contacting farmers with land adjacent to the tract in need of improvement. Once selected, the participating farmer is permitted to develop irrigation sources and farm approximately 50 percent of the wildlife tract free of charge. His restrictions include following proper crop rotation and soil conservation practices and controlling weeds on the entire area. In years grain is grown, he must also leave a certain amount of grain and grain stubble standing for wildlife use. In return, the farmer is required to plant and irrigate a permanent wildlife cover on the rest of the tract or an equal portion of his own land (Figure 3). Acreages may vary if shelterbelts or water developments are used, but usually these plantings are a grass/legume mixture that is provided by the cooperating BLM district. This irrigated cover is left undisturbed throughout the nesting period. Occasional single cuttings are permitted on areas where irrigation is impeded by the accumulation of too much residual cover. This decision is up to the manager, however, not the farmer. These cuttings are delayed to permit hens the opportunity to renest if their nests on neighboring farmlands have been lost. The agreement areas are entirely open to public hunting and recreation.

Table 1. Summary of cooperative wildlife habitat farming agreements, Idaho Cooperative Wildlife Management Program, 1986.

District	Number of agreements	Agriculture		Irrigated wildlife habitat		Private land opened to public hunting	
		Acres	Hectares	Acres	Hectares	Acres	Hectares
Boise	5	214	87	165	67	1,528	619
Burley	21	1,090	441	471	191	2,624	1,062
Shoshone	24	516	209	528	214	1,966	796
Total	50	1,820	737	1,163	472	6,118	2,477

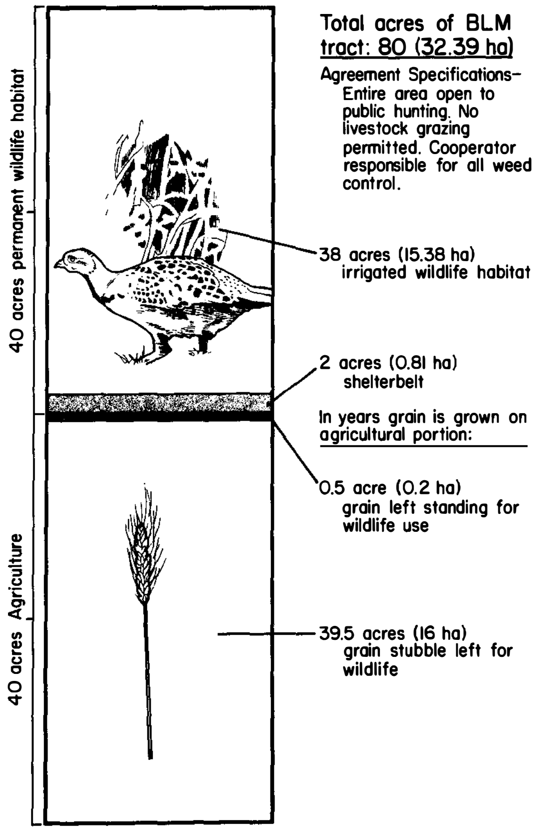

Figure 3. Example of a cooperative wildlife habitat farming agreement on a BLM tract.

IDFG has also negotiated with a number of cooperators to permit public hunting on their private land, which is adjacent to the wildlife area (Table 1).

An additional benefit of the cooperative wildlife habitat–farming agreements has been their use as a means of solving trespass and habitat–improvement problems on the tracts. Twenty–eight of the existing 50 agreement areas were originally in trespass. After settling the trespass rental fees and penalties, these individuals were given the opportunity to enter into the wildlife habitat agreements. Since many of these areas were already developed for irrigation, more–rapid establishment of irrigated habitat was possible. These agreements have generally provided greater wildlife and public benefits than the standard dryland rehabilitation requirement would have done.

On the whole, there has been little problem with cooperator compliance. All of the agreements are written up in a standard form and signed by the IDFG Region IV supervisor, the respective BLM district manager and the cooperator. Changes in the agreements are negotiable, but any noncompliance can result in cancellation. If this should occur, the cooperator is required to rehabilitate the entire tract at his own expense, using species selected by IDFG and BLM.

The cooperative habitat–farming agreements are now the most–popular part of the program and will probably be so for some time. The success achieved by the agreements can largely be attributed to the manner in which they avoid the problems typical of past pheasant habitat programs in which pheasant habitat production directly interfered with the farmer's income (MacMullan 1961, Kebbe 1973, Olsen 1977). An intensive signing effort by the BLM has also aided in the success of the agreements (as well as the dryland tracts) by identifying the areas for public use. Although the cooperative farm habitat acreages involved certainly cannot offset the continuing loss of pheasant habitat on agricultural lands, their role has been vital in gathering support and meeting the original objectives of the project.

Wildlife and Vegetative Studies

IDFG has been largely responsible for carrying on a number of wildlife studies since the beginning of the project. Designed to assess the impact of the program on wildlife populations, these studies include monitoring pheasant and upland game population trends, quarterly trend surveys on selected dryland tracts and irrigated agreements, nesting surveys on the agreements, pheasant habitat selection, and hunter bag checks. Seasonal condition of the irrigated habitat areas is also being monitored and recorded by IDFG personnel. While this paper cannot address the results of these continuing studies, preliminary analyses indicate a favorable wildlife response to the habitat changes. Examples include a 32–percent increase in the number of species observed during quarterly trend transects of selected tracts from 1980 to 1984, and a 227–percent increase in birds observed per mile on the Boise District's pheasant brood surveys from 1978 to 1984 (IDFG 1985).

The results of a number of tract vegetation studies and evaluations are currently being written by the IFRES. Most of the experimental dryland seedings have been successful, with averages as high as 400 shrubs per acre being established (Steve Monsen, IFRES, pers. communication). The station is also involved in a dryland nesting habitat study with IDFG and BLM. The information gained from this work should prove useful in managing the tracts.

Future of the Program

The high level of cooperation exhibited between the agencies involved and private landowners has virtually assured the success of the Idaho Cooperative Wildlife Management Program. In October 1985, the Burley BLM District proposed that a minimum of 14 more tracts (2,825 acres or 1,144 ha) be added to the program. An additional 21,000 acres (8,502 ha) have also been identified in the Idaho Falls District and are scheduled for implementation in the near future. A number of the newly identified tracts will emphasize management for Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) and big game winter range. The past three winters have shown this latter use to be an increasingly important component of the existing tracts.

The program continues to receive growing support from the public sector. Hunter–use surveys indicate hunters are concentrating on the tracts during the upland game seasons. In an aerial survey of 35 tracts during the opening two hours of the 1985 pheasant season, an average of five hunters per tract were observed on the wildlife areas (IDFG 1985).

Similarly, public support is growing from an economic standpoint. In the Twin Falls and Mini–Cassia areas of Idaho, the 1978–1982 average number of pheasant hunters per year was 84,000, and the average number of pheasant hunter days expended per year was 460,000. These hunters spent more than $18 million annually on pheasant hunting. In a 1982 BLM economic analysis, this information was used in conjunction with very conservative figures on the project's pheasant population goal (1 bird per 10 acres), the estimated number of hunter–days increased, the value per hunter–day, and the economic benefits of cooperative farming and trespass abatement. Conducted for the Boise and Burley BLM Districts' wildlife tracts, this analysis estimated the minimum economic benefits would total almost $8.6 million over the first 20 years of the project. It should be noted that the value per hunter–day used in the calculations was less than one–half of the 1978–1982 average value ($19.00 vs. $39.13) (Thomas 1985).

As interagency and public support grows, the future of the program looks very promising. Intensive wildlife habitat management will continue to ensure protection for wildlife using the tracts, and provide additional recreational opportunities to the public. The key to the program's continued success is cooperation.

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Wildlife Management, An Integral Part of Intensive Multiple Use: Land Between The Lakes, A Case History

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Introduction

During the past 25 years, the U.S. Congress has clearly expressed its interest in and intent for multiple use of the nation's natural resources. Passage of the Multiple–Use Sustained–Yield Act of 1960 and subsequent legislation, such as the Forest and Rangeland Renewable Resources Planning Act of 1974, specifically mandate multiple–use action on some properties. In the next few years, as the demand for resource–related recreation increases and as public land acquisition decreases, there will undoubtedly be renewed emphasis on multiple–use management. The President's Commission on Americans Outdoors is at present gathering and sorting recreation supply and demand data, and will soon be addressing issues regarding public lands. It is likely that multiple use will be one of these issues since it is increasingly apparent that the real owners of our public lands—the nation's people—expect more from them than timber, livestock grazing, and minerals. A greater diversity of benefits, among them recreation and education, is being demanded of the resource base.

Multiple–use management for widely diverse and sometimes conflicting uses will become a critical skill for resource managers. In fact, the future of the country's more ecologically sensitive areas, such as many national parks, may indirectly depend on it. With the transfer of multiple–use management systems, like the one now in place at Land Between The Lakes (LBL), to other strategically located public lands, the recreation load in the more sensitive areas primarily set aside for preservation could be reduced to tolerable levels.

LBL is a successful 21–year case history of intensive multiple–use management and serves as an example to consider in managing lands for a diversity of benefits. The Tennessee Valley Authority (TVA) has been involved in multiple–use planning and management since its inception in 1933. Preceding the Multiple–Use Sustained–Yield Act by some 27 years, the Tennessee Valley Authority Act of 1933 mandated TVA with "the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory."

When the 170,000 acres (68,000 ha) known as "Land Between The Lakes" was announced in 1963 by President John F. Kennedy, TVA was charged to "develop a national recreation area as a demonstration in resource development . . ." and specifically to "demonstrate how an area with limited timber, agriculture, and industrial resources can be converted into a recreational asset that will stimulate economic growth of the region" (Office of the White House 1963). TVA had more than 30 years of Valley–wide experience to draw on, and was selected to acquire and manage the area over other likely Federal candidate agencies in part because its broad mandate would facilitate acquisition and in part because its unusual management flexibility and diverse staff would permit a balancing of specific program interests that would result in a wide array of public benefits.

What makes LBL unique—indeed a national demonstration area—is not its natural resources or its scenic beauty but rather its mission and its management. That mission is clearly multiple use: (1) to manage the resources for optimum yield of outdoor recreation and environmental education benefits for the American people; (2) to utilize TVA's demonstration assignment to research, test and implement innovative techniques and programs; (3) to help stimulate quality development of the surrounding region; and (4) to extend the beneficial results as widely as possible.

The management philosophy is geared toward upgrading and developing the natural resources of the area to achieve the desired diversity of recreational and educational uses.

Description

The Resource

LBL occupies a 170,000-acre (68,000–ha) strip of land in western Kentucky and Tennessee, approximately 8 miles (13 km) wide and 38 miles (61 km) long, which separates the TVA Kentucky Lake impoundment from the Lake Barkley Reservoir operated by the U.S. Army Corps of Engineers. A canal linking the two reservoirs serves as the northernmost boundary of the area, making it, in effect, a peninsula.

In terms of natural resources, the area is not particularly well–endowed. The area's most outstanding feature is its 300 miles (186 km) of undeveloped, freshwater shoreline. The soils are those generally associated with ridgetops, since the more fertile river bottom areas now lie under Lake Barkely and Kentucky Lake. LBL's forests are predominantly western mesophytic hardwoods, featuring white oak, red oak and hickory. More than 55 species of commercially valuable trees can be found at LBL. A wide variety of game and nongame wildlife species abound. Because of extensive forest habitats (89 percent forest) forest–oriented species—such as woodpeckers, owls, deer, turkey, squirrel, and raccoon—flourish. Farm game species such as quail and rabbit abound along LBL's long, narrow creek drainages.

The Process

Attainment of multiple goals and objectives requires not only a shift in traditional land–management practices toward greater biotic diversity, but also a shift in staffing practices toward greater skills diversity.

LBL's mission, combined with its broad–based professional staff, sets the stage for a successful demonstration of multiple–use management. The staff of educators, biologists, foresters, engineers, entomologists, recreation planners, historians, agriculturists, landscape architects and law enforcement specialists is involved in land–managment decision making to help keep specific program interests from becoming dominant land uses. As an example, LBL's multiple–use philosophy dictates that land–management activities provide not only a wide variety of wildlife populations for recreational and educational use but also the setting or backdrop for many other public uses, among them hiking, camping, historical interpretation and environmental education.

To accomplish wildlife objectives, development of habitat diversity does not override protection or upgrading of the overall quality of the resource base. Certain inherent constraints, such as productivity of soils and topography, dictate the limits of various activities, but the multiple–use mission itself requires a continual process of making trade–offs between conflicting uses. The interdisciplinary decision–making team is called upon in such circumstances to maintain balance, and has generally been successful. On a land base where timber production or even white–tailed deer management could easily have become the dominant land use, the interdisciplinary team approach for the past 20 years has acted to create and keep a wide diversity of visitor opportunities.

Almost as important to the long–range success of LBL as the staff's diversity is management–policy flexibility. The ability to "change with the times" in developing and administering policies is invaluable. Smaller agency size and fewer legislative constraints (less bureaucracy and red tape) have allowed TVA to move quickly to implement new ideas and technologies as well as to facilitate research and product testing, further enhancing LBL as a multiple–use area. For example, LBL was the first area in the country to respond to the 1972 Executive Order 11644 that required federal agencies to establish proper control and direction of off-road vehicles (ORV) on public lands. LBL set aside a 2,350-acre (951–ha) tract specifically to accommodate ORV use. LBL also is quick to adopt new technologies, such as eagle hacking, as they develop, adding to the body of available information and providing a national demonstration area.

Management flexibility enables staff to plan and rapidly implement research endeavors that address emerging issues. An example is a current cooperative effort with the U.S. Department of Agriculture (USDA) to determine the most effective means of controlling ticks in campgrounds and other high–use recreation areas (USDA 1984). Lone star and American dog tick populations are a rapidly growing problem at LBL as well as in other parts of the country. Heavy infestations cause losses of millions of dollars annually to the recreation and tourism industry as a result of irritating bites and transmission of disease (i.e., Rocky Mountain Spotted Fever). Also, research is being done at LBL on the recently discovered, tick–transmitted disease Lyme Arthritis.

Another example of management flexibility allowing for rapid change involved institution of a fee system for hunters utilizing LBL. As federal appropriations declined, significant reductions had to be made in wildlife management efforts. To offset these budget cuts, a hunter–use fee was developed to help enhance the level of wildlife habitat improvements. This is only one of many new systems being implemented by LBL. Increasingly, TVA and other federal agencies' decisions are being directed toward investments in revenue–producing activities rather than in activities that must be heavily subsidized.

Another example of flexible management is that LBL was able to advertise nationally, accept bids and negotiate a five–year timber sale contract (with a five–year renewable clause). This type of negotiation allowed the successful bidder to make a large capital investment and it introduced a greater level of market stability into the entire LBL region.

Primarily because management flexibility has allowed it, commercial product testing has been done at LBL to improve a variety of products. For example, LBL has tested and critiqued such items as fish attractors, vehicle–mounted deer alerts, lantern hangers and soil–disturbance equipment.

Proactive management, essential to multiple use, requires a flexible planning process. The early planning process involved developing long–range plans for such capital investments as family and group camps, roads, and information and interpretative facilities. It also included writing a resource management plan to ensure the coordination and integration required to reach LBL's stated multiple–use objectives.

The Plan

Input for writing the resources plan was obtained from a variety of experts and agencies (state agencies, U.S. Forest Service and universities). The draft plan was reviewed by experts (Dr. Henry S. Mosby, Virginia Polytechnic Institute and State University, and Dr. Leslie L. Glasgow, former Assistant Secretary of the U.S. Department of the Interior), conservation groups (National Audubon Society and National Wildlife Federation) and state organizations (Kentucky and Tennessee fish and wildlife agencies and divisions of forestry). The plan identifies long–range goals, strategic planning elements, and operational guidelines for resource development and use. It is modified and revised periodically to reflect changing needs and new technology.

The revised resource–management plan (LBL 1985) calls for maintaining 15,000 acres (6,070 ha) of open land (9 percent of the total area), with 6,000 acres (2,428 ha) in evergreen cover (4 percent of the total area). The size class distribution objective of the total forest area (153,000 acres: 61,918 ha) is to be 60 percent sawtimber, 10 percent old growth, 15 percent poles and 15 percent young growth. Specific land–management plans are prepared and reviewed annually.

The 15,000 acres of open land are managed through contracts with local farmers on up to 5,000 acres (2,023 ha) of class I and II farmland and by a variety of land treatments by LBL personnel or contractors on the remaining acreage. Farmers leave up to 20 percent of the corn, soybeans or wheat crop in the field for wildlife, in exchange for use of the land. Crop varieties and locations are determined jointly by the wildlife biologists, agriculturists and farmers.

Forest and open land habitat plans are developed cooperatively by foresters and biologists. They are charged to place *high* values on aesthetics and the interests of recreation and education users. Plans are reviewed by and comments solicited from representatives of the various recreation and education groups at LBL. Every effort is made by resource managers to have management activities complement recreational use. In a review of LBL's program, Chester McConnell (1979), Southeast Representative of the Wildlife Management Institute, commented, "The present prescription process of developing detailed resource management plans for all work areas is noteworthy. With each resource discipline having two weeks for prescription review and comments, management decisions are made that enhance all resources and aid in carrying out LBL's total mission."

Since LBL is 89 percent forested, most of the habitat manipulation involves timber harvest. The harvest level in 1966 was 0.5 million board feet, and in 1985, it was 9.9 million. The current harvest level represents 32 percent of the net annual growth from growing stock five inches (diameter breast height) and up (Continuous Forest Inventory 1976). Much of the responsibility for making the multiple–use philosophy work lies with developing worktable timber–harvest prescriptions. LBL's approach to forest management led Dr. Carl Reidel (1979), former president of the American Forestry Association, in a review of LBL resource–management practices, to say, "Forest management on L.B.L. (sic) is not *timber* management; it is *forest* management—management that is sensitive to the niche requirements of trees and wildlife alike."

Ensuring that prescriptions are correctly implemented is also important. Resource specialists continually monitor the work of timber contractors to ensure that all environmental criteria specified in the contracts are met, an action that minimizes the short term public relations problems normally associated with timber harvest operations. The results of this implementation process led McConnell (1979) to comment further that the quality of timber harvest ". . . surpasses any observed during recent visits to approximately 55 National Forest Districts and thousands of acres of industrial forest land in the southeastern United States."

For the most part, the silvicultural practice used is shelterwood or a modified version—when desirable oak regeneration occurs, plans are made for its release. About 50 small clearcuts, from 5 to 15 acres (2 to 6 ha), are planned annually to aid in the balancing of age classes and regeneration of shade–intolerant species. These two systems provide LBL with habitat diversity and scenic integrity. Multiple–use management is not universally applied, however. In many instances some form of spatial or temporal zoning is used to minimize potential conflicts between user groups or to provide needed protection to plants or animals. All–terrain vehicle (ATV) users are a rapidly growing group of outdoor recreation users. If not regulated, they can possibly do extensive environmental damage as well as anger other recreationists pursuing more passive forms of outdoor enjoyment. To accommodate ATV users, LBL restricts use of their vehicles to a designated area where environmental damages are localized and controlled. A similar area has been established for horseback riders to accommodate heavy trail use and overnight stays. Another form of zoning employed at LBL is a network of wildlife refuges and sanctuaries that provides varying degrees of seasonal protection from visitor impacts to rare, endangered or otherwise sensitive species of wildlife (e.g., bald eagles and waterfowl).

In 1972, stands were identified to be used as study areas. Initially, three Society of American Foresters (SAF) Natural Areas were set aside. That number has increased to 29 areas that include rare or unusual plant communities found in the LBL. The Tennessee Department of Conservation has registered one Natural Area and has a native shortleaf pine stand under consideration. All study areas now have baseline data collected under an inventory described by Ohmann and Ream (1971). The objective is to identify 10 percent of LBL's forest as "old growth"—some stands will have no management; others will be managed to ensure that old age hardwood stands (150 years plus) remain throughout LBL. This further enhances habitat diversity and aesthetic parameters and, in some situations, can minimize potential environmental problems (e.g., by locating old—growth management areas on steep slopes).

In summary, the uniqueness of LBL's resource management program lies *not* in the techniques or practices employed but in (1) the *method* by which plans are developed and considerations given to all potential uses, (2) the *process* of implementing management programs, and (3) the *resulting combination* of uses that occurs on one land base. The resource–management methodology used at LBL for the past 21 years requires interdisciplinary teams rather than "textbook" prescriptions. As stated in the Society of American Foresters' 1985 annual meeting, ". . . we must learn to plan habitat management proactively, not reactively. Silviculture prescriptions must address a richer set of purposes. Biologists and foresters need to work as a team and increase their sense of partnership."

Results

Table 1 compares LBL's timber harvest with that of the national forests of the region. While LBL's forest acreage is smaller than any of the surrounding national forests, and the acreage and volume harvested per year is less, the percentage of the overall forest harvested annually is greater than three of the four other areas. On actual acres harvested, however, LBL's average annual cut per acre is less than three of the four. In other words, even though LBL proportionally cuts a slightly higher percentage of the overall forest each year, it distributes the harvest over more acres so that the intensity of the cut per acre is less (i.e., fewer board feet harvested per acre). These data support LBL's philosophy of providing dispersed habitat diversity on an annual basis and suggest that the forest is being fairly intensively managed. The abundance and densities of various wildlife species at LBL provide an attraction for a large number of these visits. Forest wildlife population levels, for example, have reached levels similar to, and in some cases higher than, areas developed principally for wildlife management purposes.

Examples of these increases, featuring two big game species—eastern wild turkey and white-tailed deer—follow. LBL's eastern wild turkey population, now estimated at 5,000 birds, has increased approximately tenfold since the area was established in 1964. The annual harvest levels have increased from six on the first gobbler-only hunt in 1965 to a record level of 291 in 1985. During this same 20-year period, turkey hunter use of LBL has increased more than thirteenfold (approximately 6,500 hunter days in 1985). LBL's 1985 turkey harvest equates to approximately 1.70 turkeys harvested per 1,000 acres (405 ha), which compares with an average of 0.15 turkey per 1,000 acres on four similar wildlife management areas in Kentucky (J. Phillips, personal communication, Kentucky Department of Fish and Wildlife Resources, 1986) where turkey restoration efforts are very active, and 0.79 per 1,000 acres on one similar Tennessee wildlife management area (J. Murrey, personal communication, Tennessee Wildlife Resources Agency, 1986) where turkey restoration efforts are nearly complete.

LBL's white-tailed deer herd has shown similar increases. From 1964 until 1979, when LBL's deer population peaked at approximately 10,000 deer, there was a fivefold population increase. Populations levels have since intentionally been reduced some 25 to 30 percent to achieve a more quality-oriented deer management philosophy. LBL's current white-tailed deer population level is estimated to be 7,500 and provides for an average deer harvest of 12.3 deer per 1,000 acres (405 ha). This compares favorably with the 1985 average deer harvest rates of 10.2 deer per 1,000 acres for 11 similar wildlife management areas in Tennessee (L. Marcum, personal communication, Tennessee Wildlife Resources Agency, 1986) and 17.0 deer per 1,000 acres for 9 similar Kentucky wildlife management areas (J. Phillips, personal communication, Kentucky Department of Fish and Wildlife Resources, 1986). Hunter interest in white-tailed deer has been overwhelming. Interest peaked in 1981 when over 39,000 hunters applied for the 12,000 permits randomly selected by com-

Table 1. Comparison of timber–harvest data from Land Between The Lakes and four national forests, 1982–1985.

Area	Total forest acres	Acres harvested annually[a]	Volume harvested annually[a] (million board feet)	Percentage of forest harvested	Volume harvested annually per acre cut (board feet/acre)
Daniel Boone National Forest[b]	672,000	5,638	35.1	0.8	6,226
Cherokee National Forest[c]	624,000	3,777	36.6	0.6	9,690
Shawnee National Forest[d]	262,000	5,476	13.2	2.1	2,411
Mark Twain National Forest[e]	1,470,000	18,261	64.3	1.2	3,521
Land Between the Lakes[f]	153,000	2,928	9.9	1.9	3,381

[a]Figures are averaged from 1982–85.
[b]Data from C. Crail, Daniel Boone National Forest.
[c]D. Rollins and B. Stanfield, Cherokee National Forest.
[d]D. Gillan and M. Moore, Shawnee National Forest.
[e]J. Law and L. Wilkins, Mark Twain National Forest.
[f]LBL forest records.

puter. In an attempt to distribute hunter opportunity to as many different persons as possible, a change was implemented in 1982 that prohibited a hunter from applying for a permit if he/she had been issued one the previous year. Even with this change, which effectively reduced the number of applicants by 12,000–15,000 a year, LBL still averages receiving 22,000 applications annually.

Small game forest species have generally also become more abundant. While comparative harvest data are not available, hunter–success rates are similar to those found in wildlife management areas in the region. Farm game species (e.g., cottontail rabbit and bobwhite quail) can be locally abundant but are generally restricted to long, narrow creek bottom lands that comprise 5–7 percent of LBL.

While the hunting program is important, LBL's mandate calls for a wide variety of wildlife populations, including nongame species, for the public's enlightenment and enjoyment. Intensive habitat–management practices adjacent to higher use public facilities and along major roadways allow for increased viewing opportunities. Trails, observation blinds, and tours provide abundant opportunities for the appreciative user to enjoy wildlife. In addition, cooperative efforts with other state and federal agencies to restore native species have been implemented. Species involved in either current or past programs include the bald eagle, osprey, giant Canada goose, ruffed grouse and river otter.[1]

As LBL's resource management activities provide a sustained timber yield, improve habitats for a wide variety of fish and wildlife, and ensure aesthetic benefits, they also increase the recreation and education offerings of the area. A 1976–77 recreation–use study conducted at LBL showed that over 40 percent of LBL's visitors came primarily to enjoy activities directly dependent on healthy fish and wildlife populations (James 1977). The total number of annual visits for hunting purposes is estimated at nearly 250,000; nonconsumptive wildlife uses account for approximately 200,000 visits.

Family campgrounds, lake–access areas, and such special–use areas as archery and firearm ranges have been developed to accommodate public recreation. Four interpretive centers and three group camps provide the foundation for LBL's education program, but multiple–use management is what makes these activities possible on the same landscape.

Over 2 million visits per year result from the diversified recreational and educational activities conducted at LBL. In a recent two–month survey jointly developed and conducted by the U.S. Army Corps of Engineers, U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, and TVA, 40 of the 53 recreational activities identified on the questionnaire were taking place at LBL (PARVS 1985). (Those activities that were missing–saltwater, anadromous fishing and snow–related activities—are not possible in western Kentucky and Tennessee.)

In 1985, people from all 50 United States and 20 foreign countries visited LBL. Table 2 compares LBL's visitation with that of a sampling of national parks. It is important to note that, though LBL's visitation is substantial, it has not yet ap-

[1]The only unsuccessful cooperative effort to date involved the red wolf. This 1983–84, four-agency effort (Tennessee Wildlife Resources Agency, Kentucky Department of Fish and Wildlife Resources, U.S. Fish and Wildlife Service, and TVA) proved that lifetimes of fears and misconceptions cannot be overcome in a short period of time or without extensive educational efforts. While the restoration proposal's biology was sound and risks were evaluated and minimized, adverse public reaction shelved the project.

Table 2. Comparison of annual visits between Land Between The Lakes and eight national parks, 1984

Area	Annual visits/acre	Size acres[a]	Annual visits (millions)[b]
Great Smoky Mountains National Park (Tennessee and North Carolina)	16.4	517,268	8.5
Land Between The Lakes (Kentucky and Tennessee)	12.4	170,000	2.1
Rocky Mountain National Park (Colorado)	8.3	263,791	2.2
Grand Teton National Park (Wyoming)	4.5	310,515	1.4
Yosemite National Park (California)	3.2	760,917	2.4
Sequoia National Park (California)	2.5	403,023	1.0
Grand Canyon National Park (Arizona)	1.8	1,218,375	2.2
Yellowstone National Park (Wyoming, Montana, Idaho)	1.0	2,219,822	2.2
Everglades National Park (Florida)	0.4	1,398,800	0.6

[a]Superintendent of Documents, U.S. Government Printing Office (1982).
[b]U.S. Department of the Interior (1984).

proached the carrying capacity. Because of natural ecology and intensive management, LBL's carrying capacity for visitor use is estimated to be at least 5 million recreational visits per year. LBL's multiple–use management practices clearly provide room for future growth and diversity in outdoor recreation activities.

LBL serves as a focal point for a major recreation tourism industry in western Kentucky and northwestern Tennessee. According to Kentucky's Office of Tourism Development, the value of this industry, as measured by total travel expenditures in the region of the state immediately surrounding LBL (Western Lakes region), was $155 million in 1984 (Carr 1984). A conservative value for the region of Tennessee immediately surrounding LBL is estimated at $50 million.

There is an increased international interest in LBL as a demonstration of multiple–use management, and a demand for tours and information. In the last four years, LBL has hosted professional visitors from 25 countries, including several United Nations/USDA sponsored tours, and 8–10 out–of–country midcareer internships. Countries less land–rich than the U.S. apparently have a pressing interest in multiple–use management techniques.

Conclusion

Today, LBL receives more than 2 million visits annually and serves as a focal point for the $200 million regional tourism industry. In addition to such traditional outdoor activities as camping, hiking, hunting and fishing, LBL provides facilities and programs for a wide variety of activities, including ORV use, horseback riding, astronomy programs, and cultural and natural resource interpretation. Land–management activities provide the setting for environmental education and professional development training programs. In more than 20 years of dealing with people–oriented programs, LBL resource managers have developed planning procedures to maximize consideration for all uses, minimize any identifiable conflicts, and enhance multiple–

use benefits. Integrated forest and wildlife management programs designed to help achieve these benefits have produced dramatic results. Timber harvesting has increased from 0.5 million board feet in 1966 to 9.9 million in 1985. Current timber–harvesting volumes represent about 32 percent of annual growth. During the same period, the total estimated turkey flock has increased tenfold and hunting use has increased over thirteenfold. Harvest–success rates for turkey, deer and other popular game species are comparable with other of the region's forested areas managed almost exclusively for wildlife. Additionally, wildlife–restoration programs for native species such as bald eagle, osprey, wild turkey, giant Canada goose, ruffed grouse and river otter have been or are being conducted to enhance future recreational use and enjoyment. While trade–offs must occur in a broad–based, multiple–use program, the LBL experience illustrates that an intensive wildlife–management program can be successfully integrated into multiple–use planning and development.

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Management Needs of Certain Individual Species

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Opening Remarks

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The title of this session allows many of us to focus immediately on the bobwhite quail, the wolf, the mallard, the bobcat and so on. However, what we have for you today is broader than that. We have the opportunity to focus on the biology and ecology of the individual wildlife species and on the human species: its sociology; its behavior; its biases; its prejudices; its differences in experience and background (such as rural vs. urban); its increasing educational sophistication; and its increasing involvement in management needs of certain individual species.

We look at individual species in the biological, sociological, biopolitical real–world of the democratic decision–making process. Our challenges are great in at least three areas:

I. Increased biological sophistication, including
   A. Population estimation
   B. Behavioral variability of age and sex classes and cyclic annual changes
   C. Techniques of managing problem wildlife, including
      1. Some applicable to managing for the welfare of endangered species
      2. Some applicable to reducing human/wildlife interactions involving "pest" species
   D. Believable, repeatable, biological techniques that allow consistent application and results over wide geographical areas

II. Increased sophistication in presenting biological alternatives to the many publics with varying abilities to absorb biological data and to understand scientifically based management recommendations and decisions

III. Combine economics, sociology and behavior of humans with biological/ecological information on individual wildlife species to formulate management options and actions

This is your opportunity to:

- integrate the messages of economics, biology and sociology available in these presentations; and
- consider how best to combine all three into "management needs for certain individual species."

The Economic Valuation of Endangered Species of Wildlife

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Introduction

Policy debates regarding the preservation of endangered species of wildlife often seem to focus on a conflict between the interests of the current generation and those of future generations. Individuals and groups whose interests conflict with preservation objectives are quick to point out the associated costs in terms of what the present generation must forgo. A classic example is the case of the snail darter and the Tellico Dam, although later analysis showed that construction of this dam was not economically feasible (Davis 1979). Wildlife advocates often take the other side of the issue, by arguing for the potential benefits of genetic diversity to future generations (Myers 1979).

From an economic perspective, debates over the preservation of endangered species of wildlife should focus on a comparison of benefits and costs accruing to members of different generations (Bishop 1978 and 1980). However, to consider only the costs of preservation borne by members of the present generation and the potential benefits to future generations may result in an economic cost–benefit analysis that overlooks important benefits of preservation enjoyed by the current generation. For example, members of the current generation may enjoy viewing endangered species in the wild or simply knowing that these species continue to exist. Only a few studies have actually attempted to measure these benefits (Brookshire et al. 1983, Hageman 1985, Stoll and Johnson 1984).

This paper focuses on the monetary values that members of the current generation assign to the preservation of endangered species of wildlife and wildlife habitat in general. First, we will develop a conceptual framework for examining the monetary values that members of the current generation assign to the preservation of endangered species of wildlife. We will then report on the results of two applications of the conceptual framework. The first involves measuring values for two of Wisconsin's endangered species of wildlife—bald eagles (*Haliaeetus leucocephalus*) and striped shiners (Notropis chrysocephalus). The second study examines the value of the Illinois Beach State Nature Preserve. An attribute of this Nature Preserve is that it provides habitat for several threatened and endangered species of wildlife, as well as providing habitat for wildlife in general. The results of the endangered species empirical application indicate that members of the current generation, in fact, do place a substantial value on the preservation of endangered species of wildlife.

The Economic Problem

Economists who have estimated monetary values for wildlife historically have tended to focus on values that are derived from consumptive uses, such as hunting and fishing (Davis 1963, Hammack and Brown 1974, Brown and Mendelsohn 1984). There are two reasons why empirical valuation studies have focused on such *consumptive–use values*. First, wildlife populations are an example of a broad class of environmental assets, including air and water quality, freedom from unpleasant noise and odors, and recreational opportunities in state and national parks or forests that are generally provided outside of the market system. As a result, market information that records prices paid for the use of these resources is not available to establish the monetary values that people place on these resources. Economists have developed several methods of estimating market–like values for these types of environmental assets. See Anderson and Bishop (1986) for a survey of these methods. However, most of the development and validation of these methods has been conducted in the context of use values that arise when individuals actually interact with a resource, and some of the methods are only applicable to measuring use values (Boyle and Bishop 1985, Cummings et al. 1986). The second reason is that consumptive users, such as hunters and fishermen, are relatively easy to identify.

Consumptive–use values are relevant to the valuation of endangered species of wildlife only to the extent that populations are rehabitated so that such uses become feasible in the future. If economists are to examine the values that members of the current generation assign to the preservation of endangered species of wildlife, they must look beyond consumptive–use values. A widely recognized set of values might be referred to as *nonconsumptive–use values*. Bird watching is an example of an activity that generates this type of value. The distinction between consumptive use and nonconsumptive use is that the former involves extracting animals from the wild and the latter does not.

A third type of use value is what we call *indirect–use value*. That is, many people never have direct contact with wildlife in its natural habitat, but do derive satisfaction from indirect contact with it. Among other activities, they enjoy reading about wildlife, viewing photographs of wildlife and watching television specials about wildlife. Another form of indirect use arises from some types of wildlife research, e.g., research on birds that signaled rapid accumulations of pesticides.

A fourth type of value, *existence value,* was proposed by Krutilla (1967), who reasoned that people may value an environmental asset even though they are sure that they will never personally use it. The important characteristic of existence values is that they are motivated by altruism (Boyle and Bishop 1985, Randall and Stoll 1983). People may hold existence values for wildlife populations because they want to make a bequest to friends and relatives or, more generally, to future generations. Other motivations might arise from a feeling of responsibility toward the environment or a belief in the importance of genetic diversity. It is also conceivable that users and potential users of an endangered species may hold existence values. The large amount of coverage that endangered species receive in the popular press may indicate substantial indirect–use values and existence values for these species.

The *total value* that an individual places on an endangered species is a combination of nonconsumptive and indirect–use values, as well as existence values. Any individual can hold any one or a combination of these values. Furthermore, when uncertainty enters the valuation framework, a new component of value enters the conceptual framework, which is referred to as *option value*. Once uncertainty becomes an issue, the total value that people place on the future availability of a wildlife species is called "option price." Option prices arise when individuals are uncertain about the *future* availability of wildlife, *future* costs of viewing wildlife, *future* income levels, or other economic parameters (see Bishop 1982, Smith 1983, Weisbrod 1964).

As with any taxonomy, the set of definitions presented here is somewhat arbitrary, and the distinction between the various components of value may be somewhat fuzzy at the margins. The important consideration is that members of the current generation may place a positive monetary value on the preservation of endangered species of wildlife for a number of reasons. To argue that members of the current generation do not hold values for endangered species is tantamount to arguing that their nonconsumptive–use values, indirect–use values, existence values and option values are zero. This is clearly an empirical question which can be answered if such values can be measured.

Measurement of Value

In the preceding section, we identified the types of monetary values that an individual might place on an endangered species of wildlife and briefly discussed some of the motivations for these values. Any individual can hold more than one type of value and, in turn, these components need to be aggregated to determine total value. A practical approach is to measure only the total value that an individual places on an endangered species, rather than measuring each of the components separately. The issue at hand, then, is to consider what is the best procedure for measuring total value.

As stated in the preceding section, economists must use methods of nonmarket valuation to infer values for environmental assets such as endangered species of wildlife. Only one of the methods, *contingent valuation,* is appropriate for measuring the total values that individuals place on endangered species of wildlife and wildlife species in general (Boyle and Bishop 1985). A typical contingent–valuation study is conducted by eliciting values from a randomly selected sample of individuals. The survey format includes an explanation of the study, questions designed to collect relevant socioeconomic data, and questions asking people to state the monetary values they hold for the item being valued. In this type of survey, no money changes hands and all stated values are hypothetical. Thus, the name "contingent valuation" arises because respondents are asked to state their maximum values "contingent" on the existence of the hypothetical market set forth for trading the item to be valued.

The contingent–valuation method is still being refined and improved, and some people question whether it provides an accurate reading of the values people actually place on environmental assets. Much research is being devoted to addressing this concern. For example, some researchers have compared contingent-valuation estimates with value estimates derived in parallel studies where actual cash transactions were involved. These studies are yielding tentative evidence that contingent–valuation estimates of use values are not statistically different from corresponding estimates derived using actual cash transactions (Coursey et al. 1984, Dickie et al. 1986, Heberlein and Bishop 1985, Welsh 1986). Another approach to validating contingent valuation has been to compare contingent–valuation estimates with value estimates derived using other methods of nonmarket valuation. The results of these studies indicate that contingent valuation and other valuation methods produce similar estimates of use values (Bishop et al. 1983, Brookshire et al. 1982, Desvousges et al. 1983, Schulze et al. 1981, Sellar et al. 1985).

The validation research cited above not only focused on use values, but only a subset of these values were actually evaluated. In terms of wildlife valuation, the validation research directly applies to consumptive–use values. Currently, economists are making their first effort at measuring total values for wildlife species in general and for endangered species in particular. The total values reported in this paper, therefore, are indicative that the current generation does place a substantial value on endangered species of wildlife. However, the accuracy of these types of values can only be determined with more research.

Bald Eagle and Striped Shiner Value Estimates

In a recent study, we used the contingent–valuation method to estimate the value of preserving two of Wisconsin's endangered species of wildlife—bald eagles and striped shiners (see Boyle and Bishop 1985). Although the bald eagle is classified as an endangered species in Wisconsin, its status at the federal level has been upgraded to threatened. The striped shiner is a minnow whose habitat is in sections of the Milwaukee River and it is not federally classified as a threatened or endangered species. Bald eagles are of interest because they represent the type of endangered species which is well-known and receives a lot of media attention. In contrast, as with the striped shiner, most endangered species are relatively obscure.

The objectives of our research were (1) to estimate the total monetary value that Wisconsin's taxpayers place on bald eagles and striped shiners, and (2) to test whether there are significant values that are not derived from direct contact with these wildlife resources. To facilitate the latter objective, two types of bald eagle values were estimated. The first was a total value (BETV) for maintaining the existing population of bald eagles in Wisconsin, where people would have an opportunity to view these birds in the wild. The second was a conditional value (CBEV). For this case, respondents were asked to assume that bald eagles would continue to exist in Wisconsin, but that their habitat would be in remote areas of the state, and any given person would be unlikely to have an opportunity to view them in the wild. Only a total value (SSEV) was estimated for striped shiners. Striped shiner total value is existence value since there is not any current or anticipated use associated with these fish in Wisconsin.

The contingent–valuation questions for the present study were included in a mail survey conducted by the Wisconsin Department of Natural Resources (DNR). The purpose of the DNR's survey was to determine why Wisconsin residents did or did not contribute to the State's Endangered Resources Donation (ERD) program in 1983. Questionnaires were mailed to samples of individuals from two subpopulations of Wisconsin taxpayers—contributors and noncontributors to the ERD program. One half of the individuals in each sample were asked a BETV question and the other half were asked the CBEV question. All respondents were asked the SSEV question.

The estimated values are reported in Table 1, and the estimates are annual values for a typical individual. The bald eagle values are classified as to whether respondents were viewers or nonviewers of eagles. This split was made on the basis of whether respondents reported ever having made a trip where one of their intentions was to view bald eagles. Thus, an average individual who contributed to the ERD program and was a viewer of bald eagles would place a total value (BETV) of about $75.00 per year on the maintenance of the existing population of bald eagles in

Table 1. Wisconsin taxpayers' estimated values of bald eagles and striped shiners

Type of value	Endangered Resources Donation program	
	Contributor	Noncontributor
Bald eagle total value (BETV)		
Viewer	$75.31	
Nonviewer	18.02	$11.84
Conditional bald eagle value (CBEV)		
Viewer	28.38	25.97
Nonviewer	30.78	10.62
Striped shiner estimated total value (SSEV)	5.66	4.16

Wisconsin. A comparable value for noncontributors is not reported because of an insufficient sample size.

The values in Table 1 show some obvious patterns. Contributors consistently placed a higher value on these endangered species than did noncontributors, and bald eagle values were higher than striped shiner values for both contributors and noncontributors. A more–interesting result is that respondents placed a substantial value on the preservation of bald eagles, even though they would not have an opportunity to view these birds in the wild. Furthermore, respondents did place a value on the preservation of striped shiners—a relatively obscure species that most respondents probably never have heard of prior to receiving the DNR's survey in the mail.

We hypothesized that BETV would equal CBEV for nonviewers. This null hypothesis could not be rejected at a 90–percent level of confidence for either contributors or noncontributors. On the other hand, if there are significant values associated with viewing bald eagles, then BETV would be significantly larger than CBEV for viewers. The null hypothesis that these two values are equal could be rejected for contributors. A similar test was not conducted for noncontributors because we did not report a BETV for noncontributors who are viewers.

The values reported in Table 1 were expanded to provide estimates of aggregate value for the population of Wisconsin taxpayers. These aggregate values are reported in Table 2. At first glance these values appear to be amazingly large, but once put into perspective, their magnitudes seem quite plausible. First, there are about 3 million taxpayers in Wisconsin, and an average value of just a few dollars per person will add up to a sizeable total. For the striped shiner—a relatively obscure species—the average value across contributors and noncontributors is only about $4.00—a

Table 2. Bald eagle and striped shiner values[a] expanded to all Wisconsin taxpayers.

Type of value	Endangered Resources Donation program	
	Contributor	Noncontributor
Bald eagle total value (BETV)		
Viewer	1,486.5	
Nonviewer	487.2	26,179.1
Striped Shiner estimated total value (SSEV)	264.7	11,762.2

[a]Multiplied times $1,000.

small amount for a taxpayer to spend annually. Also, the corresponding median value for striped shiners is $1.00, indicating that half of Wisconsin taxpayers place a value of less than $1.00 per year on the preservation of these minnows in Wisconsin. Thus, there is no implication that all or even a majority of Wisconsin's taxpayers assign a large value to striped shiners. In turn, the values reported in this section indicate that, on the whole, current taxpayers in Wisconsin place a significant aggregate monetary value on the preservation of these two endangered species of wildlife—bald eagles and striped shiners.

Illinois Beach State Nature Preserve Value Estimates

The Illinois Beach State Nature Preserve, located on the western shore of Lake Michigan within the boundaries of Illinois Beach State Park, contains about 830 acres (336 ha). This is the oldest designated state nature preserve in Illinois, and also one of the largest preserves. In addition to providing habitat for endangered species of wildlife, the Nature Preserve provides excellent wildlife habitat in general. For example, the area is an important refuge for migratory birds. Further, the Nature Preserve is a sand prairie, containing rare species of plants and a variety of unique plant communities. The sand dunes within the Nature Preserve provide the oldest record of the geologic history of Lake Michigan. Illinois Beach State Nature Preserve is, therefore, an area that contains many unique and interesting attributes. This characteristic of multiple features and uses would seem to be typical of many areas that provide wildlife habitat. Thus, people may place a value on an area that provides wildlife habitat for more reasons than simply that of supporting wildlife.

The conceptual framework for considering monetary values for the Nature Preserve is somewhat similar to that which was outlined for wildlife species. Values for the Nature Preserve could arise by direct use, such as hiking on the nature trails within the area, while for those who do not currently visit the Nature Preserve, values could arise from indirect use. Indirect use occurs when someone reads about or views pictures of the area, or when someone benefits from scientific research that is conducted at the Nature Preserve. Others might value the option of visiting the area in the future. Alternatively, values could arise even when an individual will never use the area, for reasons such as a bequest to future generations or maybe from a sense of responsibility toward the environment (existence value). Any individual can place more than one type of value on the Nature Preserve. Ultimately, all of these types of value arise because of the features of the Nature Preserve that we previously identified.

The objectives of the present study were (1) to estimate the total values that Illinois heads of households place on the Illinois Beach State Nature Preserve, and (2) to examine how respondents' values vary with the number of visits they made to the area in 1984 (see Boyle 1985). Within this analytic framework, we were able to estimate values for individuals who had not visited the area, as well as for those who had made multiple visits to the Nature Preserve.

A mail questionnaire containing the contingent–valuation question was sent to a stratified sample of 600 Illinois heads of households. A total of 200 questionnaires were mailed to individuals in the two counties adjacent to the Nature Preserve — Lake and McHenry counties. The remaining 400 individuals in the sample were selected from all other Illinois counties. We will refer to these two subsamples as Sample A and Sample B, respectively.

The estimated values for Sample A are reported in Table 3, and are interpreted in the following manner. Ninety-one percent of the sample did not visit the Nature Preserve in 1984, and these individuals placed a value on the area of about $22 per year. This is a total value and may include indirect–use, option and existence values. About 3.3 percent of the sample visited once in 1984, and held an annual value of $37. Thus, as would be expected, values increased with the number of visits an individual made to the Nature Preserve. A weighted average value of about $32 is also reported. This is an average annual value for all respondents in Sample A, regardless of the number of visits each made to the Nature Preserve.

The overall value for respondents in Sample B was $28. Only an overall value is reported for this group because only two of the respondents in this subsample visited the Nature Preserve during 1984. This overall value and the weighted average value for Sample A were used to compute an aggregate estimate of value of roughly $56.6 million.

Conclusions

The monetary values reported indicate that members of the current generation do, in fact, benefit from the preservation of endangered wildlife species and their habitats. The absolute magnitude of these benefits appear to be substantial. In turn, these results indicate that the preservation of endangered species is not simply a case of the current generation bearing the costs and future generations having an opportunity to reap the benefits, but rather, such activities may provide benefits that can be enjoyed by all generations. In concludion, it seems to us that current expenditures to preserve endangered species at both the federal and state levels are modest, compared with the potential benefits of such actions.

Acknowledgments

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Table 3. Illinois Beach State Nature Preserve values for Sample A.

Number of visits in 1984	Average total value
0	$ 21.67
1	36.70
2	51.53
3	71.46
4	73.86
5	99.91
10	159.32
12	199.66
30	456.16
Weighted average	31.19

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Management of Grizzly Bears in the Northern Continental Divide Ecosystem, Montana

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Introduction

The Montana Department of Fish, Wildlife and Parks (DFWP) began preparation of a Programmatic Environmental Impact Statement (PEIS) for grizzly bear management in the Northern Continental Divide Ecosystem (NCDE), Montana, in 1984. This effort was a major task—essential to ensure a responsible grizzly bear management program with long-term continuity.

Public interest, changing management situations and additional grizzly bear population·data dictated a need for review of the current management program. Public concern over hunting seasons, increasing grizzly bear depredation problems and new data from the Rocky Mountain East Front needed to be incorporated into a cohesive plan.

Also at issue was the threat of litigation over DFWP's management program. Defenders of Wildlife—a special interest group with a record of opposition to hunting—threatened a lawsuit to stop hunting of grizzly bears if DFWF did not revise management.

Montana is the only state in the conterminous U.S. where sportsmen have the opportunity to hunt grizzlies. It is no accident that this opportunity still exists, when one considers the history of grizzly bear management in Montana. The record is clear that where this species is managed under game status it has fared much better than where it was or is managed as threatened or endangered. Limiting or banning grizzly bear hunting in Arizona, Colorado, Idaho and Washington in 1929, 1954, 1946 and 1969, respectively, did not stop mortalities of grizzly bears or their extirpation from Arizona and Colorado and near extirpation in Idaho and Washington.

Management of the grizzly bear presents a unique set of problems because grizzlies do kill people on occasion. The most recent incident was in 1984 in Yellowstone National Park. Incidents such as these dictate that management of bears must be different than for other species. The endangered peregrine falcon (*Falco peregrinus*), for example, is known to nest on bridges in New York City, and obviously tolerates and is tolerated in close proximity to people. The same, however, cannot be said for grizzly bears.

The PEIS was completed in February 1986, after two years of preparation, including professional and public review. The process culminated in a progressive plan that should provide security well into the future for Montana's state animal. The document reviews the available data pertinent to grizzly bears and their management in northwestern Montana. It presents management alternatives, the Preferred Alternative adopted by DFWP, recommendations to other agencies on their grizzly bear policies and, in general, prescribes a complete management program for northwestern Montana. This paper is a summary of that document (Montana DFWP 1986).

DFWP Goals

DFWP is committed to protect, conserve and manage the grizzly bear in Montana. Specific program goals of DFWP for the NCDE grizzly bear population are consistent with this policy. The goals for the management area (Figure 1) in the NCDE (excluding Glacier National Park) are to manage for a recovered grizzly bear population at an average density of between 1 bear per 30 square miles (1 per 78 km²)

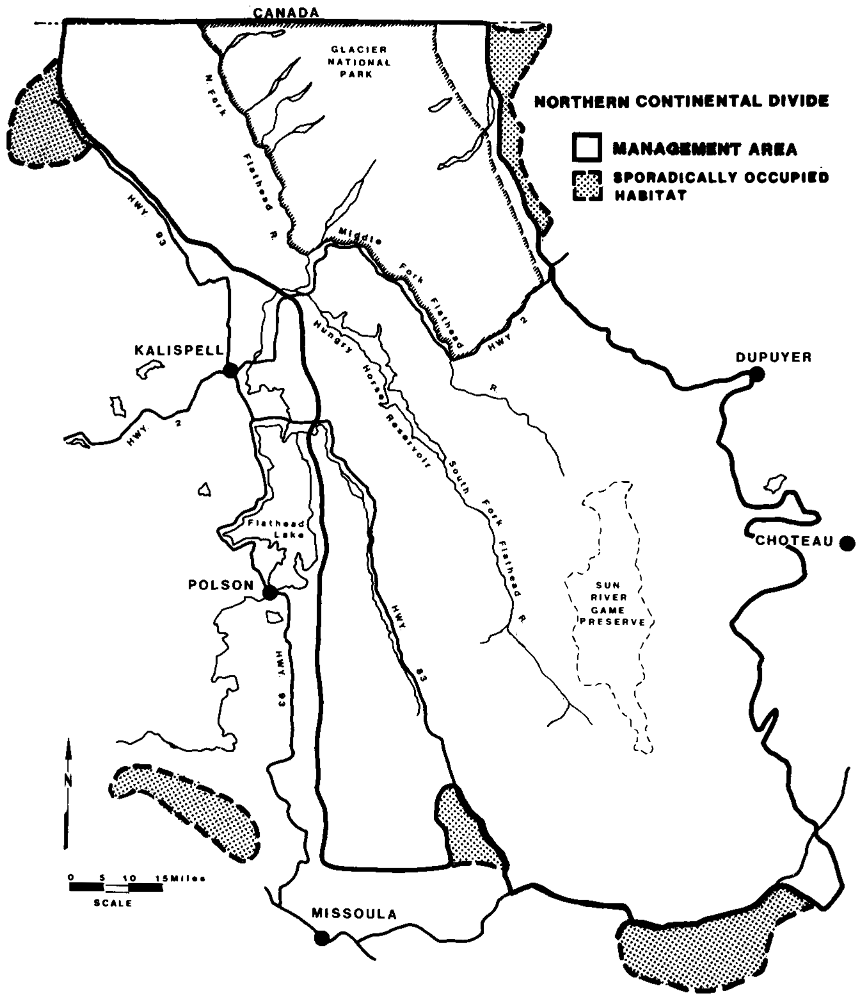

Figure 1. Grizzly bear management area for the Northern Continental Divide Ecosystem, Montana.

and 1 bear per 15 square miles (1 per 39km^2), and seek to maintain the habitat in a condition suitable to sustain this density.

Information on minimum population size (Shaffer 1983), minimum effective population size (Franklin 1980), viability of remnant European brown bear populations (Elgmork 1978, Roth 1972, Mysterud 1977), and grizzly/brown bear densities in all areas was considered in establishing the population goal in the NCDE. This goal is consistent with the suggested recovery goals in the Grizzly Bear Recovery Plan (U.S. Department of Interior 1982).

The density goal was selected because it should provide for the continued existence of grizzly bears. A literature review of brown bear densities suggests that the NCDE is of intermediate habitat quality. Densities vary from a high of 1 bear per 0.6 square miles (1 per 1.5 km^2) on Kodiak Island, Alaska (Troyer and Hensel 1964), to a low of 1 bear per 110 square miles (1 per 285 km^2) in the Central Brooks Range of Alaska (Crook 1972).

Population Biology

Estimated ranges of grizzly bear densities in the NCDE for 12 units (Table 1) were based on similarity in habitat-use patterns, mortality patterns, home-range size and overlap, levels of human activity and encroachment, and pooled expertise from wildlife professionals.

These estimates (Figure 2) were developed utilizing known minimum densities from five study areas (Table 2) within and adjacent to the ecosystem and applying them to larger areas. Reynolds and Hechtel (1980) reported that extrapolations of bear densities from areas and habitats of intensive study give the best population estimates. Others (Zunino and Herrero 1972, Martinka 1974, Pearson 1975, Lortie

Table 1. Grizzly bear density estimates for the Northern Continental Divide Ecosystem, Montana.

Unit	Area (square miles)	Density (square miles per bear)			Number	
		Minimum[a]	Low	High	Low	High
Glacier National Park	1,583	8	8	6	193	264
Red Meadow	215		15	10	14	22
Whitefish	831		25	18	33	46
St. Mary	211		20	10	11	21
Badger–Two Medicine	323		20	16	16	20
Swan Front	780		30	20	26	39
South Fork	1,624	19	15	10	108	160
East Front	1,119	22	18	12	62	93
Mission Mountains	1,044	56	45	25	23	42
Scapegoat	1,903	28	30	18	63	106
Total	9,633		18	12	549	813
Total excluding Glacier National Park	8,050		23	15	356	549

[a]Reported in the literature or from re-evaluated data from research studies (Montana Department of Fish, Wildlife and Parks 1986).

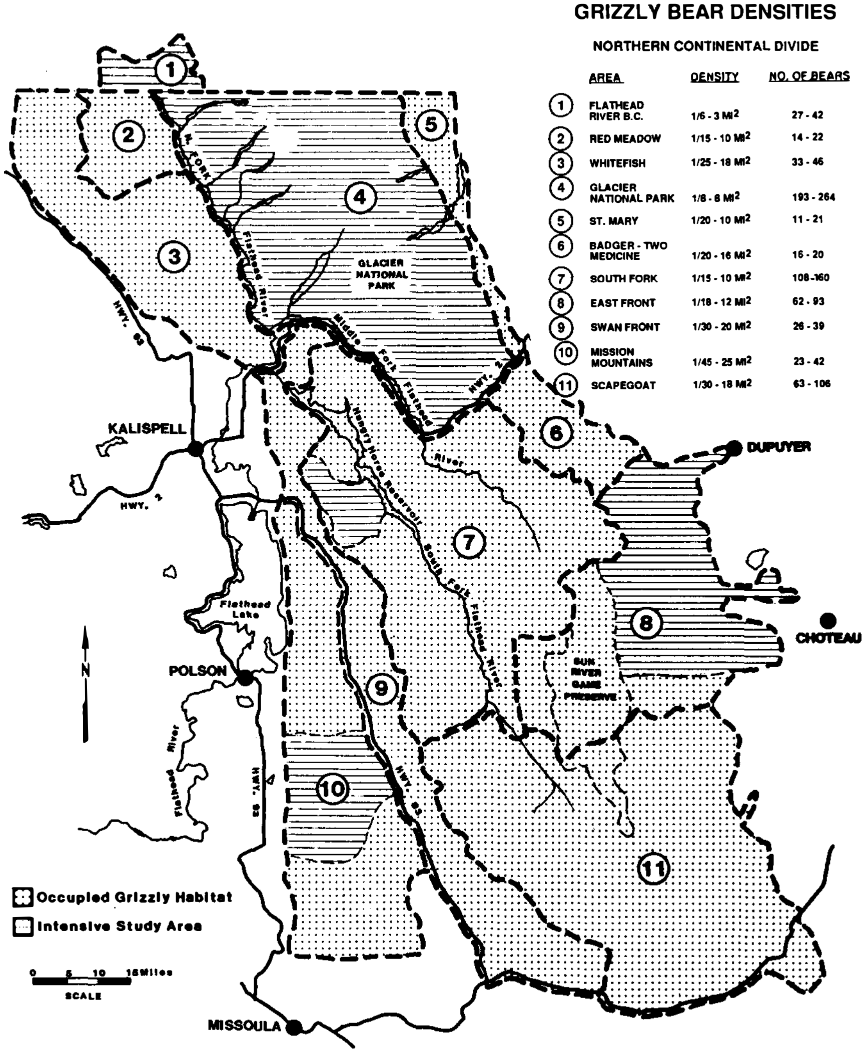

Figure 2. Grizzly bear density units in the Northern Continental Divide Ecosystem, Montana.

1978, Miller and Ballard 1982, Tompa 1984, van Drimmelen 1984) estimate population numbers using data extrapolated from intensive study areas. This procedure is widely used for other species (Schemnitz 1980). In areas where direct extrapolation was judged to be inappropriate, based on habitat, human impacts and pooled expertise of wildlife professionals, to be conservative, we applied a lower density.

Grizzly bear litter size has been determined for five study areas within the NCDE (Table 3) (Aune et al. 1985, C. Jonkel personal communication, Martinka 1974, McClellan 1984, Bureau of Indian Affairs files). Reproductive potential from the NCDE is more favorable than in less productive habitats with limited food sources

Table 2. Grizzly bear density estimates from study areas in and adjacent to the Northern Continental Divide Ecosystem, Montana.

Unit (source)	Area (square miles)	Density (square miles per bear)	Number
Glacier National Park (Martinka 1974)	1,583	8	193
Rocky Mountain Eastern Front (Aune et al. 1984)	689	11.5–22.2	31–60
Mission Mountains (Servheen 1981)	301	19	16
South Fork (Mace and Jonkel 1980)	128	10	13
Flathead River, British Columbia (McClellan 1984)	163	3.4–6.0	27–42

(Pearson 1975, 1976, Reynolds 1976, Miller et al. 1982). However, more information on reproduction would be desirable for the NCDE.

Few age composition data are available for grizzlies in the NCDE. Data from the Rocky Mountain East Front (Aune et al. 1984) were compared with other populations in North America. McLellan's (1984) reported age structure in British Columbia is similar to that of Aune et al. (1984), and is from an area exhibiting an increase in grizzly bears.

Mortality rates by age class are not available for grizzly bears in the NCDE. However, of the mortality that has occurred, Aune et al. (1984) reported that 62.5 percent has been subadults and 37.5 percent has been adults. Nonhunting mortality accounted for more than 50 percent of the total (Aune et al. 1984). The high subadult mortality may be due to subadult dispersal from an expanding population (K. Aune personal communication). Martinka (1982) reported average annual losses of 3.5 to 5 percent for a region encompassing most of the NCDE, a rate indicated in the literature as an acceptable level (Cowan 1972, Craighead et al. 1974, Martinka 1974, Reynolds 1975, Lortie and McDonald 1977, Lortie 1978, British Columbia Fish and Wildlife Branch 1979, Bunnell and Tait 1980, McCullough 1981, Sidorowicz and Gilbert 1981, Tompa 1984, van Drimmelen 1984, B. Smith personal communication, R. Harris unpublished data). Martinka (1974) had no data on mortality rates within Glacier National Park, but stated that mortalities outside the park had little effect on the population within the park.

Although methods used in deriving the population estimates varied, it is possible to compare historical grizzly bear population estimates. Hickie (1952) reported an estimate of 758 grizzly bears in all of Montana in 1952. Cooney (1953) reported a current population estimate of 800 in Montana. Marshall (1955) reported an estimate of 700 grizzly bears for the entire state in 1954. Montana listed 439 grizzlies in 1955, exclusive of national parks (Cooney 1956). Based on a survey of wildlife professionals and user groups, Hamlin and Frisina (1975) reported that the grizzly population in Montana was at least stable and possibly increasing.

Comparing this historical information with our present estimates indicates the current grizzly bear population in Montana is as high or higher than that reported 30–40 years ago. It appears that such factors as acquisition of some key habitats, imple-

Table 3. Reproductive characteristics of North American grizzly bear populations.

Location (source)	Mean litter size	Mean age at first litter	Litter frequency (years)
Rocky Mountain Eastern Front, Montana[a] (Aune 1985)	2.16	5.5	2.1
North Fork Flathead River, Montana[a] (C. Jonkel personal communication)	2.66	5.0	
Mission Mountains, Montana[a] (U.S. Bureau of Indian Affairs, Flathead Indian Reservation)	2.12	5.5	3.3
Flathead River, British Columbia[a] (McClellan 1984)	2.5	5.5[b]	3.1
Kodiak Island, Alaska[a] (Hensel et al. 1969)	2.23	4–5	3+
Eastern Brooks Range, Alaska[a] (Reynolds 1976)	1.77	9.9	3+
Western Brooks Range, Alaska[a] (Reynolds and Hechtel 1980)	2.03	8.4	4+
Southwest Yukon[a] (Pearson 1975)	1.6	7.8	3+
Northern Yukon[a] (Pearson 1976)	1.4–1.8	7.5	4
MacKenzie Mountains, Northwest Territories[a] (Miller et al. 1982)	1.83	8[b]	3.8
Glacier National Park, Montana[c] (Martinka 1974)	1.7		
Glacier National Park, Canada[c] (Mundy and Flook 1973)	2.0	5+	2.8
Yellowstone National Park, Wyoming and Montana[c] (Craighead et al. 1974)	2.24	5.8	3.4
Yellowstone National Park, Wyoming and Montana[c] (Knight and Eberhardt 1985)	1.9	6.2	3.0
McNeil River, Alaska[c] (Glenn et al. 1976)	2.5	6	3.6

[a]Hunted population.
[b]Earliest age observed.
[c]Unhunted population.

mentation of more conservative control programs, restrictions on hunting and controls on predator poisoning have allowed growth in Montana's grizzly bear populations. This growth has occurred despite habitat encroachment.

It is difficult to use age data from hunter harvest to describe grizzly bear population status (Harris 1984). It is important, therefore, that when using harvest age data to interpret population status, it should be considered in conjunction with other population and trend indicators. Harris (1984) examined age and sex structure from simulated grizzly populations subjected to various harvest levels. When applied to 1982–84 harvest data for the NCDE, the index indicated a 10 percent or less chance the population was declining (R. B. Harris personal communication).

R. W. Klaver (personal communication) has modeled the 1970–84 mortality data for the NCDE using the traditional methods of Gilbert et al. (1978) and a simplified approach to the Fraser et al. (1982) method. Klaver's analysis shows that harvest rates have been declining in recent years and that population indices indicate a stable or increasing population.

Population trend information is available for three intensive study areas within or adjacent to the NCDE. The portion of the ecosystem on the Rocky Mountain East Front (K. Aune, personal communication) and the British Columbia portion of the North Fork of the Flathead River (McLellan 1984) are both stable to increasing. Grizzly bear numbers in the Mission Mountains are reported to be declining (Claar et al. in Press).

Management Program Review

Montana is the only state in the 48 conterminous states authorized to allow hunting of grizzly bears under the Endangered Species Act. In 1975, the Code of Federal Regulations established a human–caused mortality quota of 25 grizzly bears for northwestern Montana. DFWP elected to be conservative in 1983 when it established a female subquota of nine for the NCDE. In 1985, an Emergency Federal Regulation reduced the total mortality quota to 15 and the female subquota to 6. These quotas involve the total man–caused grizzly mortality, including illegal kills, accidents, control actions and hunter harvest. Thus, hunter harvest is adjusted to reflect the other sources of mortality. In addition, quotas are reviewed annually to determine if they need adjustment.

Since 1967, the grizzly hunting season in the NCDE has coincided with deer and elk seasons (approximately mid– to late–October through late November, except in the wilderness areas where the season opened September 15). Season dates have a large influence on the sex ratio of bears harvested. Chi–square analysis indicates that significantly (X^2 = 5.13, P = 0.02) more females are shot in the NCDE before October 20 than after. Troyer (1961) stated that, since fall hunting produced a heavier harvest of females and the earliest part of the fall season is the most productive, seasonal restrictions would have the best results by limiting the early fall season. Pearson (1975) reported a decreasing proportion of females in the total kill as the fall season progressed in the Yukon. H. V. Reynolds (personal communication) stated that fall–only seasons in Alaska were used where harvest, sex and age data indicated some caution was necessary.

Since 1983, the hunting program in Montana has protected females through a female subquota of nine, and by prohibiting the taking of females accompanied by cubs (since 1947). Further protection was provided in 1985 by (1) prohibiting the shooting of females accompanied by young—defined as two–year olds or younger, and (2) a request that hunters not shoot any bear in a group.

The Montana Fish and Game Commission has the authority to close a hunting season at any time. Since quotas were initiated in 1975, the season has been closed three times, in 1975, 1984, and 1985, because total or female mortalities were approaching the quotas. Since inception of the quota, it has been recognized as improbable but possible that these quotas could be reached before the hunting seasons opened. In 1985, the season in one management area did not open because the female subquota had been met prior to the season. Alaska and the Canadian provinces and territories also have closure authority, but not based on a quota system.

Since 1967, hunters killing a grizzly have been required to report their kill within 48 hours to an officer of DFWP, and to purchase a trophy license and present the hide and skull within 10 days for tagging and recording the kill. Evidence of sex intact on the carcass or skin has also been required. It has also been prohibited for any person to remove any portion of a grizzly bear from Montana without first obtaining a trophy license. Since 1947, the annual limit per grizzly bear licensee has been one grizzly bear of either sex. Alaska, Alberta, British Columbia, the Yukon and Northwest Territories all have regulations similar to Montana's, with variations based on population status.

Montana hunters have been required to purchase species–specific grizzly bear licenses since 1967. Since 1971, these licenses had to be purchased before August 31. Because the hunting season has not opened prior to September 15, this regulation eliminates the possibility of a hunter killing a grizzly bear and then buying a license.

Analysis of trophy license data shows that between 1967 and 1985, 95 percent of 224 hunters have harvested only one bear, 5 percent have harvested two bears, and 1 hunter has harvested four bears.

Mortality Patterns

Total Man–caused Mortality

Grizzly bear mortalities from 1967 to 1985 have been analyzed by K. Greer of DFWP. Prior to the quota of 25 mortalities from all human causes, initiated in 1975, the average annual mortality was 28 grizzly bears. Since 1975, 18 grizzly bears on the average have been killed annually from all causes.

The average proportion of hunting to nonhunting mortality during 1967–85 was 55:45. Reported nonhunting mortality exceeded hunting mortality in 6 of the 19 years. Male grizzly bear mortality exceeded female mortality in 15 of the 19 years. The ratio of male to female mortality averaged 59:41 for the entire period, and the ratio of adult to subadult mortality was 51:49.

Hunting Mortality

From 1975 to 1985, the average annual hunting mortality was 10.2 individuals (range = 5–17), of which an average of 3.8 individuals (38 percent) were females. Males in the hunter harvest were younger (mean = 5.83 years, $P = 0.03$) than females (mean = 8.20 years). The ratio of adult to subadult animals was 51:49.

Nonhunting Man–caused Mortality in the NCDE

Since 1975, an annual average of 8.4 grizzly bears (range = 6–12) have been lost for man–caused reasons other than hunting. Nonhunting mortalities include illegal and control deaths as well as losses due to live translocations from the NCDE.

Male grizzly bears are more prevalent in the nonhunting mortality than are females. During the period 1968–1985, females constituted an average of 42 percent of the man–caused, nonhunting mortality. This percentage of females has decreased to 39 percent since 1975. Subadults comprise 52 percent of the nonhunting mortality.

Nonhunting mortality has been stratified into four major categories that allow accurate interpretation of nonhunting mortality patterns in the NCDE.

Defense of life or property. Fifty–two percent of the recorded nonhunting mortalities in the NCDE since 1975 has occurred in the defense of life or property. Mortality from this source averages 4.3 deaths annually. Sheep depredations are the leading cause (89 percent) of both citizen and agency actions.

Mistaken identity. During the period 1975–85, 11 grizzly bear mortalities due to accidental killing by black bear hunters have been recorded. The average is one such death per year.

Documented poaching and malicious deaths. Animals killed for profit or from malicious intent are difficult to document. Not all illegal grizzly bear deaths are reported to DFWP, so documentation is not complete. Twenty–seven records of poaching or vandal killing are present in DFWP records (averaging 2.5 per year).

Unreported illegal mortality. There is another source of mortality that is not reflected in DFWP records. These are grizzly bears accidentally or intentionally killed and the fact not reported. We estimated the extent of this unreported mortality in the NCDE using data from radio–instrumented grizzly bears.

Six of 71 instrumented animals monitored during a 10–year period were confirmed illegal deaths that would not have been recorded had it not been for their radio collars. Furthermore, five of these six instances occurred in roaded areas, although the animals' annual home ranges included roadless areas or designated wilderness. These data suggest that bears are more vulnerable in roaded areas than elsewhere.

Using these data, we estimated an average annual mortality rate of 4 percent. This rate was applied to bears in the ecosystem (excluding Glacier National Park) to establish an upper limit for this type of mortality (14). Because all bears in the ecosystem are not equally vulnerable, an average of seven represents a reasonable estimate of the annual average of mortality due to this source. As an additional test of the unreported mortality rate, we applied the 4 percent rate to the estimated proportion of subadults in the NCDE. Data from the East Front (Aune 1985) suggested a population structure of approximately 25 percent subadults (two to four years old). Assuming 25 percent of the NCDE population is subadult bears, then there are approximately 89 subadults in the NCDE. A 4 percent unreported mortality rate applied to these 89 subadults results in only four unreported deaths per year.

Mortality Summary

DFWP documented all sources of man–caused grizzly bear mortality in the NCDE. The analyses show that an average of 25 grizzly bears are either killed or translocated each year (Table 4).

Management Alternatives

Two major alternatives were evaluated in the DFWP PEIS—one using recreational hunting as a management tool and the other excluding recreational hunting. Within these two alternatives, five management options were developed (Figure 3). Management direction is the same under each option, whether under the hunting or non-

Table 4. Average annual man–caused grizzly bear mortality in the Northern Continental Divide Ecosystem, Montana, 1975–1985.

Mortality cause	Average number of grizzly bears per year
Hunting	10.2
Nonhunting	
Defense of life or property	4.3
Known poaching/vandal killing	2.4
Mistaken identity	1.0
Vehicular collision	0.6
Unreported	6.8
Total	25.3

hunting alternative, but management techniques differ. In this manner, present and future management direction was identified and evaluated.

DFWP's population goal for the NCDE represents the optimum population status—termed "Status C" (Figure 3). If the grizzly bear population were to change over time from Status C. more–or–less stringent management techniques would be necessary to return the population to the optimum. The techniques used would depend on whether recreational hunting was available as a technique.

DFWP has evaluated the possible management techniques under both the hunting and the nonhunting alternatives for each of the five populations statuses. If, for example, the NCDE population was to increase from Status C to Status E, and hunting was not allowed, DFWP would seek to increase substantially the man-caused mortality other than hunting mortality. This would be accomplished by encouraging the unlicensed killing of nuisance grizzly bears. If recreational hunting was allowed in this situation (Alternative 2), then it could be used to lower the population to Status C. If the status was to decline from Status C to Status A under the hunting alternative, then the hunting season would be closed, control kills of nuisance grizzlies would be severely reduced and population augmentation would be recommended.

Under the hunting alternative, DFWP also evaluated several types of season struc-

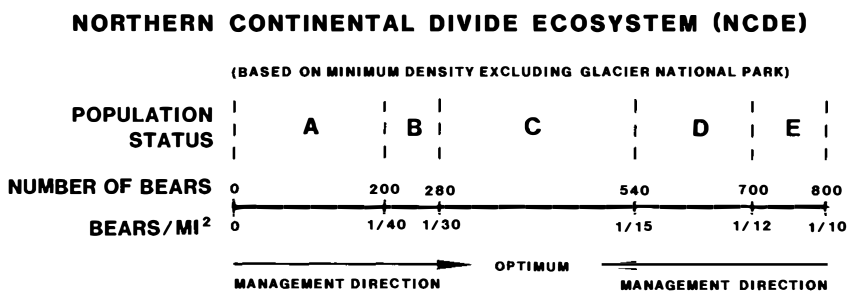

Figure 3. Grizzly bear management options for the Northern Continental Divide Ecosystem, Montana.

tures. These included spring season only, fall season only and a split season. Limited entry methods and unlimited entry methods were also considered.

Preferred Alternative

The management program preferred by DFWP is the hunting alternative. The present status of the NCDE is stable–to–increasing at an estimated minimum of 356 bears (excluding Glacier National Park). This indicates that a regulated hunting season under population Status C should be recommended. This hunting season will be conducted under a total mortality quota and a female mortality subquota. A hunting season is recommended for the following reasons:

1. An average of 10 grizzly bears are legally harvested annually in the NCDE. There is no evidence in the population–structure data or population–trend data to suggest this level of legal harvest is detrimental to the population.
2. Hunters might legally harvest problem bears, and bear/human conflicts could be reduced through such harvest.
3. Hunting may reduce the need for agency control of problem bears. Troyer (1961), Greer (1976b), Mysterud (1980), Poelker and Parsons (1980), and Waddell and Brown (1984) indicated that hunting can reduce the need for control actions.
4. Hunting may cause bears to be wary of humans. Evidence was provided by Mysterud (1977) and Elgmork (1978), who reported wariness in brown bear populations long exposed to human exploitation. Herrero (1985) provided evidence that bear/human incidents are more frequent in unhunted than hunted bear populations.
5. Hunting grizzlies may increase cub survival and recruitment, providing for population increase (Lindzey et al. 1983, Inukai 1972, Young and Ruff 1982, Troyer and Hensel 1964, Glenn et al. 1976, Pearson 1976, Reynolds and Hechtel 1980, Stringham 1983).

DFWP's future management actions will be based on the status of the grizzly population in the NCDE. Several important factors have been identified that will be evaluated by DFWP (1986) when determining population status. It should be recognized that population status will be determined not by any one criterion, rather, by a collection of the best–available information from all criteria will be used.

Hunter harvest, total known man–caused mortality, and total known man–caused and estimated unreported man–caused mortality have averaged 3, 5, and 7 percent of the population (excluding Glacier National Park), respectively, in the NCDE since 1975.

The mortality rates of 8.2 and 14.4 percent reported by Craighead et al. (1974) for recorded and total mortality are from a population they reported to be increasing at an annual rate of 2.4 percent. McCullough (1981) re–evaluated the Craighead et al. (1974) findings, and derived a population estimate of 312. Using this estimate and the annual known mortality of 18.9 bears per year reported by Craighead et al. (1974), yields an annual mortality rate of 6.1 percent.

R. B. Harris (unpublished data) has indicated that an annual mortality rate of 6.5 percent is sustainable, based on efforts designed to model the NCDE population. This mortality rate consisted of 69 percent males; harvests with higher proportions of males would allow for a higher mortality rate. The management actions prescribed in the PEIS, including the prohibition on shooting females with young and the request not to shoot any bear in a group, should reduce female mortality and increase the proportion of males in total mortality. In 1985, the proportion of males in the hunter harvest was 100 percent, while total mortality was 81 percent male.

The current grizzly population status in the NCDE, the apparent trend of this population in relation to past mortality rates, and the recommended and reported mortality in the literature indicate that a proposed total man–caused mortality rate (known and unreported) of 6 percent (21 bears) will not be excessive for the NCDE population and should allow for a continuing increase in numbers.

Although DFWP has chosen to exclude Glacier National Park from management consideration, it is important to relate the proposed mortality rate to the entire NCDE. The estimate of the minimum population for Glacier is 193 bears, thus the estimate of the minimum total population for the NCDE is 549 grizzly bears. Under the present quota a maximum of 21 deaths would be allowed from this population. Considering this park population reduces the mortality rate to 4 percent, which is well within that recommended or reported in the literature.

It is also recommended that the proportion of females in the total known man–caused mortality not exceed 40 percent. This is based on recommended or reported male/female ratios of 60:40 to 76:24 in the literature (van Drimmelen 1984, British Columbia Fish and Wildlife Branch 1979, Lortie and McDonald 1977, R. B. Harris (unpublished data); R. A. DeMarchi personal communication), as well as the past ratios in the NCDE. While it is important to keep female mortality at a minimum, and DFWP is working to keep it at a minimum, it does not need to be entirely eliminated. Proposed harvest restrictions on females and relocation guidelines regarding females should reduce female mortality from that of previous years.

Recommendations

Several recommendations are presented that should make DFWP's management program more effective in the future. The Preferred Alternative presented earlier and the recommendations presented here provide for a reasonable and responsive grizzly bear management program for the NCDE.

Management Area Changes

DFWP recognizes that grizzly bears can and do live outside the boundary of management areas. The presence of bears outside these boundaries will be encouraged as long as conflicts with humans do not occur. If a conflict occurs, the bear responsible will be treated according to agency guidelines. If sufficient numbers of grizzlies begin to occupy land outside current management area boundaries without conflict, then DFWP will evaluate modifying the boundary to include the newly occupied area(s).

Population Trends

The ability to document long–term population trends is an important aspect of grizzly bear management, DFWP will assist in developing and evaluating new trend–monitoring techniques, including systematic subjective surveys of wildlife professionals and various user groups. Surveys should be developed by professional surveyors to ensure statistical validity.

Focus Concern for the Grizzly Bear to Other Ecosystems

It is DFWP's position that an effort must be made to focus concern for the grizzly to other ecosystems identified in the grizzly bear recovery plan (USDI 1982). To accomplish this will require the cooperation of all agencies dealing with grizzly bear management, as well as public support. This is important because grizzlies in the NCDE are least biologically vulnerable, due to the size of the current population and its proximity to the rest of the population in Canada. In addition, the status of bear habitat is much more secure in the NCDE, due to land already established as national park and wilderness.

The same situation is not true of bear populations in other ecosystems. Those populations are much lower and tend to be more isolated from areas with a healthy population. Suitable habitat is much less secure in such ecosystems.

If agencies continue to focus so extensively on the NCDE (largely a result of the limited recreational harvest), vital opportunities to recover the bear in some of the other ecosystems may be lost. The record is clear that once grizzlies are totally eradicated from an area, the support for their re-establishment is minimal. As progress is made toward recovery in other ecosystems, management will be more flexible and public support will increase.

Continued focus on grizzly bears—a *species* that is not biologically threatened with extinction—increases the risk of extinction to other species that *are* endangered.

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Mountain Lion Management in California

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Introduction

The mountain lion (*Felis concolor*) is widely distributed in California. Evidence suggests it coexists with mule deer (*Odocoileus hemionus*)—its primary prey—over approximately 70,000 square miles (181,300 km^2) of habitat (Weaver 1982). Although densities vary, it appears that all suitable habitat currently supports mountain lions. However, the lion's secretive and generally solitary behavior makes it difficult to study. That mountain lions are highly mobile and occur at low densities, compared to most other large mammals, further complicate monitoring and assessing population trends (Russell 1978).

Mountain lions are economically important in California because of actual and potential damage to livestock production and the costs of state–mandated damage–control programs. Lions are also socially and politically important in that public attitudes towards the species tend to be highly polarized. Throughout the history of mountain lion management, politics—more so than biological facts—have played the major role in directing laws and policies governing management programs. Since the 1960s, public concern for the welfare of mountain lions in California has resulted in very specific and often controversial laws that have not resolved management problems.

This paper reviews the history of mountain lion management in California from the early 1900s, with emphasis on legal status, statewide population estimates, depredation problems and public attitudes. Current research and future management options are also discussed.

Legal Status

Prior to the early 1900s, the mountain lion had no formally recognized legal designation in California. In 1907, as a result of conflicts with livestock production, the mountain lion was classified by the legislature as a bountied predator. The bounty system was eliminated in 1963, based on concern for the program's cost effectiveness. It is estimated that approximately 12,500 lions were taken during the 56–year program.

In 1963, the mountain lion was designated as a nongame mammal. By the mid–1960s, concern for appropriate measures of protection for the mountain lion, and the prospect of controlling livestock–depredation problems in selected areas, resulted in a proposal to establish regulated hunting programs similar to those used in other western states. In 1969, the legislature responded by designating the mountain lion as a game mammal and authorizing the Fish and Game Commission, under its general powers, to regulate the take of the species.

In 1972, after only two years of regulated recreational hunting during which 4,953 tags were sold and 118 mountain lions were taken, the legislature enacted the first in a series of complex statutes that created a moratorium on mountain lion hunting. The lack of specific information related to the statewide population was cited as the primary rationale for this legislative action. The mountain lion was initially classified a protected nongame animal. In 1982, the legislature designated the species as a specially protected mammal, under a complex set of laws which provided specific mechanisms addressing livestock damage, and continued the moratorium on recreational hunting.

On January 1, 1986, after intense legislative actions failed to extend the specially protected mammal status, the mountain lion reverted to game mammal status prescribed by the legislative designation in place prior to 1972. This event was marked by highly polarized public concern and political pressure, rather than objective analysis of available information related to the mountain lion and its management problems. Public attitudes ranged from demands for mountain lion control to prevent livestock damage and excessive predation on deer to claims that the mountain lion required complete protection as a threatened species. Unfortunately, more heat than light was focused on basic issues related to mountain lion population status, goals and objectives for management, appropriate uses of this renewable resource, and biologically sound methods of resolving or reducing conflicts between mountain lions, livestock and intensively managed prey species.

Although the option of authorizing recreational hunting of mountain lions was not available during the period 1972–1985, the Fish and Game Commission had specific authority over other aspects of lion management. Administrative regulations were adopted to authorize: the possession of mountain lions under a domesticated game breeder's permit; the take of lions causing damage; and the pursuit of mountain lions by licensed hunters under provisions of a permit, as long as the animals were not captured, injured or killed. In 1985, 112 permits were issued for pursuit of mountain lions under the provisions of the regulations.

In response to statutory changes as of January 1, 1986, the Commission promptly exercised its authority when it superseded provisions of state law to retain restrictive regulations controlling the take of mountain lions causing damage to livestock, domestic animals and other property. This regulatory action was the initial step taken to ensure protection of the mountain lion population as a game mammal. Other aspects of mountain lion management, including potential recreational hunting regulations, will be considered annually by the Commission during March and April, along with general mammal hunting and trapping regulations as prescribed by law. It is illegal to take mountain lions except as specifically provided by Commission regulations.

Statewide Population Estimates

The California Department of Fish and Game has produced four mountain lion population estimates, based on opinion of field personnel and analysis of available data. They are: (1) 600 in 1920 (California Department of Fish and Game files); (2) 2,400 in 1972 (Sitton 1973); (3) 2,400–3,000 in 1982 (Weaver 1982); and (4) 4,100–5,700 in 1984 (California Department of Fish and Game 1984). In addition, Koford (1977) estimated the statewide population to be approximately 1,000 animals during the period 1973–76, based on track surveys and the assumption that lions were resident in only 15,000 square miles (38,850 km^2) of habitat. A review of the results of intensive field studies, combined with trends in the number of lions killed under depredation permits and by vehicles on highways annually, suggests, with the exception of the 1984 estimate, that these estimates were probably low (Sitton and Wallen 1976, Weaver 1982). Mountain lion population densities up to 10 lions per 100 square miles (3.9/100 km²) and average litter sizes of 2.5 kittens were documented.

Damage Trends

Since 1971, the California Department of Fish and Game has attempted to record confirmed mountain lion damage incidents and the number of lions taken under depredation permits. Regulations related to mountain lions causing damage require that the Department promptly investigate reported damage. A permit for the take of the offending lion may be issued under specific conditions. The trends in confirmed damage incidents and the number of lions killed under depredation permits are illustrated in Figure 1.

The number of lions reported killed has tended to double every five years since 1971. Confirmed damage incidents have increased at a more–rapid rate. The validity of these trends being associated with increases in the mountain lion population during this period is supported by a similar increase observed in the number of lions killed by vehicles on highways. During the 1970s, an average of four mountain lions was

Figure 1. Confirmed livestock–damage incidents and mountain lions killed in California during the period 1971 through 1985.

killed annually on highways. In 1984, a minimum of 12 lions was confirmed killed by vehicle accidents. However, an increase in vehicle use is generally thought to be partially responsible.

Current Investigations

Three intensive mountain lion investigations are currently being conducted in California. One project involves the Mount Hamilton area of Santa Clara County, where mountain lions have been studied since 1979. The Department of Fish and Game has cooperated with investigators from state colleges and universities. Emphasis has been placed on obtaining information related to mountain lion population density and trend, food habits, home range characteristics, and interactions with other large mammals. Preliminary findings based on monitoring radio-collared lions suggest a population density of at least 5–6 adults per 100 square miles (1.9–2.3/100 km^2) for this central coast habitat.

Another investigation involves mule deer and mountain lions in eastern Fresno County. The project evolved from initial studies of deer mortality factors in an intensively managed, migratory herd. Since 1978, radio collars have been placed on both fawns and adult deer, as well as mountain lions, in an effort to determine the influence of mountain lion predation. Management objectives for the deer herd were developed during a 10-year study sponsored by a variety of public agencies and private groups interested in improving deer herd management. Preliminary findings indicate mountain lion densities of approximately 10 adults per 100 square miles (3.9/100 km^2). Radio collars have been placed on 20 lions, with over 600 radio-telemetry locations obtained from several lions of both sexes. Adult home ranges overlap and the reproductive rate appears near normal (2.5 kittens per litter) despite the relatively high population density. Rates of mountain lion predation on fawns and adult deer have been estimated. These data may be the basis for evaluating options to resolve conflicts between deer and mountain lion management programs.

The third investigation involves a plan for managing mountain lions in a portion of Placer County when there is a history of serious damage suffered by sheep-grazing operators. A total of 14 mountain lions were taken under depredation permits issued after damage was confirmed during the period 1972–84. Under the plan prepared by the Department and approved by the Fish and Game Commission in April 1985, up to five lions were to be taken each year in an effort to prevent livestock damage. The plan proposes that control efforts be conducted for a five-year period, subject to annual review. The objective is to reduce the recent annual loss of sheep from mountain lion damage by at least 50 percent.

During the period 1980–84, 4.6 confirmed damage incidents occurred and 33.4 sheep were killed annually in the Placer County area. In the 1985 grazing season, four male lions were taken prior to damage, and one adult female lion was taken pursuant to a permit after damage was confirmed. Only two damage incidents were confirmed and five sheep were killed by mountain lions. Results of the initial year of the proposed five-year program suggest that selective removal of mountain lions immediately prior to and during the grazing season, may be effective in reducing damage to sheep in the study area.

Discussion

The greatest mountain lion management problem in California is defining the desired results of future management programs. Several fundamental questions must be answered through a combination of scientific investigation and socio-political processes that will resolve conflicts and serve as a basis for sound management. How, for example, can livestock damage be controlled or prevented? Can mountain lion management be linked to intensive deer management programs? How many mountain lions are enough? And is consumptive use of the mountain lion resource appropriate?

Biologically sound and cost-effective programs to minimize negative impacts on livestock and intensively managed prey species such as deer can best be achieved by developing management plans for specific geographic areas. Priorities must be clearly established in the form of quantifiable objectives for programs in each area. Preliminary evaluation indicates that six to eight ecological regions may be appropriate for future mountain lion management programs. Strategies to achieve management objectives will probably vary between geographic areas. However, each should address such factors as analyzing mountain lion populations, appropriate types and levels of use of the lion resource, and maintenance of mountain lion habitat.

Despite the political unrest, need for additional research and refined management programs, the mountain lion's future in California appears secure. Its broad distribution, adaptability and apparent stable–to–increasing population trend in recent years suggest a low degree of threat to the species. However, there is a need to address more effectively the conflicting public attitudes, in order to generate support for more–efficient mountain lion management programs.

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Management of the North American Bobcat: Information Needs for Nondetriment Findings

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Introduction

The bobcat (*Felis rufus*) has been and continues to be the subject of much controversy among resource managers and the general public. The present controversy was initiated by participation of the United States in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the resulting regulations and restrictions on exporting pelts. These regulations and restrictions and the information required for nondetriment findings prior to export have changed in response to court actions, political pressure, expert opinion and amendments to the Endangered Species Act. Thus, the purposes of this paper are (1) to review the history of current regulations and information required by the regulations, and (2) to review the data used to manage the bobcat harvest and monitor population trends.

Regulation of International Trade in Bobcats

CITES was negotiated by representatives of 80 countries in Washington, D.C., during February and March 1973. The basic purpose of CITES is "the protection of certain species of wild fauna and flora against over-exploitation through international trade." Trade is defined as all imports, exports, re-exports and introductions into a country. CITES operates by a system of permits and certificates administered by designated Management Authorities in each participating country. Exporting any specimen of a species included in Appendix II requires an export permit. An export permit is issued when (1) the Scientific Authority (SA) of the State of export has advised that such export will not be detrimental to the survival of that species, and (2) the Management Authority (MA) of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State. In 1976, the Endangered Species Scientific Authority (ESSA) was designated as the SA, and the Secretary of the Interior was designated as the MA.

In the summer of 1977, ESSA reviewed applications for the export of bobcat pelts to determine whether such export would be detrimental to the survival of the species. These applications, which came mostly from dealers and buyers, provided little useful information from which ESSA could make nondetriment determinations. Therefore, ESSA looked to state wildlife agencies for additional information. In August

1977, ESSA and the Secretary of the Interior published a notice stating that authorized levels of export of bobcats for the 1977–78 season would be based on a state–by–state assessment of the status of the species.

Based on information received from the states, ESSA gave general approval until 1 November 1977, for exporting all bobact pelts taken from the wild before 30 August 1977, but disallowed the export of bobcats taken in the 1977–78 trapping season. These negative findings were made due to a lack of population data and a general lack of mechanisms by the states for regulating the harvest, rather than to specific evidence of declining bobcat populations. CITES required that decisions to export pelts be based on evidence that such export would not be detrimental to the survival of the species rather than assuming that a lack of data on the status suggests that export is allowable. Many managers characterized this as a guilty–until–proven–innocent attitude.

In response to new information and management commitments provided by the states, ESSA approved the export of bobcats from some states for 1977–78. In nearly every case, the state agreed to tag pelts to be exported, and ESSA assigned an export quota based on the state's past harvest and population estimates.

In January 1978, ESSA convened a workshop on the bobcat, lynx and river otter in New Orleans, to determine what minimum biological data and management programs were required to ensure that the harvest of these three species was not detrimental to their survival or to their normal functional roles within their ecosystems. The working group of the workshop, which consisted of 12 professional biologists under the chairmanship of Dr. L. David Mech, recommended that no pelt from any of these species be allowed into international export unless it came from a state in which the wildlife management agency had the authority to regulate the taking of the species, and only pelts taken and registered in any state which met the minimum standards for biological information and management programs should be approved for international export (Mech 1978:10). Specifically, the working group recommended the following as minimum requirements for biological information and management programs:

Minimum Requirements for Biological Information

1. Population trend information . . . the method of determination to be a matter of state choice.
2. Information on total harvest of the species.
3. Information on distribution of harvest.
4. Habitat evaluation.

Minimum Requirements for a Management Program

1. There should be a controlled harvest . . . methods and seasons to be a matter of state choice.
2. All pelts should be registered and marked.
3. Harvest level objectives should be determined annually.

Johnson (1982) and Dixon (1981) have since recommended the collection of similar information to monitor and manage furbearer populations.

In 1979, amendments to the Endangered Species Act transferred the functions of the SA and the MA to the Secretary of the Interior (hereafter referred to as the Secretary). On 9 November 1979, Defenders of Wildlife sued ESSA and the Department of the Interior in the U.S. District Court for the District of Columbia, to halt the export of bobcats on the grounds that the export findings were not in compliance with CITES standards. The case resulted in a court order issued on 12 December 1979 which enjoined export of bobcat pelts harvested during the 1979–80 season in five states and in portions of two others.

On 3 February 1981, the U.S. Court of Appeals ruled that existing standards for export approval of bobcats were invalid under CITES. The Court contended that the "findings that the export of bobcats would not be detrimental to the survival of the species . . . are not based upon reliable estimates of the bobcat population."

On 23 April 1981, the U.S. District Court issued an order that prohibited the export of all bobcats killed after 1 July 1981. The Secretary was enjoined from allowing exports until new guidelines were formulated. These guidelines were to include provisions for reliable population estimates and harvest limits.

In reauthorizing the Endangered Species Act of 1973 in December 1982, Congress added a paragraph to Section 8A of the Act to overrule the Court of Appeals' 1981 decision. The amendment made it clear that the Secretary is to base export determinations on the best available biological information derived from professionally accepted practices used in wildlife management, and that he may not require any state to submit estimates of population size in making such determinations.

Following this amendment, the District Court on 23 December 1982 vacated the April 1981 injunction which prevented export of bobcats pending nondetriment findings based on population estimates. The December 23 order also dismissed the case brought by Defenders of Wildlife.

In April 1983, at Botswana, the parties to and Secretariat of CITES gave the United States the latitude to manage bobcats for reasons of similarity in appearance to other cat species under Article II.2(b) of CITES, rather than as species which are themselves threatened with extinction. Thus, in August 1983, the Secretary proposed to make export findings to span more than one harvest season. The final findings and rule on export of bobcats were issued on 5 January 1984 and are currently in effect.

The Finding of Nondetriment

Management and research programs for the bobcat in each state where a harvest is allowed are relied on by the Secretary in determining nondetriment and whether similarity–in–appearance treatment remains suitable in the future. If problems arise for a geographic population, the Secretary will afford that population more–restrictive treatment. The Secretary will maintain export requirements in order to monitor the trade and to limit it where necessary to avoid detriment to the subspecies involved. Although the national population of bobcats is not now believed to be threatened because of international trade, monitoring will enable the Secretary to detect any significant downward trend in the population and, where necessary, advise on more–restrictive export controls in response to such trend. To aid the Secretary in monitoring the status of bobcats, annual certification is requested from each state in which bobcats are harvested, as to whether the best–available biological information derived from professionally accepted wildlife management practices indicates that harvest during the forthcoming seasons will not be detrimental to the survival of the species.

The Management Biologist View of Information Needs

In response to concerns about CITES regulations, the Mississippi Agricultural and Forestry Experiment Station, in cooperation with the U.S. Fish and Wildlife Service's Cooperative Units Office in Washington, D.C., hosted a two–day workshop at Mississippi State University on August 26–27, 1982. The primary objective of the workshop was to assess, in an unencumbered environment, the needs of state furbearer biologists in managing bobcat populations and in meeting CITES regulations (Gluesing 1982). The workshop was attended by over 40 biologists from 14 southern and southeastern states. One of the main conclusions of the workshop was that all participants would like to have a reliable population estimate or at least reliable indications of population trends. While none of the participants believed it was truly possible to census bobcats or that such absolute count was necessary to manage wildlife populations, all agreed that better indicators of year–to–year population trends were necessary. Most representatives indicated that a technique was needed in which they could be at least 80 percent confident that it could detect a significant change in a bobcat population. Some suggested the ability to detect a 25 percent change would be adequate, while others desired more sensitivity in the technique. Most agreed that high trophic level carnivores, such as bobcats, required more monitoring in general than did the more–abundant herbivores which their agencies managed.

Current Knowledge about Bobcat Population Dynamics

States are presently collecting and analyzing data on sex ratios, age structures and age–specific reproductive rates in order to determine or monitor the status of their bobcat populations (Gluesing 1982). Typically, these data are compared to data collected and analyzed in a similar manner in prior studies. This has lead to a situation where unknowns are compared to other unknowns.

Sex ratios of wild bobcats are obtained from samples of hunted and trapped populations. Sex ratios of bobcats obtained by these methods range from 88:12 (male:female) (Zezulak and Schwab 1979) to 30:70 (Fredrickson and Rice 1979). Of the 17 data sets we examined from 13 published studies, 8 showed more males in the harvest, 7 showed more females and 2 showed no difference. The overall sex ratio for the 17 data sets was 51:50.

Sex ratios should not differ substantially from 1:1 unless there is a differential expenditure of energy in producing the sexes (Fisher 1930), or some factor causes differential mortality after parturition. The average birth weight of three males ($\bar{x}$ = 157.3 *g*, *S.D.* = 31.0) and five females ($\bar{x}$ = 142.3 g, *S.D.* = 16.2) born at Mississippi State University was not significantly different (t = .953, $P > 0.4$). Although males may be slightly larger at birth, these data suggest that the difference is not significant. We agree with McCord and Cardoza (1982) that, under normal conditions, sex ratios of adult populations should not differ from 1:1.

Sex ratios of harvested populations that differ significantly from 1:1 require explanation. A frequent explanation is trapping bias. Gilbert (1979), citing data from Bailey (1974), Crowe and Strickland (1975), and Fritts and Sealander (1978), suggested that males, because of their larger home ranges, should be more vulnerable to trapping than are females. However, this disagrees with studies of Fredrickson and

Rice (1979), Lembeck and Gould (1979), and Creed and Ashbrenner (1983), which found fewer males than females in trapped samples. McCord and Cardoza (1982:750–752) reviewed and analyzed numerous studies and concluded that "the evidence does not generally support the assumption that skewed sex ratios in bobcats are caused by the increased vulnerability of a particular sex due to the time of year or season or the harvest method." Lembeck and Gould (1979) suggested another possible explanation. During a period of high bobcat density in their study, males outnumbered females 21:10; at low bobcat densities, sex ratios were closer to unity—46:54.

How much sex ratios can differ from 1:1 before they can be used to detect a change in a population's status is presently unknown. Similarly, if sex ratios do differ substantially from 1:1, the reasons for these differences are conjectural at best. Controlled experiments are needed to determine the effect of trap bias on sex ratios versus ecological or population changes that can produce the same effect.

Parturition for free–ranging bobcats is thought to occur from March to October with the peak period occurring in April and May (Gashwiler et al. 1961), May and June (Crowe 1975a), or March to May (Fritts and Sealander 1978), depending on location. The range in parturition dates is thought to result from recycling females or from late–cycling yearlings. Estimates of parturition dates are based primarily on back–dating from a dentition–eruption schedule, an age–index curve or a growth curve developed by Crowe (1975a). The dentition–eruption schedule and the two curves presented by Crowe (1975a) are based on the dentition–eruption schedule of the domestic cat presented by McClure et al. (1973). Unfortunately, no experiments have been conducted to determine how well the domestic cat models the bobcat.

Using a gestation period of 62 days and back–dating from estimated parturition dates, the peak of estrus nationwide is probably the last week of February, but it may occur as early as the last week of January. Thus, trapping seasons that extend beyond the middle of February may impact pregnant females.

Estimates of annual reproduction are derived primarily from the number of corpora lutea or placental scars in reproductive tracts collected during the trapping season. The use of corpora lutea to indicate annual reproduction was originally questioned by Duke (1949), Gashwiler et al. (1961) and Crowe (1975a) because of the possibility that bobcats may retain corpora lutea for life. We are currently conducting research to determine if corpora lutea counts are viable indicators of annual reproduction.

The number of placental scars in uterine horns is commonly used to estimate litter size. The number of placental scars per female reported in the literature (Gashwiler et al. 1961, Crowe 1975b, Bailey 1979, Blankenship and Swank 1979, Brittell et al. 1979, Parker and Smith 1983, Beeler 1985, Johnson and Holloran 1985, Rolley 1985) ranged from 2.6 to 3.9 and averaged 2.9 (*S.D.* = 0.40).

Placental "scars" are the result of hemosiderins that stain the wall of the uterus on both sides of the attachment site. Hemosiderins are removed through time by phagocytosis. How long it takes for phagocytosis to remove hemosiderins, or if removal rates are relatively constant among bobcats, is unknown. We do know that the length of time hemosiderins can be detected after parturition varies greatly among species (Martin et al. 1976) and even among individuals within the same species (Pearson 1944). The reliability of using placental scars to estimate annual reproduction in bobcats needs to be ascertained.

Many states are collecting age data (Blum and Escherich 1979, Gluesing 1982) in an effort to assess the status of bobcat populations. The problems associated with collecting, analyzing and interpreting age data are reviewed by McCord and Cardoza (1982), and are obvious to all who have attempted it. Despite these limitations, age data are still the major source for estimating mortality rates in wild populations, and we used age data collected by Hardisky (1986) for free-ranging bobcats in Mississippi in order to assess the sensitivity of bobcat populations to different reproductive rates and kitten survival rates. Age-specific cohort survival rates were estimated from these data. The resulting survivorship curve (Figure 1) shows low survival during the first year of life, but high survival thereafter, until bobcats reach the older age classes.

We used a Leslie matrix (Leslie 1945) to assess the effects of different reproductive rates or kitten survival rates on population dynamics when adult mortality rates were held constant. Once we determined stationary conditions ($r = 0$), we varied kitten survival or litter size to see the effect on population dynamics. (The effect of varying kitten survival or litter size is the same.) When we used Beeler's (1985) estimate of 1.6 female kittens per female for Mississippi bobcats, the population was stationary when kitten survival was 23.8 percent. When we increased kitten survival by 10 percent, the population grew at an annual rate of 2.7 percent. If we increased kitten survival by 20 and 30 percent, the population increased at an annual rate of 4.5 and 6.7 percent, respectively. Conversely, decreases of 10, 20 and 30 percent in kitten survival produced decreases in the population growth rate of −2.5, −4.7 and −8.2 percent, respectively.

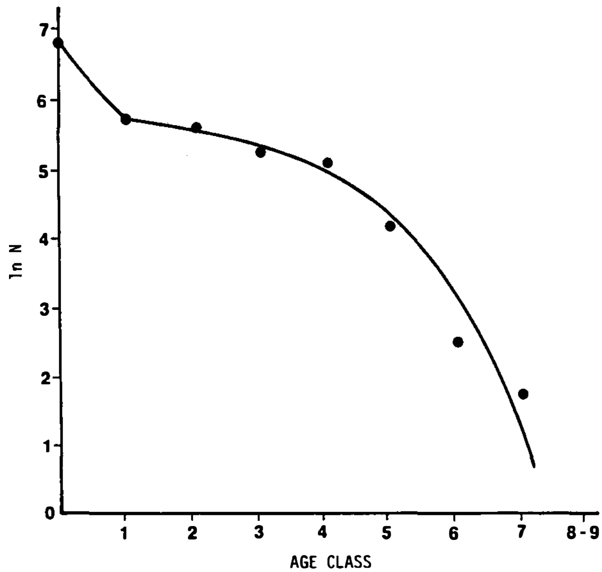

Figure 1. The number (N) of individuals per cohort age class estimated from time-specific age distributions of Mississippi bobcats reported by Hardisky (1986).

We performed the same calculations using 1.15 female kittens per female, the average size of 93 litters born in captivity (Gluesing in preparation). The results were identical. Increases in kitten survival of 10, 20 and 30 percent produced annual increases of 2.4, 4.5 and 6.7 percent, respectively, while decreases of 10, 20, and 30 percent decreased annual growth by 2.5, 5.2 and 8.1 percent, respectively. Population dynamics were related ($R^2 = 0.99$) to litter size or kitten survival by the equation $Y = 0.42X - 0.31$, where Y is annual percentage change in the finite rate of increase and X is the percentage change in litter size or kitten survival.

We also simulated increases of 10, 20 and 30 percent in annual adult mortality, while holding litter size or kitten survival constant, to see what effect that had on population dynamics. Reducing annual adult survival rates by 10, 20 and 30 percent produced annual declines in the simulated population of 5.2, 10.7 and 16.4 percent, respectively. Population dynamics were related ($R^2 = 0.99$) to adult mortality by $Y = .56Z + .43$, where Y is as previously defined and Z is the percentage change in adult mortality.

In our simulated population, which was based on estimates of mortality and reproduction for Mississippi's free–ranging bobcat population, annual changes in adult survival had twice the impact on population dynamics as did the same degree of change in litter size or kitten survival. How well these simulations model the population dynamics of Mississippi's wild population is unknown. If they are indicative of population dynamics, then small changes in kitten survival, litter size or adult mortality can cause increasing populations to decline or vice versa. On the other hand, the simulations also suggest some buffering in the population to changes in mortality or litter size. Changes in adult mortality or litter size of 10 percent did not produce a corresponding 10–percent change in annual growth rate, but produced smaller changes of 5.8 and 2.2 percent, respectively. However, a population that sustains an annual percentage decrease of 5.8 percent will be only half as large in 13 years as it is now.

Conclusions

The bobcat, as a species in North America, does not appear to be in jeopardy, and the data required to meet CITES regulations have been relaxed accordingly. Data from management and research programs for the bobcat in each state where a harvest is allowed are used by the Secretary in making his determination of nondetriment. Sex ratios, age structure and estimates of reproductive rates based on numbers of corpora lutea or placental scars are common types of data currently being collected under state management or research programs. Unfortunately, despite over 10 years of interest and research, the reliability of these data to detect changes in a population's status or to depict the dynamics of a population is largely untested.

Sex ratios of bobcats in harvested samples have ranged widely, but nationwide they are 51:50. Departures of sex ratios from 1:1 may indicate a sampling bias or that some other factor has caused differential mortality. However, how far a sex ratio can differ from 1:1 before it can be used as an index of a change in a population's status is unknown. Research is needed to determine the effect of trap bias on sex ratios versus population changes that can produce the same effect.

Parturition is thought to occur from March through July, with most births occurring in April and May. Late litters are thought to be the result of recycling or late–maturing females. Breeding is thought to occur from February through May, or possibly later. Estimates of breeding and parturition dates are based primarily on dentition–eruption schedules and growth rates of the domestic cat. How well dentition and growth rates of the domestic cat depict these same parameters in the bobcat has yet to be determined. Research is needed to determine if the house cat is a suitable model for the bobcat.

With few exceptions, estimates of litter size are derived from the number of placental scars or corpora lutea or both. Duke (1939), Gashwiler et al. (1961) and Crowe (1975a) have seriously questioned the use of corpora lutea. Placental scars may also be misleading. The length of time placental scars can be detected after parturition varies among species (Martin et al. 1976) and between individuals in the same species (Pearson 1944). Captive populations with known litter sizes need to be established in order to determine the reliability of using placental scars as an estimate of litter size.

Simulations of population dynamics based on estimates of age–specific mortality for Mississippi's bobcat population suggest that bobcat populations may be more sensitive to changes in adult mortality than to changes in litter size or kitten survival. Each 10–percent change in kitten survival or litter size produced an average corresponding change of 2.2 percent in annual growth, while each 10–percent decrease in adult survival reduced the annual population growth by an average of 5.8 percent. If these simulations accurately depict the dynamics of bobcat populations, they are good news, because adult mortality rates are easier to manage than kitten survival or reproductive output.

How long the current situation will exist is anyone's guess. The status of the bobcat is likely to change as a result of changes in or the loss of habitat. The research required to measure or predict population dynamics more accurately will take time. Immediate needs include the validation and standardization of techniques currently used to estimate reproduction or to detect changes in a population from sex and age data and the validation and standardization of scent station lines and catch per unit effort as indices of population trends. Other long–term research needs—which time and space do not permit us to discuss—range from dispersal studies to habitat and population models. While the cost of this research will be high, the cost to the resource from not doing it may be too high to be acceptable. We encourage the formation of research cooperatives that will attack these problems in a systematic way and that can seek funds from sources unavailable to individual units.

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The Public and the Timber Wolf in Minnesota

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This paper examines results of a study of public attitudes, knowledge and behaviors toward the timber wolf (*Canis lupis*) in Minnesota (Kellert 1985b).[1] Management of the Minnesota timber wolf has been marked by more than two decades of highly divisive conflict, involving protracted litigation, legislative confrontation, and an enduring legacy of bitterness and unresolved differences (Van Ballenberghe 1974, Llewellyn 1978). This study was intended to foster a more–precise consideration of public perception that might enhance the development of effective and conciliatory policy involving the timber wolf in Minnesota. The wolf continues to exercise its hold on the human imagination, with myth, bias and supposition exerting as much influence on public values and policies as does the rapid growth in scientific understanding of this animal (Hook and Robinson 1982). The wolf remains an important symbolic fulcrum on which people project some of their deepest and strongest views of nature (Lopez 1978).

Historic management of the timber wolf in Minnesota was largely an expression of the American quest to eliminate this predator (Matthiessen 1959, Scarff 1972). In the past, the wolf was despised for its association with wilderness, regarded as both a perceived threat to personal safety and livestock and as an impediment in the march of progress and civilization (Young 1946, Kellert 1985a). This national bias led to the extirpation of the wolf from much of the 48 contiguous states, with the exception of northern Minnesota. A bounty for timber wolves persisted in Minnesota until 1965, however, with the survival of this animal stemming largely from the remoteness of the boundary waters area and the possible recruitment of wolves from a more–abundant Canadian population (Mech 1970).

The 1950s and '60s witnessed a remarkable increase in public sympathy and positive media attention for the wolf (Mowat 1963, Ricciuti 1974). This species became for many a symbol of human persecution of wildlife and, in 1966, the first national endangered species act fostered a perception of this animal as in imminent danger of extinction (Goldman–Carter 1983). In 1970, the first timber wolf sanctuary in Minnesota was established in Superior National Forest and, in 1973, the endangered species act officially listed four subspecies of wolf as endangered. This protection effectively eliminated wolf hunting outside of Alaska, and management authority was transferred from the state to federal government (U.S. Fish and Wildlife Service 1978).

In 1978, an Eastern Timber Wolf Recovery Plan was produced (Bailey 1978),

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calling for the establishment of timber wolf density zones in Minnesota, control of depredating animals and the possibility of a limited harvest. Studies by Mech (1977) concluded some 1,200 timber wolves existed in Minnesota. In 1978, the timber wolf was reclassified from endangered to threatened, to allow for control of individual animals that committed "significant depredations on lawfully present domestic animals" (Sierra Club and Defenders of Wildlife vs. Clark 1984). Additionally, a state program was instituted providing financial compensation to farmers who experienced verifiable livestock losses to wolves. A 1982 study (Fritts 1982) reported that less than 1 percent of northern Minnesota farms with livestock were directly affected by wolves, although a small number experienced significant losses.

In 1980, the Minnesota Department of Natural Resources (1980) issued its own plan, including most of the Recovery Team's recommendations. This plan tended to treat the timber wolf as a renewable resource, recommending a limited harvest and legal sale of wolf pelts. In 1983, the U.S. Fish and Wildlife Service (1983) proposed sharing management responsibility for the timber wolf with Minnesota and, thus, largely endorsed the state plan. A consortium of 15 environmental groups, which had previously brought suit against the wolf–control program (Fund for Animals vs. Andrus 1978), legally contested this transfer of authority and the proposal to allow a harvest of at least 50 wolves per year (Sierra Club and Defenders of Wildlife vs. Clark 1984). The courts recently ruled in favor of the environmental groups (U.S. Fish and Wildlife Service 1985), noting, "an attempt to . . . [allow] a sport season and . . . market in wolf pelts is to treat the wolf as a furbearer . . . Congress has . . . mandated that each person who would slay the wolf must stay his hand . . . An increased 'war on wolves' will not be permitted" (Lord, Federal District Court, Sierra Club and Defenders of Wildlife vs. Clark 1984).

Methodology

Data for this study were collected through 45–minute telephone interviews with 621 respondents, representing samples of the Minnesota general public, deer hunters, trappers and livestock producers. The general public sample consisted of randomly selected residents of the Minneapolis–St. Paul area ($n=186$) and 10 northern Minnesota counties ($n=183$); this latter sample was stratified to include mostly rural residents. Samples of livestock producers ($n=97$), deer hunters ($n=102$) and trappers ($n=53$) were randomly chosen from lists provided by the Minnesota Farmers Union and the Minnesota Department of Natural Resources. Farmers and deer hunters largely resided in seven southern, eight metropolitan Twin Cities and nine northern Minnesota counties. A much–smaller list of trappers, and problems of respondent availability, necessitated less–stringent sample–selection procedures and a smaller trappers sample. No respondent occurred in more than one sample group. A pre-interview letter, initial telephone contact and three telephone callbacks were required to increase the response rate. The overall sample completion rate was 79 percent, ranging from 69 percent of Minneapolis–St. Paul residents (i.e., 31 percent refused to participate) to 98 percent among trappers. All interviewers were experienced employees of Quality Control Services of Minneapolis, and specially trained for this study.

The survey consisted of 125 questions covering attitudes, knowledge, behaviors and symbolic perceptions toward the timber wolf, as well as respondent demographic and animal–related activity characteristics. All but three questions were closed–ended. Attitude question answers generally included five response options, from strongly agree to disagree to no opinion. Knowledge questions were largely true–or–false items. Attitude–toward–timber wolf scales were constructed, based on cluster analysis of individual attitude questions. Brief definitions of the attitude scales include: dominionistic—strong support for mastery and control of the timber wolf; ecologistic—primary concern for systemic relations between the timber wolf, other species and the natural environment; moralistic—strong opposition to presumed cruelty and harm toward the timber wolf; naturalistic—primary concern for outdoor recreational contact with the timber wolf or wilderness areas including wolf populations; negativistic—strong fear, dislike or indifference toward the timber wolf; utilitarian—primary focus on pragmatic exploitation of the timber wolf, or subordinating the wolf and its habitat for the material benefit of human beings. All scale scores were standardized on a 0 to 1 basis.

Results

Somewhat–limited factual understanding of the timber wolf among the general public (although not trappers and less so hunters) was suggested by responses to various knowledge questions. Most general public respondents revealed deficient knowledge of the difference between a timber wolf and coyote, the size of a typical wolf, this species' predation tendencies, the typical role of plants in a wolf's diet or its population size. On the other hand, most Minnesotans correctly recognized the wolf's tendency to feed on other animals and the rarity of its attacking human beings. Cumulative responses to 19 knowledge questions were used to create a knowledge of timber wolf scale (scores were standardized on a 0 to 100 range). The lowest knowledge scores were found among Twin Cities residents, respondents of limited education, nonwhites and females. In contrast, relatively high knowledge scores occurred among trappers and, to a less–exaggerated degree, hunters and higher–income respondents.

A wide variety of attitude questions were included in the survey, although space limitations necessitate a review of only some of these results. More–complete information can be found, however, in the study's final report (Kellert 1985b). Several attitude questions focused on the potential conflict between the timber wolf and various human activities. Most respondents favored the protection of the wolf and its habitat, but not to the exclusion of important human needs. For example, most respondents supported the right of farmers to protect their livestock from wolves and of private citizens to eliminate wolves that threatened their pets, and opposed limitations on human settlement in northern Minnesota to protect wolf habitat. Although most respondents supported the notion of controlling wolf depredations on livestock, the great majority (except farmers) favored control methods focusing on the individual problem wolf as well as the use of presumably more–humane control techniques. In addition, the most–preferred methods for potentially increasing the deer herd in northern Minnesota were reductions in the number of human hunters or "doing nothing," while the least–favored option was reducing the number of timber wolves.

Most respondents (except farmers) viewed the wolf in highly favorable and positive terms. For example, most expressed strong appreciation of the wilderness and the outdoor recreational values of the timber wolf, indicated a desire to see or hear a wolf in the wild, believed wolves are an important part of the Minnesota environment, and regarded wolves as a symbol of nature's wonder and beauty. Despite these views, a moderate degree of fear of this animal was revealed; relative liking for the wolf ranked low in comparison to 17 other animals (Figure 1). Most respondents, however, disagreed that wolves represent a threat to people, particulrly children, or that this animal was inherently "cruel."

A number of questions explored public support for utilizing the timber wolf for its fur or for sport. Respondents were ambivalent regarding the economic benefits that might be derived from legal sale of wolf pelts, although most disagreed that support for wolf conservation would increase if this animal had greater economic value, or that capturing a wolf would be a challenging and rewarding experience. Additionally, most of the general public (although less than a majority of farmers, trappers and hunters) believed a legal season on wolves might increase poaching of this animal because of legal sale of its pelt, and might confuse the public about the need to protect endangered wildlife.

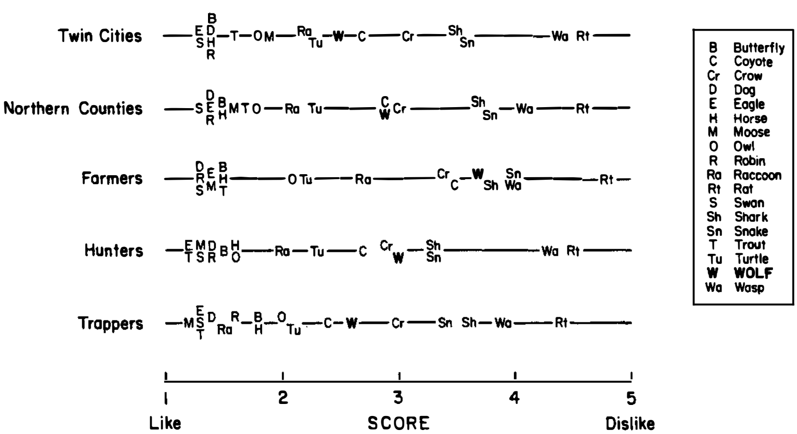

Figure 1. Minnesotans relative liking of 18 species of wildlife (Kellert 1985b).

As previously described, attitudes toward timber wolf scales were constructed based on cluster analysis of individual questions. As indicated in Table 1 and Figure 2, significant variations in basic attitudes and knowledge of the timber wolf were found among farmers, trappers, hunters, and Twin Cities and northern counties residents.[2]

Farmers strongly supported the practical exploitation and dominance of the timber wolf, as suggested by very high utilitarian and dominionistic scale scores. Moreover, farmers expressed the most negative, hostile, and unsympathetic views of the timber wolf, as reflected in much higher negativistic and lower naturalistic, ecologistic and moralistic scores.

Trappers were somewhat similar to farmers in their practical and ethical attitudes toward wolves, as suggested by relatively high utilitarian and dominionistic scores

[2]Knowledge scale results are included in the presentation of these findings to provide an overall indication of group perceptions of the timber wolf.

Table 1. Minnesotans' attitudes toward and knowledge of timber wolves.

Attitude and knowledge scale	Survey respondents' mean score				
	Twin Cities	Northern counties	Farmers	Hunters	Trappers
Dominionistic	0.23	0.32	0.46	0.37	0.41
(F = 16.9; significance of F = 0.001; TC/NC[a] = 0.0003)					
Ecologistic	0.41	0.31	0.20	0.29	0.31
(F = 9.6; significance of F = 0.0001; TC/NC[a] = 0.0001)					
Moralistic	0.29	0.24	0.17	0.18	0.14
(F = 8.4; significance of F = 0.0001; TC/NC[a] = 0.05)					
Naturalistic	0.54	0.46	0.29	0.47	0.58
(F = 10.4; significance of F = 0.0001; TC/NC[a] = 0.02)					
Negativistic	0.12	0.16	0.25	0.15	0.11
(F = 7.3; significance of F = 0.0001; TC/NC[a] = 0.04)					
Utilitarian	0.17	0.26	0.44	0.31	0.37
(F = 21.5; significance of F = 0.0001; TC/NC[a] = 0.0001)					
Knowledge	58.0	63.2	64.4	67.5	70.8
(F = 24.8; significance of F = 0.0001; TC/NC[a] = 0.0001)					

[a]Significance of difference in scores of respondents in the Twin Cities and of those in the northern counties.

and low moralistic scores. On the other hand, trappers expressed considerable outdoor recreational interest in, and the least fear and dislike and most knowledge of, the timber wolf, as reflected in very high naturalistic and knowledge scores and low negativistic scores. Hunters attained attitude and knowledge scores somewhat similar to trappers, although to a less–exaggerated degree.

A highly protectionist attitude toward the timber wolf was found among Twin Cities residents, as suggested by very high moralistic and ecologistic scores. Additionally, despite relatively limited knowledge of the wolf, Twin Cities residents expressed strong affection and outdoor recreational interest in this animal. In contrast, northern counties respondents had significantly higher utilitarian and dominionistic scores and lower ecologistic and moralistic scores than did Twin Cities residents, suggesting a more–pragmatic, more–authoritarian and less–protectionist attitude toward the timber wolf among rural people living in proximity to this animal.

Some behavioral contacts with the timber wolf were examined. Most respondents reported seeing timber wolves in zoos, as well as reading about them or viewing wolves in films. Additionally, an unexpectedly large number reported seeing a timber wolf in the wild, ranging from approximately 60 percent of northern counties', hunter, trapper and farmer respondents to even 25 percent of Twin Cities residents. A cross–tabulation of this finding with knowledge questions concerning the difference between a timber wolf and coyote suggested the possibility that Twin Cities residents may have confused these two animals.

Relatively few respondents indicated having an animal killed by a timber wolf, although 19 percent of farmers reported this occurred (7 percent reported being this victimized six or more times). Additionally, more than 40 percent of northern counties', hunter, trapper, and farmer respondents reported knowing someone who had an animal killed by a timber wolf. Somewhat surprisingly, 12 percent of farmers and 17 percent of trappers reported capturing or killing a timber wolf. Additionally, 38–

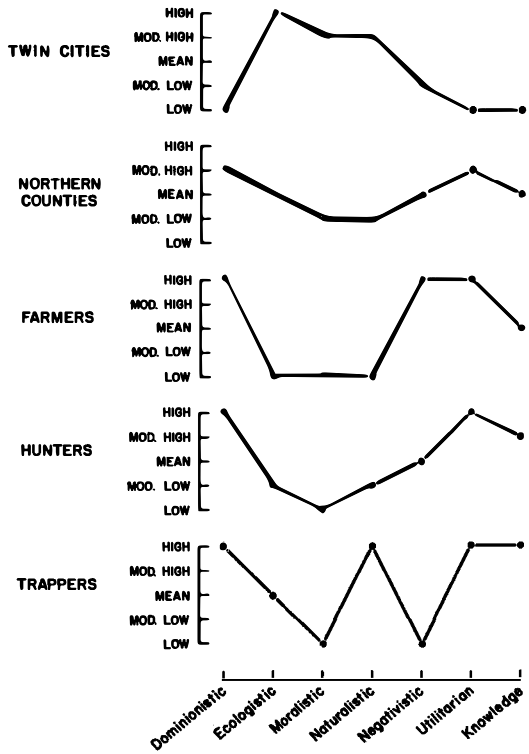

Figure 2. Knowledge and attitudes toward timber wolf scale scores of general public, farmers, hunters and trappers in Minnesota, 1984.

58 percent of farmer, hunter, trapper and northern counties respondents reported knowing someone who had killed or captured a timber wolf. Finally, more than 30 percent of farmers, hunters and trappers, and 26 percent of northern counties respondents, indicated they might shoot a timber wolf if they encountered one while deer hunting.

Conclusion

A great deal of data has been presented suggesting fundamental differences in perception, understanding and concern for the timber wolf as a likely basis for protracted conflict regarding the management of this animal. Additionally, some data suggested a potentially serious problem of inordinate amounts of illegal killing and removal of timber wolves from the wild.

Despite these problems and differences, the possibility for agreement regarding management of the timber wolf also appeared evident. The respondents often viewed the wolf as a potential source of enjoyment and practical benefit. This species also tended to be regarded as a valuable component of the Minnesota wilderness and as a symbol of nature's wonder and beauty. Extensive public awareness and education programs, as well as innovative economic–development efforts, could nurture and broaden this basis for agreement. For example, current efforts to develop a major recreational tourist attraction in northern Minnesota—the "International Wolf Center"—could represent an opportunity to promote the practical value of the timber wolf for rural Minnesotans.

An additional possibility for fostering agreement might involve the use of nontraditional conflict–resolution techniques. Historically, the Minnesota wolf conflict has been marred by extensive litigation and court confrontation, management paralysis, bitterness, polarization, and an incredible waste of time and resources. The antagonists are more divided than ever, while the cause of wolf conservation and recovery has hardly been served. A different model of dispute resolution seems warranted. Recent advances in the development of environmental mediation techniques, based on principles of negotiation and compromise, could offer a promising alternative (Bacow and Wheeler 1984). Fundamental differences clearly separate the antagonists on the timber wolf issue, but areas of common concern and the basis for compromise appear evident. Unfortunately, no institutionalized mechanism has existed for facilitating a mediated outcome. The chance exists for innovative leadership that could courageously attempt to fashion a new context for consensus and common ground.

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Wildlife Habitat by Design

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Setting the Stage

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In terms of land use—and at peril of oversimplification—wildlife habitats seemingly fall into one of three general categories: (1) those set aside largely intact and unaltered as preserves, such as wilderness areas; (2) those acquired and developed as more–or–less single–purpose management units, such as wildlife refuges and parks; and (3) those habitats that are simply fortunate but often temporary arrangements stemming from other land–use developments, such as fallow fields or odd areas on farms, commercial forests, cemeteries and fenced rangelands. In dealing with the latter category, we often please ourselves with the belief that such habitats are models of multiple–use management. In fact, wildlife (and wildlife managers) too often take what they can get, then attempt to make the best of it. Indeed, such is the basis of environmental trade–offs, mitigation lands and similar dealings in our affairs but, in truth, the ecological results for wildlife may reveal a pattern of diminished returns and little more than fitting a "square peg into a round hole."

To many of our colleagues, of course, goes well–deserved credit for the research and development of practices associated with the restoration of wildlife populations via habitat improvement. Yet, artificial reefs, nest boxes for wood ducks and other well–founded techniques remain remedies for ills plaguing an environment manipulated by short–sighted planning.

On a large scale, we try to preserve species by preserving biomes. Precious little of the American tallgrass prairie remains today. The folly of a spruce monoculture ("Fichtenomania") once imposed on the German landscape is behind us, but the destruction of tropical rain–forests and many wetlands goes on unabated. Conversely, the cacophony of construction reminds us daily of urbanization's relentless sprawl into environments of every type.

On a smaller scale—one where most of us live, work and play—we must learn to shape and manage the interface between humans and animals. Such is accomplished in that basic unit we call "the landscape." Regrettably, however, the landscape has fallen victim to a piecemeal existence, where human uses of the land have improved the habitats of relatively few organisms (several exotic and domestic species excepted) but degraded or eliminated those of many others. Thus, we face the imperative of maintaining diversity not only with protective measures (e.g., wilderness preserves but also zoo collections and gene banks) but also by our abilities for designing habitats and whole environments. John T. Lyle, author of the stimulating book, *Design for Human Ecosystems* (1985), concluded that, without conscious efforts to design habitats, human uses of land almost certainly lead to the domination of generalists rather than a balanced, interacting fauna.

New concepts are emerging to address these concerns. One great promise—and challenge—is landscape ecology (Forman 1981, Forman and Godron 1986). Most notably, a workshop convened in 1983 under the auspices of the National Science Foundation addressed the development of a synthesis that brings into focus the spatial–temporal patterns of the landscape (Risser et al. 1984). The process of redistribution of organisms, materials and energy among the various components of the landscape remains an essential feature of that synthesis. This involves a *conscious* effort by thoughtful design, given the opportunities offered by the manipulation of landscapes, rather than succumbing once again to the risks of environmental default and the lifeless panorama it so often produces. A new coalition is forming among and between public interest groups and scientific organizations. Many related disciplines, of course, intersect in the manipulation of landscapes, but within these, we have a wealth of data and skills to create and share habitat with wildlife populations (Rodiek 1986). In particular, we note the talents and interests of our colleagues in the American Society of Landscape Architects, American Institute of Planners and the American Institute of Architects. And we believe that the management applications of wildlife biologists are likewise of growing concern to these sister groups. The relationship between design and management is fundamental to the mutual interests of wildlife biologists and a spectrum of land planners.

Of immediate focus today, however, is a question raised (among others) at the 1983 workshop: How can conventional natural resource management be enhanced through a landscape ecology approach? Quite understandably, our program this afternoon will not fully resolve that and myriad other questions. But it can begin our profession's inquiry into landscape ecology by touching on some issues and case histories wherein we explore Wildlife Habitat by Design.

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Wildlife Habitat by Design: National Forests in the Blue Mountains of Oregon and Washington

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Introduction

Signatures on the Land

Aldo Leopold (1949:68) said the best definition of a conservationist was ". . . written not with a pen but with an axe. It is a matter of what a man thinks about while chopping, or while deciding what to chop. A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of the land. Signatures of course differ, whether written with axe or pen, and this is as it should be."

The USDA Forest Service (FS) is writing its signature on the face of national forests (NF). A landscape much different from today's will emerge—the managed forest of tomorrow. How will the managed forest look? What factors will determine which human desires are satisfied and how well? What of the ecology of this evolving landscape?

The managed forest is being formed primarily by two forces: (1) the elaborate, broad–scale, intensive, land–use planning process mandated by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) and the National Forest Management Act of 1976 (NFMA); and (2) how the legislative and executive branches of government fund the activities outlined. The interactions between these factors form the seminal forces shaping the managed forest.

Considerations for Wildlife Habitats Influence Landscape Design

The forest–management plans will give consideration, ranging from a little to a lot, to wildlife habitat in the design of the managed forest. At minimum, there will be attempts to maintain viable populations of all native wildlife species—this is required by regulation (MacCleery 1982). Habitats of endangered wildlife species will be given attention—this is required by law (Endangered Species Act of 1973). Likely there will be concern for the welfare of selected "indicator species"—probably species hunted or trapped or species dependent on habitat components that could be lost without special management (MacCleery 1982). The emerging landscape on NFs, therefore, will be determined to some extent by managers providing wildlife habitat. In fact, many NFs are well–down that road; those of the Blue Mountains are used here as an example.

The Blue Mountains Experience

Formative Forces

In the 1950s, NF managers' concerns were largely with Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*), and were confined to limiting the size of most timber regeneration units for even–aged timber management to 50 acres (20.2 ha) or less. Attention to wildlife on NFs intensified with a spate of laws in the late 1960s and early 1970s, including The Multiple-Use Sustained Yield Act in 1960, The National Environmental Policy Act of 1969, The Forest and Rangeland Renewable Resources Planning Act of 1974, The Federal Land Policy and Management Act of 1976, and the capstone National Forest Management Act of 1976. By the end of 1976, the times and the requirements of laws demanded and began to produce intensified attention to wildlife habitats as part of forest management (Thomas 1979b).

There is now some 10 years of experience in producing or maintaining wildlife habitats through design of the emerging managed forests on the four NFs in the Blue Mountains of Northeastern Oregon (Malheur, Ochoco, Wallowa–Whitman and Umatilla). The experience includes: developing, testing and modifying criteria for considering wildlife habitat in planning and management; developing techniques to evaluate and prescribe wildlife habitats; evolving technical skills for inventorying and monitoring habitats; and cultivating group dynamics among managers, foresters and wildlife biologists to foster the concept that habitats are a product of managed forests and to apply that concept in forest management.

The NFs of the Blue Mountains were, relative to adjacent or interspersed private lands, largely unexploited for timber prior to 1950. After 1950, more of the timber cut came from NFs, as mature timber on private lands dwindled (Bolsinger and Berger 1975, and USDA Forest Service 1979, *see* Thomas 1979b for a review). Between 1960 and 1975, many people interested in wildlife began to question the adage that "good timber management is good wildlife management." Construction of roads in unroaded areas was initially welcomed as improving access for hunters, but began to be questioned when mule deer populations declined dramatically and no one was certain why. By 1976, there was a perceived need for change in NF management. A quantitative and more–comprehensive approach to defining and meeting wildlife habitat objectives was essential.

Wildlife Habitat Guidelines for Timber Salvage—The Turning Point

FS managers were trying to comprehend and incorporate the requirements of the new laws and regulations when supervisors of NFs in the Blue Mountains faced a management crisis in the full glare of national attention. During 1973–75, a major eruption of the Douglas–fir tussock moth (*Orgyia pseudotsugata*) occurred (Brookes et al. 1978). There was widespread defoliation of Douglas–fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*) and white fir (*Abies concolor*) over much of the Blue Mountains. There was intensive debate over application of DDT to control the outbreak (DDT had been recently banned for such use partially because of suspected adverse impacts on wildlife). DDT was eventually applied on areas where tussock moth populations had not collapsed.

As a consequence of public attention, of the legislation that required consideration of wildlife habitat in NF management, and of the supervisors' interests in wildlife, the forest supervisors and the regional forester were sensitive to impacts of tree harvest on wildlife values. With the end of the tussock moth outbreak, attention shifted to salvaging dead and damaged timber.

The supervisors organized a team of wildlife biologists and other natural resource management professionals from the FS and the Oregon Department of Fish and Wildlife (ODFW), and charged them to develop guidelines to protect or enhance wildlife habitat during the salvage operations. Emphasis was on habitat for deer and elk. The salvage operations were to take place, but with flexibility in how the job would be done.

Within two weeks, the team produced guidelines that influenced how the salvage operations were conducted. There was only dim recognition at the time that managers had expanded what they thought about while chopping to include wildlife or that they were contributing to the signature being inscribed on the developing landscape.

Development of Wildlife Habitat Relationship Packages

Key members of the guidelines team recognized that the concepts developed could be used as a comprehensive approach for evaluating wildlife habitats across a spectrum of timber types and wildlife species. The team dedicated itself to developing such a tool. It became obvious that special habitat features, such as snags and old–growth forest stands, also should receive attention. There still was emphasis on the evaluation of habitats of species featured in management—mule deer and elk in this first effort.

Drafts of later–published techniques for habitat evaluation (Black et al. 1976, Thomas et al. 1976, Hall and Thomas 1979) were first used in 1974 to evaluate and lay out timber sales. A polished and updated version, *Wildlife Habitats in Managed Forests—The Blue Mountains of Oregon and Washington,* was published in 1979 (Thomas 1979a). The information and procedures contained therein have been in a process of updating and revision since that time. These efforts have led to similar documents being prepared for other geographical areas of the United States, such as the Sierra Nevada in California (Verner and Boss 1980), Oregon and Washington west of the Cascades (Brown 1985), the central Rocky Mountains (Hoover and Wills 1984), and other less formally published efforts.

Wildlife Habitat Considerations That Are Shaping Landscapes

Three wildlife habitat criteria that alter developing landscapes have been applied in timber sales on Blue Mountain NFs over the period 1976–86 which have been the primary mechanism in forming the developing forested landscape. The criteria are: (1) Production and maintenance of an array of stand conditions from bare ground to mature forests necessary for maintenance of a diversity of wildlife (retention of old-growth forest stands so distributed as to sustain diversity of plants and animals being the crux of that effort); (2) production and maintenance of standing dead trees (snags) of appropriate size and numbers to provide nesting and roosting habitat for woodpeckers and secondary cavity nesters; and (3) maintenance of a mosaic of stands of appropriate size, structure, and juxtaposition to provide habitat for deer and elk.

Criteria for Evaluating Elk Habitat—The Mark I Model

Of the above criteria, providing elk habitat has had the most impact on the developing landscape and is emphasized here as an example. Evaluation of elk habitat (Black et al. 1976, Thomas et al. 1979) was based on observations that: (1) elk use was highest within 600 feet (183 m) of forest–opening edges and declined as distances increased from the edges into cover and into the opening; (2) elk use of conifer stands 40 feet (12.2 m) or more tall with canopy closure exceeding 70 percent was much greater than the occurrence of such stands; and (3) elk use of habitat was reduced with the presence of roads open to vehicular traffic.

Three habitat components based on vegetative structure were defined. Conifer stands 40 feet (12.2 m) or more tall with 70 percent or more canopy closure were called thermal cover. Vegetation that could hide an elk at 200 feet (61 m) or less was called hiding cover. All natural and manmade openings and areas that did not qualify as thermal or hiding cover were termed forage areas. It was assumed that, in forests managed to produce optimum elk habitat, stands would be arranged so that most cover and forage areas would be 600 to 1,200 feet (183–366 m) in width—i.e., all points within 600 feet (183 m) of a cover–forage area edge. It was further assumed that 10–20 percent of the area would be in thermal cover (Thomas et al. 1979).

Then, curves describing potential elk use as related to ratios of cover and forage areas for a defined management area were developed for each land type from the consensus of consulting biologists (see Figure 1a for an example). Habitat adjacent to roads open to vehicular traffic was used less than habitat distance from roads. The

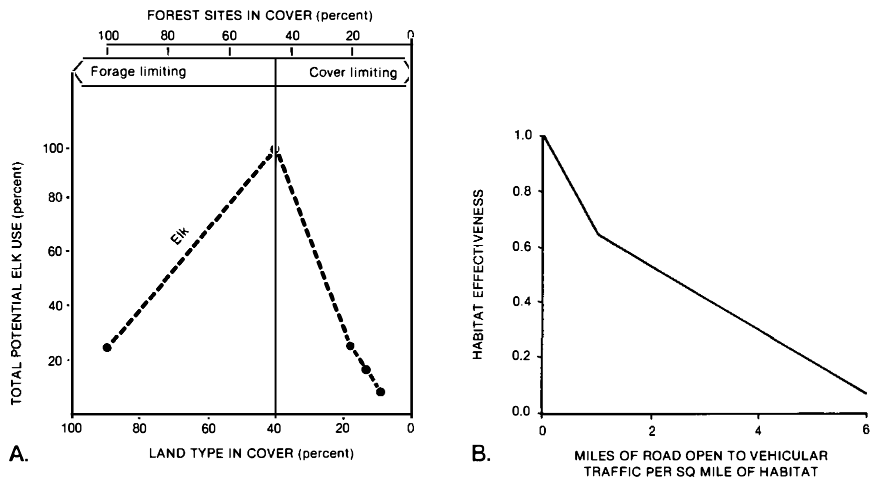


Figure 1. The Mark I habitat effectiveness model assessed elk use of an area from A. proportions of cover and forage, and B. the density of roads open to vehicular traffic.

original model for the impact of roads per square mile on elk use of habitat considered three classes of roads (Thomas et al. 1979). This was modified to use the relationship between density of roads and elk use described by Lyon (1983) (Figure 1b). What became known as the Mark I model to judge elk habitat effectiveness (HE) was derived as follows:

$$HE = (HE_{c/f})\ (HE_r)$$

where:

HE = overall habitat effectiveness for elk

$HE_{c/f}$ = habitat effectiveness score derived form cover/forage area ratios (see Figure 1a) and

HE_r = habitat effectiveness as influenced by road density (see Figure 1b)

The Regional Forester for the FS Pacific Northwest Region and the Director of ODFW formally agreed to use this technique to evaluate elk habitat on NFs of the Blue Mountains.

Research Evaluation of The Mark I HE Model

Research began in 1976 to test assumptions and relationships used to develop the Mark I model. Results indicated that the general relationships used to develop the Mark I model were valid (Leckenby 1984). Further, data specific to elk use of habitat in the Blue Mountains were then available for use to refine the Mark I model. For example, thermal cover stands were used more frequently than predicted by extent. Hiding cover was used less than predicted by extent. Therefore, we concluded that thermal cover was probably more important to elk than was assumed in the Mark I model, and hiding cover was less important. Obviously, a new model should apply these insights into elk use of habitat.

Experience Also Reveals Need for Improvement—The Mark II HE Model

Meanwhile, experience in use of the Mark I model showed that assumptions about appropriate sizing and spacing of cover stands and forage areas were seldom met. The concepts and the model were useful but users needed and began to develop specific ways to deal with sizing and spacing of cover and forage areas. Thus, the Mark II model evolved. It was also difficult to deal with differences in cover quality. Further, timber sales were being laid out faster than biologists could evaluate them, because detailed on–the–ground work and analysis using standard aerial photo interpretation techniques were slow and laborous.

It became obvious that the cumulative effect of silvicultural manipulations had to be measured on elk habitat–management units of 5,000–25,000 acres (2,023–10,117 ha) for which management objectives for HE had been stated. Dealing with one timber sale at a time, and then determining HE scores for a larger management unit which contained those timber sales, produced HE scores for the management unit that were far below objectives, even though each sale might have a satisfactory HE score. This meant that, not only was it necessary to determine habitat effectiveness on each timber sale alternative, it was essential to make simultaneous calculations among alternatives for the management area as a whole, in order to evaluate accumulating effects on HE from all sales.

It was desirable, then, to develop: (1) an improved HE model; (2) a means to quantify cumulative effects of timber sales and silvicultural treatments on HE; and (3) a faster, equally accurate and more-efficient process for doing the analysis through computerized in-place mapping.

The Current Elk Habitat Evaluation Model—Mark III

An improved HE model, the Mark III model (Thomas et al. in press), was developed for use on elk winter ranges. As suggested by research (Leckenby 1984), size and spacing of forage and cover areas were weighted, measured and evaluated directly, without need for assumptions (Figure 2a). The effect of the density of roads open to vehicular traffic on elk use of adjacent habitat was considered as shown in Figure 2b. A cover quality component was added, in which two classes of cover were weighted with elk preference values (Figure 2c). In the case of elk winter range, it was essential to consider the quantity and quality of forage available to elk, because elk usually arrive on winter ranges in late fall or early winter, after forage has ceased growth and domestic livestock have grazed the area. The quantity and quality of forage remaining for elk on October 1 is a measure of HE (Figure 2d). The components of the Mark III model were considered to be compensating to some degree, so the interaction between components was raised to the power of the geometric mean (the n^{th} root, where n is the number of model components), as suggested by the U.S. Fish and Wildlife Service (1981). HE scores for winter ranges were derived as follows:

$$HE = (HE_s \times HE_r \times HE_c \times HE_f)^{1/N}$$

where:

HE = overall habitat effectiveness for elk
HE_s = habitat effectiveness as influenced by sizing and spacing of cover areas and forage areas (Figure 2a)
HE_r = habitat effectiveness as influenced by the density of roads open to vehicular traffic (Figure 2b)
HE_c = habitat effectiveness as influenced by cover quality (Figure 2c) and
HE_f = habitat effectiveness as influenced by the quantity and quality of forage available (Figure 2d)

The team of FS and ODFW biologists recommended that a revised version of this HE model be used to evaluate elk summer ranges (Thomas et al. in press). These biologists did not consider forage quantity to be limiting for elk on Blue Mountain summer ranges; they therefore recommended that the model component for forage evaluation might be deleted from the Mark III model when it is used to evaluate elk summer range habitat. If and when the Mark III model is mutually agreed upon by the FS and ODFW, it will become the "official" means of elk habitat evaluation.

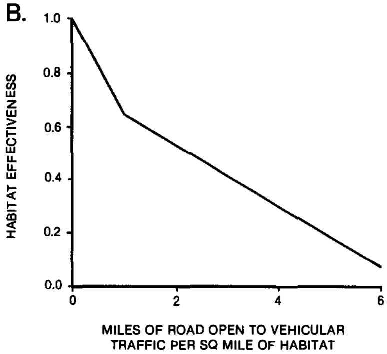
Remote Sensing Techniques Evaluated

The data necessary to determine HE_s (Murray and Leckenby 1985) and HE_c can be obtained through remote sensing techniques involving use of aerial photographic images as well as digital data from satellites (e.g., Landsat). Information on HE_r must be modified by knowledge of which roads are open to vehicular traffic and which are closed. Within the existing constraints of time, personnel, technology and

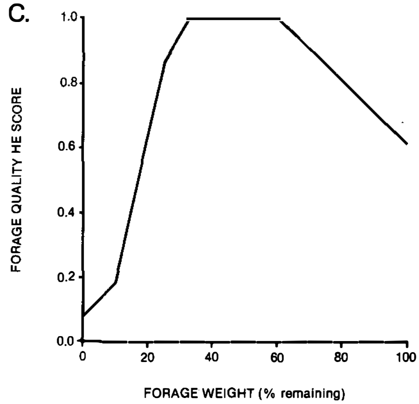
A.

		Distance from Cover-forage area edges (yards)	% of Area	Weight	HE_s
Cover-forage area edge	Cover	>400	2	.005	0.00
		101-400	26	.140	0.04
		1-100	21	1.000	0.21
	Forage Area	1-100	23	1.000	0.23
		101-300	23	.540	0.12
		301-500	5	.140	0.01
		>500	0	.040	0.00

B.



C.



D.

Cover Class	% of Cover	Weight	HE_c
Satisfactory Thermal Cover	60	1.000	0.6
Marginal Thermal Cover	40	.500	0.2

Figure 2. The Mark III habitat effectiveness model included assessment of A. size and spacing of forage and cover areas, B. density of roads to vehicular traffic, C. proportions of two qualities of thermal cover, and D. the interaction of quantity and quality of forage.

money, HE_f must be obtained through on–site inspection. The use of Landsat digital data seems to be the best option for providing data for model components of HE_s and HE_c. Further, data from Landsat can be used to measure habitat changes quantitatively over time and thus to determine cumulative effects of individual timber sales on HE within defined management units.

As part of research done to document patterns of habitat use by elk (Leckenby 1984), multispectral scanner (MSS) data from the Landsat 3, 4 and 5 satellites were analyzed to inventory and monitor changes in 12 million acres (4.856 million ha) of elk habitat (Leckenby 1979, Isaacson et al. 1980, Isaacson and Leckenby 1981, Isaacson et al. 1982, Leckenby et al. 1985) when aerial photo interpretation was found to be far too slow, expensive and labor intensive for practical use.

Computer–processed MSS data provided an acceptably accurate inventory of thermal cover, hiding cover and forage areas. Use of MSS data, then, provided a cost–effective means of inventorying, monitoring and evaluating elk habitat for units of landscape as small as 2 acres (0.8 ha) and as large as a NF.

The MSS system has provided a consistent digital data base that can be updated as often as every 16–18 days. MSS data can be computer processed and displayed in tabular form or as maps registered to U.S. Geological Survey 7.5–minute topographic and orthophotographic quadrangles scaled at 1:24,000. Once the maps of elk habitat components have been produced from the MSS data, most subsequent computer–assisted computations involving HE evaluation are straightforward and amenable to minicomputers, microcomputers and calculators.

Applications

Evaluating and inventorying elk habitat using the previously described techniques are now routine. Continued refinement and increasing application of the Mark III model are expected, as is expanded use of MSS data, and will enable wildlife managers to keep abreast of rapidly changing elk habitat conditions.

Application by Managers

FS resource specialists on the La Grande Ranger District of the Wallowa–Whitman NF first used MSS data to inventory elk habitat and compare proposed harvest alternatives for alteration of HE in the La Grande, Oregon municipal watershed (Leckenby et al. 1985). The area, 21,360 acres (8,644 ha), contained 102 million board feet of lodgepole pine (*Pinus contorta*) infested by mountain pine beetle (*Dendroctonus ponderosae*) and which was to be salvaged. Reliability of the MSS data for identification of elk habitat averaged at least 80 percent. Less than 4 percent of the area mapped with Landsat required adjustment to agree with ground conditions, whereas 9 percent of the field–reconnaissance maps required adjustment. Most adjustments were due to discrepancies in identifying hiding cover. HE was evaluated using the Mark II model for each of the treatment alternatives considered.

MSS data analysis provided insights necessary to stratify eight subwatersheds according to HE. Anticipated cumulative changes in HE for the entire watershed were examined for an array of time schedules for road construction and logging. Adjustments were made in road construction and logging schedules among subwatersheds to provide elk security areas (Lyon 1979, 1980) during active logging periods. These techniques for selection of appropriate schedules for road construction and logging made it possible to achieve timber–harvest objectives while maintaining HE about 20 percent higher than was anticipated using previously standard approaches to analysis. Use of MSS data reduced the time required for deriving HE scores by about 30 percent over that required using the then–standard techniques of aerial photo interpretation and on–the–ground examination. Further, the use of these new projections of changes in HE for alternative actions were more easily understood and accepted by decision makers and other resource specialists. The ability to consider the entire array of projected actions and to determine cumulative effects over the course of the salvage operation pointed out the large differences in HE that were dependent on scheduling of the harvest and silvicultural treatments. For the first time, biologists could demonstrate these differences and have schedules altered appropriately to benefit elk.

The Developing Landscape

Ten years of using the Mark I and Mark II models have made a marked difference in the developing mosaic of vegetation. This is most apparent in (1) areas where foresters and wildlife biologists have designed prescriptions to restore depleted elk habitat, and (2) design of logging operations in previously unlogged areas where one objective was to maintain or enhance elk habitat.

Group dynamics essential to getting evaluation techniques applied in land–use planning and timber sale layout evolved along with technical skills. Those involved in forest management have agreed that elk habitat is a desired product and objective of forest management. They have committed themselves to improvement in the ability to produce both elk and timber from the managed forest, and expressed a willingness to make equitable trade–offs among forest products.

Additional Research Needed

The demand for information and the techniques to describe, integrate and predict trade–offs grow with each successful application of and each improvement in HE model(s). The use of MSS data to evaluate elk habitat has passed the important tests of cost–effectiveness and user acceptance. MSS data are becoming widely used in the design of the emerging managed forest. The technical skills and group dynamics necessary for successful implementation are evolving and improving rapidly. The key ingredients for producing elk habitats by design are being shaped not only by intensive forest land–use planning, but also by an understanding by all concerned that elk habitat is a desirable product of the managed forest.

Evolution of the models and experience with the Mark I, II and III models continue to produce questions that require additional research. The Mark I model assumed, on the basis of general observation, that elk showed disproportionate use of areas near cover/forage edges and of thermal cover stands. Subsequent research statistically confirmed and quantified this preference. As a result, the Mark II model addressed size and spacing more specifically, and the Mark III model later replaced cover/forage ratios with size and spacing and cover quality (Figure 3), using criteria identified and quantified by observing free–ranging elk that could choose among an array of alternatives. The assumption was then made that elk preference was related to some advantage for the animal. There is a tendency, however, for preference to be defined as "need." In the absence of the cover attribute in question, it was assumed, from known physiological responses to microclimates (Parker and Robbins 1984), that there would be an adverse impact on elk welfare. Peek et al. (1982) suggested the need for additional research in this area.

Maintenance of significant acreages of thermal cover are necessary. Producing and maintaining thermal cover exacts high opportunity costs on potential timber production. There are wood products forgone and increased operating costs—particularly during the phase of bringing a previously unmanaged forest into a fully regulated state (Wick and Canutt 1979).

We make no apologies for the Mark I, II and III models, but we think the relationship between preference and need, as it relates to thermal cover, should be the next research effort. Research on that question is in the planning stage.

Another component in the Mark I, II and III models that needs clarification is the relationship between the density of roads open to vehicular traffic and the use that elk make of the area (Perry and Overly 1977, Thomas et al. 1979, Lyon 1983). We suspect that elk use of habitat adjacent to roads is inversely correlated with the amount of traffic per unit of time. Descriptions of such a relationship would be useful in refining the Mark III model and in developing the most–efficient road management program to enhance elk habitat effectiveness. Research on this question is also in the planning stage.

Summary

We have related one example of wildlife habitat by design–of how foresters and wildlife biologists, in meeting the needs of a species featured in management, are influencing the emerging appearance of the managed forest landscape. This required: establishing of management objectives; developing a way to evaluate habitat; being able to apply the evaluation criteria in forest planning and the design and scheduling of silvicultural treatments; conducting research to test hypotheses inherent in the evaluation criteria; adjusting the evaluation criteria as needed; adapting the latest technology to ensure maximum efficiency and compatability with evaluations conducted by other resource specialists; monitoring results to ensure that the developing landscape meets the stated objectives for wildlife habitat; and modifying models and techniques as required.

Up to now, the developing managed forest landscape has been sculpted by silvicultural practices, primarily regeneration cuts, applied timber sale by timber sale. The cumulative effect is a managed landscape molded, to a large extent, by elk habitat considerations. Site–specific applications of the models and techniques described are well–developed. Dealing with the cumulative effects over entire NFs is not so well–developed. We think that the existing technology and evaluation techniques can be used to deal with cumulative effects, and dealing with such effects is the next challenge.

Most of all, this has been a story of what, in terms of wildlife habitat, one group of forest managers "thinks about while chopping or deciding what to chop." It is an ongoing process of developing of models and techniques for application. The cycle never ends, and it should never end. What we use today will be judged primitive by tomorrow's standards. We are on the way, though, and the evolving landscape of the managed forest is being designed much differently than it would otherwise have been.

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Riparian Habitat Classification in the Southwestern United States

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Introduction

Riparian vegetation in the southwestern United States is now receiving considerable attention from state and federal land–management agencies, but this was not always the case. Awareness that riparian habitat was being lost through reclamation projects, recreation use and livestock grazing started to develop during the late fifties and early sixties, when phreatophyte control was a major water–salvaging technique in Arizona. As a result of phreatophyte research, considerable information accumulated on the autecology of saltcedar (*Tamarix pentandra*) (Horton et al. 1960), but very little data were available on the floristics of native riparian plant communities.

Riparian vegetation has been defined as that which occurs in or adjacent to drainageways and/or their floodplains, and is further characterized by different species and/or life forms than that of the immediate surrounding vegetation (Lowe 1961). In the Southwest, one important attribute of riparian vegetation is that it cuts across all biotic formations, from the dry low–elevation deserts, through the pinyon–juniper woodland, to the high–elevation ponderosa pine and moist mixed conifer forests. This longitudinal placement is in contrast to the somewhat–layered altitudinal distribution of plant formations, as characterized by life–zones (Merriam 1890).

Lowe (1961) provided species composition for riparian areas he classified as woodland, but the first quantitative information of a riparian area came from a study on succession of stream channel vegetation on Sycamore Creek in the Mazatzal Mountains (Campbell and Green 1968). The Sycamore Creek study indicated that, at least for some areas, channel vegetation probably never reaches climax because of disturbances from erosion, inundation and soil deposition.

The importance of riparian vegetation to wildlife, especially nongame birds, has been known by birdwatchers for years, but the scientific community was slow to react to a need of land managers for information on plant/animal species composition and abundance in these habitats. The need was not entirely unrecognized, however. Professionals, such as Douglas C. Morrison (USDA Forest Service, deceased) and Dale A. Jones (USDA Forest Service, retired) began to emphasize the need for research. As a result, the Forest Service (Coconino National Forest) financed a two–year study on the impacts of streamside vegetation removal along the Verde River. That same study was continued by the Arizona Game and Fish Department for another three years. Results of the study did more to generate interest in the riparian ecosystem than any other single event. Basically, the Verde River study revealed that riparian habitat supported higher bird population densities than did any other forest habitat type (Carothers et al. 1974). Later, other researchers documented similar results along the Gila (Hubbard 1971), Colorado (Anderson et al. 1977) and the Salt (Johnson and Simpson 1971) river systems.

As awareness of past use and present conditions of riparian vegetation and its associated animal life began to develop, it became obvious that a classification system was needed as a scientific information base for future management. Efforts by the Forest Service to develop a riparian classification system started when the Rocky Mountain Forest and Range Experiment Station included the riparian ecosystem in its research program in 1977. At the first southwestern symposium on riparian habitat (Johnson and Jones 1977), several papers were presented (Pase and Layser 1977, Dick–Peddie and Hubbard 1977) that contained first approximations for a riparian classification scheme. These papers and the pioneering work by Brown and Lowe (1974), which provided nomenclature and a hierarchical digitized scheme, gave the background and emphasis for the present study.

Methods

Riparian plant associations throughout the national forests and adjacent (mainly public) lands of Arizona and New Mexico were examined from 1979 to 1983 on a total of 153 sites (Figure 1). The vegetation sampling technique was a modification of that used by Daubenmire and Daubenmire (1968). Each stand to be analyzed had to have a sufficient area to contain four macroplots of 16.4 by 82 feet (5 by 25 m), with reasonably homogeneous overstory and understory vegetation. Each macroplot was located at random, but was not closer than 16.4 feet (5 m) from an adjacent plot. All plots were located with the long axis, parallel to the stream course. On each macroplot, all trees greater than 1.0 inch (2.5 cm) dbh were measured and recorded. Woody stems under 1.0 inch (2.5 cm) dbh but greater than 3.3 feet (1 m) tall were recorded as saplings. Those under 3.3 feet (1 m) tall were recorded as seedlings. All shrubs were identified and counted.

Twenty microplots (7.8 by 19.7 inches: 20 by 50 cm) were located at 8.2–foot (2.5 m) intervals along the inside long edge of each macroplot. The presence of

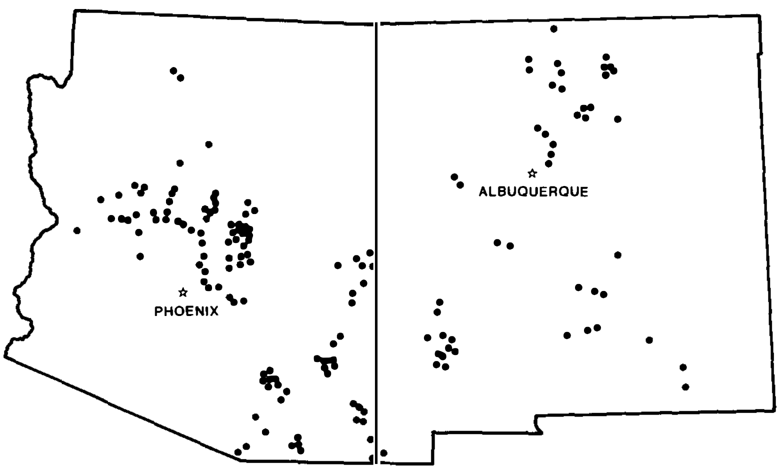

Figure 1. Study sites in Arizona and New Mexico.

perennial herbaceous species in each microplot was recorded. Densiometer readings were taken with a modified densiometer (Lemmon 1959) at each corner of the macroplot, aimed along the plot diagonals. Plant species nomenclature follows Lehr (1978) and Martin and Hutchins (1980).

Stand data were summarized, and importance values (Cottam and Curtis 1956) were determined by strata for the 153 sites. An agglomerative–hierarchical classification method, the unweighted pair–groups method using arithmetic averages, was used to identify clusters of stands (Wishart 1978). Euclidean distance was used as the dissimilarity coefficient in the analysis.

Results and Discussion

The classification of riparian vegetation in the southwestern United States has been complicated by a variety of physical and environmental factors that have contributed to high plant species diversity. Madro–tertiary genera, such as *Celtis, Juglans, Platanus* and *Sapindus* along the Mexican cordillera, are representative of families with strong subtropical affinities. More typically northern genera, such as *Alnus, Salix, Populus* and *Betula,* are examples of the Arcto–tertiary elements that extended southward into the mountains of Arizona and New Mexico during the Pliocene–Pleistocene era. The same hot, dry conditions that isolated the Mexican plateau elements also trapped these genera in moist riparian habitats.

Riparian systems are in a constant state of flux, caused by flooding, scouring, inundation, dessication, grazing or other factors (Minckley and Brown 1982). The critical features of the environment to which riparian plants are adapted are a relatively high soil moisture availability and unstable substrata (Reichenbacher 1984). The gradients created by the stream across its floodplain result in a riparian habitat continuum. High–elevation species often extend into lower elevations within canyons that have cool, moist air drainage (Minckley and Brown 1982). As a result, mosaics of various seral stages with different dominant species characterize riparian plant communities (Campbell and Green 1968).

Further compounding the problem has been the relatively small land areas of most riparian systems. On the 11 national forests in Arizona and New Mexico, riparian areas comprise only 1.3 percent of the total land area (Table 1). Because of the map scales previously used in planning and managing applications, riparian systems have typically been lumped within surrounding vegetation types. And in those cases where riparian types have been studied, each site has been considered independent of other similar sites (Campbell and Dick–Peddie 1964, Haase 1972, Harlan and Dennis 1976, Joyce 1976, Minckley and Clark 1981, Phillips 1975, Toolin et al. 1979).

We are presenting a structural framework of a classification system incorporating community types based on existing vegetation. It will allow managers and/or researchers to make comparisons and management decisions on a statewide or regional basis. Since certain species or combinations of species tend to dominate in any given stand, it is possible to develop a classification based on natural ecological units. An examination of 153 woody riparian sites in Arizona and New Mexico resulted in 31 riparian community types being delineated (Table 2, Figure 2). This is by no means a complete picture of all riparian types in both states, but a starting point to which future workers may add as more sites are studied. Plant species composition and plant densities in each community type are available from the senior author.

Table 1. Estimates of riparian area and percentages by national forest in Arizona and New Mexico.[a]

National forest	Riparian hectares	Percentage of total area within forest boundary	Percentage of previous column in private ownership
Arizona			
Apache–Sitgreaves	12,623	1.5	5.1
Coconino	11,975	1.5	9.4
Coronado	16,074	2.2	4.0
Kaibab	678	0.1	3.0
Prescott	7,948	1.4	11.1
Tonto	18,110	1.5	10.6
New Mexico			
Carson	15,451	2.4	11.8
Cibola	5,642	0.6	20.5
Gila	13,164	1.2	21.2
Lincoln	1,307	0.3	65.3
Santa Fe	12,509	1.8	12.9
Total	115,481	1.3	11.7

[a]Derived from estimates assembled by Russ LaFayette (11/21/84).

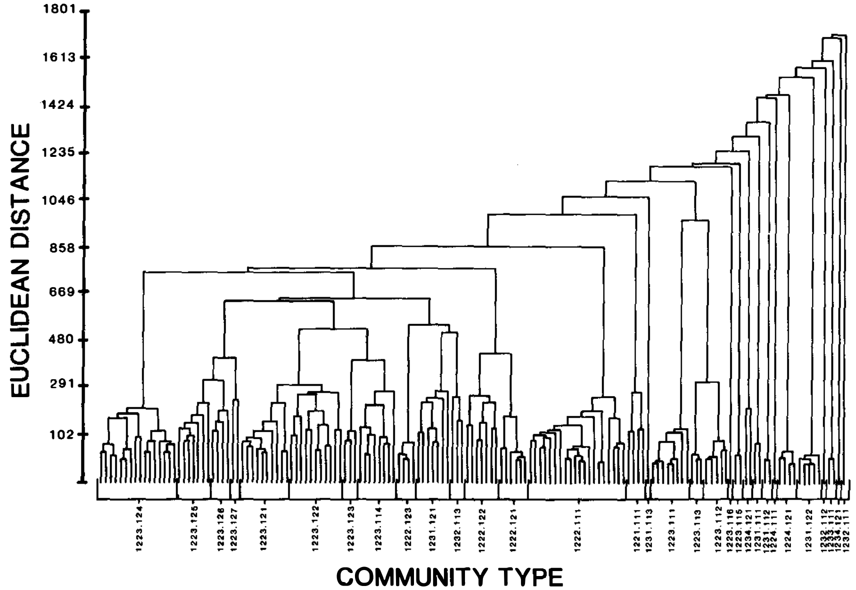

Figure 2. Cluster dendrogram of importance values of riparian trees and shrubs from 153 sites in Arizona and New Mexico. See Table 1 for dominant species in each community.

Table 2. Classification of existing riparian community types in Arizona and New Mexico[a]

1220 **Forest formation**
 1221 Boreal swamp and riparian forests
  1221.1 Southwestern riparian mixed forests
   1221.11 Blue spruce series
    1221.111 *Picea pungens*
 1222 Cold temperate swamp and riparian forests
  1222.1 Intermountain and great plains riparian deciduous forest
   1222.11 Cottonwood-willow series
    1222.111 *Populus angustifolia*
   1222.12 Mixed broadleaf series
    1222.121 *Acer negundo*
    1222.122 *Acer negundo*–mixed deciduous
    1222.123 *Acer grandidentatum*
 1223 Warm temperature swamp and riparian forests
  1223.1 Interior southwestern riparian deciduous forest and woodland
   1223.11 Cottonwood-willow series
    1223.111 *Populus fremontii*
    1223.112 *Salix goodingii*
    1223.113 *Populus fremontii–Salix goodingii*
    1223.114 *Populus fremontii–Fraxinus velutina*–mixed deciduous
    1223.115 *Salix bonplandiana*
    1223.116 *Salix laevigata*
   1223.12 Mixed broadleaf series
    1223.121 *Plantanus wrightii*
    1223.122 *Plantanus wrightii–Fraxinus velutina*–mixed deciduous
    1223.123 *Fraxinus velutina*
    1223.124 *Alnus oblongifolia*
    1223.125 *Juglans major*
    1223.126 *Juglans major–Plantanus wrightii*–mixed deciduous
    1223.127 *Sapindus saponaria–Juglans major*
 1224 Tropical-subtropical swamp, riparian and oasis forests
  1224.1 Sonoran riparian and oasis forests
   1224.11 Palm series
    1224.111 *Washingtonia filifera*
   1224.12 Mesquite series
    1224.121 *Prosopis velutina*
1230 **Swampscrub formation**
 1231 Artic Boreal Swampscrubs
  1231.1 Rocky Mountain alpine and subalpine swamp and riparian scrub
   1231.11 Willow series
    1231.111 *Salix bebbiana*
    1231.112 *Salix geyerania*
    1231.113 *Salix scouleriana*
   1231.12 Alder series
    1231.121 *Alnus tenuifolia*
    1231.122 *Alnus tenuifolia*–mixed deciduous
 1232 Cold temperate swamp and riparian scrub
  1232.1 Rocky Mountain riparian scrub
   1232.11 Willow-dogwood series
    1232.111 *Salix exigua*

Table 2. (*continued*)

1232.112 *Salix lasiandra*
1232.113 *Salix irrorata*–mixed deciduous
1233 Warm temperate swamp and riparian scrub
1233.1 Interior southwestern swamp and riparian scrub
1233.11 Walnut series
1232.111 *Juglans minor*
1234 Tropical-subtropical swamp and riparian scrub
1234.1 Sonoran deciduous swamp and riparian scrub
1234.11 Saltcedar disclimax series
1234.111 *Tamarix pentandra*
1234.12 Mixed scrub series
1234.121 *Hymenoclea monogyra*

[a]Classified using the digitized hierarchical system of North America's natural ecosystems (Brown et al. 1979).

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Habitat Management for Wildlife in Marshes of Great Salt Lake

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Introduction

The marshes surrounding the Great Salt Lake (GSL) are well–known for their rich avifauna (Nelson 1954). Explorers in the 1800s related accounts of "millions" of birds, and market hunters in the 1900s exploited these populations (Williams and Marshall 1938). Not only did the marshes provide vital habitat for breeding shorebirds and waterfowl, but the area was also extremely important for molting and wintering birds. Substantial changes have occurred in the vegetation and wildlife use since the first explorers arrived at the GSL. The purpose of this study is to highlight historical, physical and biological conditions of the GSL marshes, relate recent habitat management schemes to vegetation succession and associated wildlife use, and update wetland conditions with hypotheses concerning the future biotic composition.

Historical Perspective

The GSL is a remnant of glacial Lake Bonneville. The lake became saline as evaporation left behind salt and minerals from the adjacent mountain ranges. Therefore, in order for higher plants to become established, they required a lowering of salinity in the surface soil layers (Smith and Kadlec 1983). Prior to modern development of the area, marsh vegetation was confined to the deltas of freshwater rivers that entered the GSL, primarily the Weber, Bear and Jordan rivers (Figure 1).

The rich avifauna, fluctuating salt water levels, exploitation of freshwater supplies for irrigation (Nelson 1954) and avian botulism (Wetmore 1918) prompted the establishment of refuges and managed waterfowl impoundments. Construction of state GSL management areas started in 1923 with Public Shooting Grounds, Farmington Bay in 1935, and Ogden Bay in 1937 (Figure 1). Bear River Migratory Bird Refuge was the first federal area established, with construction beginning in 1929.

The basic design of each area followed the pattern of spreading freshwater from the rivers over the barren salt flats to reduce the salt content of the sediment and thus promote establishment of aquatic macrophytes. Freshwater was held back by a series of dikes and separated the management units from the GSL. Impounding freshwater reduced the "uncontrolled stagnant anaerobic conditions" that promoted botulism each summer and fall (Provan 1985). Water could be retained in the units during

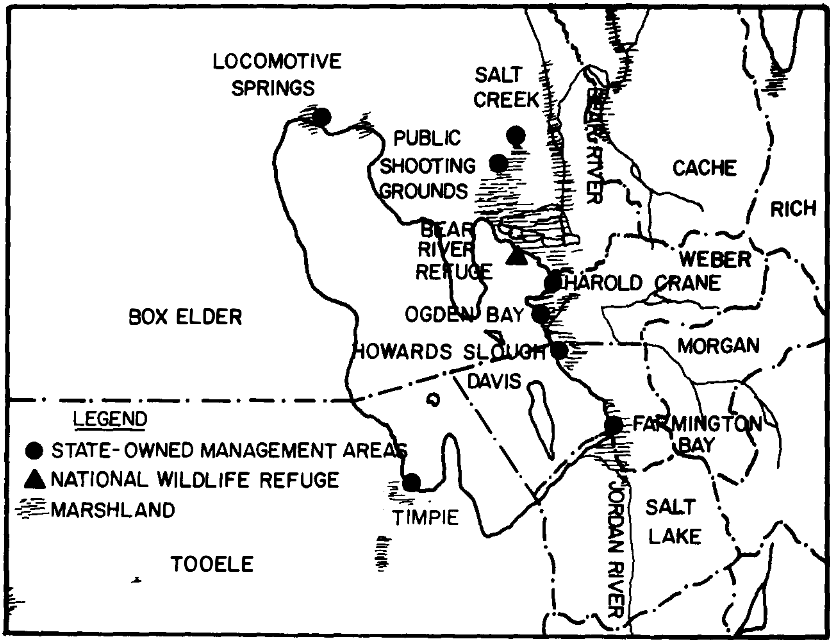

Figure 1. Location of major Great Salt Lake freshwater inflows and managed marshes.

low–supply situations, such as heavy irrigation demands, or allowed to move through with adequate river flows. The units with slightly higher water levels (18–24 inches: 45–60 cm) were dominated by sago pondweed (*Potamogeton pectinatus*), widgeongrass (*Ruppia maritima*), muskgrass (*Chara* spp.), horned pondweed (*Zannichellia palustris*), and curly leaved pondweed (*P. crispus*). These submergent macrophyte sites served as important habitat for molting and migratory waterfowl. The borders of the deeper impoundments and more shallow units were dominated by emergent plant species, primarily salt grass (*Distichlis spicata*), alkali bulrush (*Scirpus maritimus*), cattail (*Typha* spp.) and hardstem bulrush (*S. lacustris*), respectively, as sites proceed from shallow to deep where submergent plants dominated. Although emergent plant communities were important to migratory birds as a direct food source or through associated invertebrate populations (especially alkali bulrush stands), they probably were most important as nesting and brood–rearing sites. Details concerning vegetation of these sites can be found in Williams and Marshall (1938) and Nelson (1954).

After impounded marsh areas were established in the GSL, there were decreases in the losses of waterfowl to botulism and substantial increases in the population of nesting marsh birds (Williams and Marshall 1938, Nelson 1954). For example, nesting bird populations increased by greater than 500 percent after the establishment of Ogden Bay Waterfowl Management Area (Nelson 1954).

Habitat Management Research

Background

After the establishment of managed marshes and maintenance of stable water levels, the initial productivity of preferred plant (e.g., alkali bulrush) and animal life began to decline. Declines in nesting density and nest success were of great concern in the 1960s and 1970s (N. Peabody and N. Nelson personal communication, Michot et al. 1979). As early as 1954, Nelson (1954:76) stated, "Cattail has increased coverage in recent years and crowded out better duck food plants—notably alkali bulrush, wild millet [*Echinochloa crusgalli*], and smartweed [*Polygonum* spp.]. Although not too serious at present, efforts should be made to control cattail expansion." This statement and those made soon after, marked the beginning of efforts to manage some of the GSL marshes on new management schemes to maintain high avian productivity and post-breeding numbers.

Water Requirements and Salinity

Initial research efforts were aimed at marsh water requirements and plant salinity tolerance (for extensive review, see Christiansen and Low 1970). Recently, we conducted a study on the relationships of hydrology, hydraulics, salinity and vegetation in managed waterfowl marshes from 1977 through 1982. Field data consisted of measurements of (a) conductivity and selected chemical parameters of surface and interstitial water, (b) sediment characteristics, (c) vegetation, and (d) water levels and flow rates. Surface water conductivity at Ogden Bay was usually in the range 0.5–1.0 mmhos/cm, with the lowest values associated with spring runoff (May, June). Management operations had little effect on surface water salinity. Interstitial water conductivity is much higher than surface water—sometimes over 100 mmhos. In contrast to tidal salt marshes, sediments in GSL marshes become more saline with increasing depth into the sediment. There is an enormous reserve of salt in the GSL sediment, the depth of which varies with sediment texture and the depth of flow of overlying freshwater. Continuous flooding reduced interstitial water conductivity rapidly in any but totally stagnant conditions. The rate of the decrease varies to some extent with sediment texture but not with surface water–flow rate. Fine–grained silt and clay sediments retain salt, whereas coarser–grained sediments, with a higher sand content, leach more readily. Drawdowns for a whole growing season result in very high soil surface conductivities. However, the accumulated salts are dissolved very rapidly upon reflooding, so that long–term effects on sediment salinity are generally small. Salt concentrations in the surface (3 inches: 7.6 cm) sediments decrease rapidly with even low flows of freshwater, permitting establishment of desirable plants such as alkali bulrush and sago pondweed. However, areas flooded only for part of the growing season and drying at least periodically appear to maintain higher salinities.

To document changes in emergent vegetation that occurred between 1973 and 1983, aerial photographs were analyzed to determine the percentage coverage of vegetation types. A series of 32 study plots were identified where identical boundaries in both photo series could be determined. The data (Table 1) reflect several concurrent phenomena: (1) the effects of management, as illustrated by the increase in alkali bulrush at Ogden Bay; (2) long–term trends such as the increase in hardstem

Table 1. Comparison of percentages of sample areas occupied by various vegetation in Great Salt Lake Marshes in 1973 and 1983.

	Salt Lake County (24 Plots)		Ogden Bay (8 Plots)	
Vegetation types	1973	1983	1973	1983
Alkali bulrush	1.6	1.0	0.2	17.1
Hardstem bulrush	0.8	3.5	3.6	7.5
Reed	0	0	0	8.9
Salt grass	8.0	7.0	17.2	9.5
Cattail	28.8	19.2	50.4	28.4
Total emergent vegetation	39.2	30.6	71.4	71.4
No emergent vegetation	60.8	69.4	28.6	28.6

bulrush; and (3) some recent changes at Ogden Bay, such as the invasion of reed (*Phragmites australis*) and the general decrease in cattails. Note that the Ogden Bay area, with a long history of intensive management, had a far greater percentage of the study plots occupied by emergent vegetation. Part of the remaining area, in both study sites, was water areas with submersed vegetation and part was unvegetated salt flat. A larger fraction of the Salt Lake County plots was in salt flats, reflecting overall less management.

Salinity in the rhizosphere affects the survival and distribution of marsh plants (Bolen 1964, Ungar et al. 1979). Therefore, studies in the recent past were also directed at plant salinity tolerance (Christiansen and Low 1970, Mayer and Low 1970, Teeter 1965). Emergent species studied were alkali bulrush, hardstem bulrush and cattail. The main submergents studied were sago pondweed and widgeongrass. All species showed best germination rates with freshwater (0.25 mmhos). Similar results were also found for plant–growth studies (plants grew best in freshwater), but different species exhibited wider ranges of salinity tolerance, which were reflected by distribution patterns found in the field. Of the species listed above, alkali bulrush was considered by Kaushik (1963) to be most tolerant, then hardstem bulrush, with cattail as least tolerant of salinity. As sediments become less saline, alkali bulrush is replaced by dense stands of cattail.

Our studies indicated such robust emergents as cattail, hardstem bulrush and reed dominated the wetter and less–saline areas of these marshes. Alkali bulrush occupies areas of moderate sediment salinity 10–20 mmhos or even somewhat higher. Salt grass is common in areas that dry periodically and therefore develop very high salinities (> 20 mmhos) in the upper sediment layers. Pickleweed (*Salicornia rubra*) is a very salt–tolerant (> 30 mmhos) annual plant, but is intolerant of growing season inundation. Sago pondweed thrives in shallow water of low salinity, a condition provided almost automatically upon freshwater inundation of sediments near GSL.

Essentially all of the common marsh plants germinate and establish best in fresh conditions, that is, water and/or interstitial water conductivities less than 1 mmhos. However, they vary greatly in their ability to tolerate high salinities. On the basis of the observations in this study and a survey of the literature, we suggest that 18 mmhos/cm interstitial water conductivity is a "rule of thumb" value separating fresh marsh species such as cattail from halophytes such as pickleweed. Conductivities at or above that level give a competitive advantage to the halophytes. Some of the most valuable plants in these marshes, such as alkali bulrush and sago pondweed, seem to be "midsalinity species," favored by salinities high enough to reduce competition from "freshwater species" such as cattail, but not so high as to impair their own vigor seriously.

Disturbance Research

As is being demonstrated in several wetland types, periodic "disturbance" is natural and essential for long–term productivity (in terms of wildlife populations) of managed areas. For example, Weller and Spatcher (1965) noted that periodic drought and high water levels were essential for "hemi–marsh" conditions and diverse abundant avifauna in prairie potholes. Also, Pederson and van der Valk (1984) noted that stable water levels in the Delta Marsh, Manitoba, over the past 20 years resulted in a decrease in plant diversity and an increase in nuisance perennials, such as reed.

Similar situations with declines in productivity of the GSL marshes resulted in research aimed at different types of "vegetation disturbance," such as water level fluctuation. The management problem in the GSL marshes is to maintain intermediate salinity conditions for mature plants and, when needed, provide quite fresh shallow water or wet mud for seed germination. Continuous flooding, over a wide range of water flow rates, freshens sediments and provides the opportunity for seed germination (Smith and Kadlec 1983), but also permits less desirable species such as cattail to become dominant. Once established, even whole–season drawdowns and burning do not have lasting impacts on cattail, hardstem bulrush and reed. Fluctuating water levels within a growing season, with sediment drying and reflooding, seems to maintain high enough salinities to give the competitive edge to alkali bulrush.

Initial studies conducted by Nelson and Dietz (1966) were aimed at disturbance in cattail communities using burning, cutting, flooding and salinity manipulation. They noted that lowering water levels over extended periods increased salinity and killed cattail. Alkali bulrush replaced cattail on those sites. Cattail was also controlled after cutting or burning and prompt reflooding to a sufficient depth. Recent studies on cattail, alkali bulrush, hardstem bulrush and salt grass indicated that cutting and fire produced similar results, in that salt grass could be controlled with water coverage as little as 4 inches (10 cm) (Smith and Kadlec 1985a). However, the remaining species were not affected by shallow flooding and returned to pretreatment levels. Heat penetration was generally insufficient to cause substantial below–ground mortality for any of the species studied. Therefore, it is the water coverage following fire, not the fire itself, that accounted for the control of marsh plants.

Although control of specific GSL marsh plant communities by fire was often limited by insufficient water depths, fire can be used to induce other favorable management situations. Often the vegetation responding on previously burned sites was of higher nutritive quality than was the vegetation prior to fire (Smith et al. 1984). In addition, marsh vertebrates, such as muskrats (*Ondatra zibethica*), and waterfowl grazed vegetation on previously burned sites at a higher intensity than on unburned sites (Smith and Kadlec 1985b). We do not know whether wetland vertebrates selected the vegetation on the basis of its nutritive quality or if some other physical attribute of the area attracted herbivorous wetland vertebrates. Also, herbivorous wetland vertebrates accounted for substantial reductions (Smith and Kadlec 1985b) in total annual production (as much as 50 percent in cattail) on previously burned sites, suggesting some potential for biological control, especially using muskrat and geese populations. Although the specific mechanisms are not entirely clear, vertebrates do select burned sites, vegetative nutritive quality is increased, and vertebrates can cause reductions in the vegetative production of these sites.

After a disturbance on vegetated sites that causes rhizome or vegetative bud mortality (e.g., high salinity), seed banks and/or dispersed seed will then determine subsequent plant response. To understand the consequences of vegetation manipulation, it is necessary to assess the relationship of management impacts (disturbance) on seed reserves and seed dispersal (Smith and Kadlec 1985c). Initial studies of disturbance (e.g., drought, fire) effects on seed banks indicated that seed banks of the GSL marshes were resilient to disturbance. Seed banks were not affected at all by fire and only slightly by drawdown. Obviously, for seed populations of any species in a seed bank, there are three possible effects of disturbance: no impact; an increase; or a depletion of seed reserves.

Drawdowns in freshwater marshes are used to stimulate germination and establish vegetation either for nesting or food resources. During complete drawdowns in the GSL marshes, salinity increases dramatically and inhibits germination of most species; exception were salt cedar (*Tamarix pentandra*), salt grass, and alkali bulrush (Smith and Kadlec 1983, 1985c). Drawdown apparently decreased seed reserves of alkali bulrush and salt grass. Possibly, seeds of these salt–tolerant species germinated under drawdown conditions, and seedlings produced few seeds to replenish seed banks because of salinity stress during the seedling stage (Lieffers and Shay 1982). Salt cedar also germinated during drawdown but not under submersed conditions. Drawdowns of longer than one season permit advanced establishment of salt cedar (e.g., Bear River Migratory Bird Refuge). Salt cedar stands over one year old are very difficult to control.

Studies have also indicated that, in the marshes of the GSL, seed banks from submersed or sparsely vegetated sites contain few seeds when compared to densely vegetated sites (Smith and Kadlec 1983, 1985c). Similar situations have been noted in other marsh ecosystems (Pederson and van der Valk 1984). Sites with sparse seed banks are therefore dependent on seed movement into the area for establishment of emergent or moist soil vegetation. Apparently, most seed continues to move across an area by wind or water until a barrier to dispersal is reached. Therefore, in open water areas or sites devoid of vegetation, a barrier should be constructed to trap seed for vegetation establishment. In an attempt to establish vegetation and improve waterfowl nesting at Bear River National Wildlife Refuge (Figure 1), long soil mounds (contour furrows) were designed (Kadlec and Smith 1984). The seed bank from these sites previously dominated by submersed plants contained few seeds of emergent species. The contour furrows served as barriers and elevated sites of proper soil conditions (salinity, moisture), which permitted emergent seedlings to become established on previously unvegetated sites.

Current and Future Conditions

Because the GSL has no outlet, the level of water in the Lake has undergone great changes in historic times, from a peak of 4,212.8 feet (1,283.7 m) in 1873, to a low

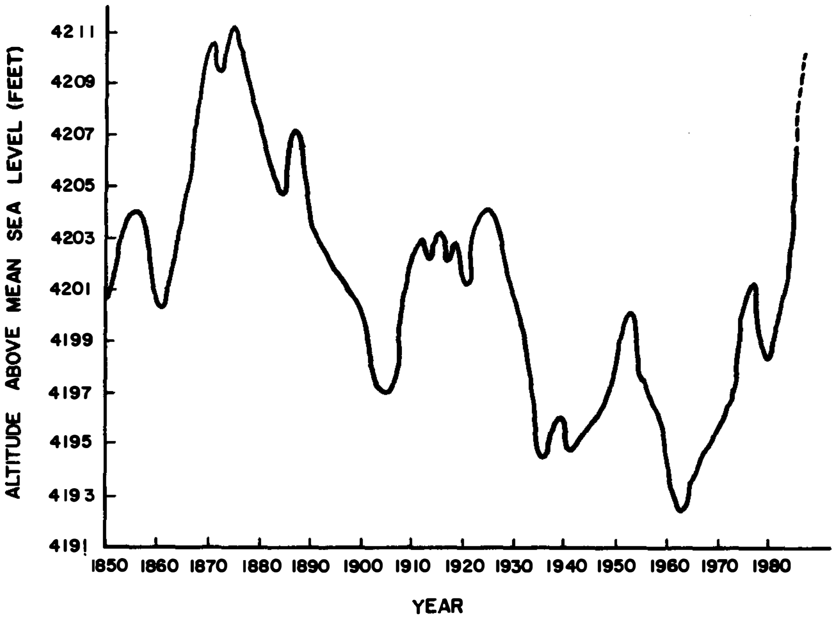

Figure 2. Annual fluctuations in the level of Great Salt Lake.

of 4,191.5 feet (1,277.5 m) in 1963—a total range of 20.3 feet (6.2 m) (Figure 2). Despite these wide fluctuations, a level of about 4,199.1 feet (1,280.2 m) was considered normal in recent years. Beginning in the fall of 1982, however, a series of years with above–normal (record–breaking in three of the last four years) precipitation and, consequently, lower–than–average evaporation has led to a dramatic increase of 9.8 feet plus (3 m) in the water level in GSL to a peak of 4,209.95 feet (1,283.1 m) in 1985 (Figure 3). This has resulted in the loss of approximately 400,000 acres (160,000 ha) of constructed marshes through both depth and salinity of inundation (Provan 1985), and a financial loss of greater than $50 million of marsh–related structures (J. D. Huener, Utah Division of Wildlife Resources, personal communication).

Only a few of the highest areas have escaped destruction. Our recent studies indicated that some macrophytes survived one year of 3 feet (1 m) of flooding by nearly freshwater in areas such as the delta of Bear River. But two or more years of flooding of 3 feet (1 m) or more have resulted in nearly total loss of both above– and below–ground parts of macrophytes, sometimes including seed banks. In shallower areas, subject to less prolonged flooding, there has been some retention of seed banks and below–ground parts of plants such as salt grass and alkali bulrush. Duck production in 1984 dropped by greater than 70 percent and geese declined by 24 percent compared to the previous five–year average (Provan 1985). Overall nongame bird use of the GSL marshes declined by 88 percent—from greater than 100 million to 12 million. In addition, migrating tundra swans (*Cygnus columbianus*) used this area extensively prior to high water levels, but virtually bypass the area now. Invertebrate populations, an essential food supply for many of the birds, have shifted from a

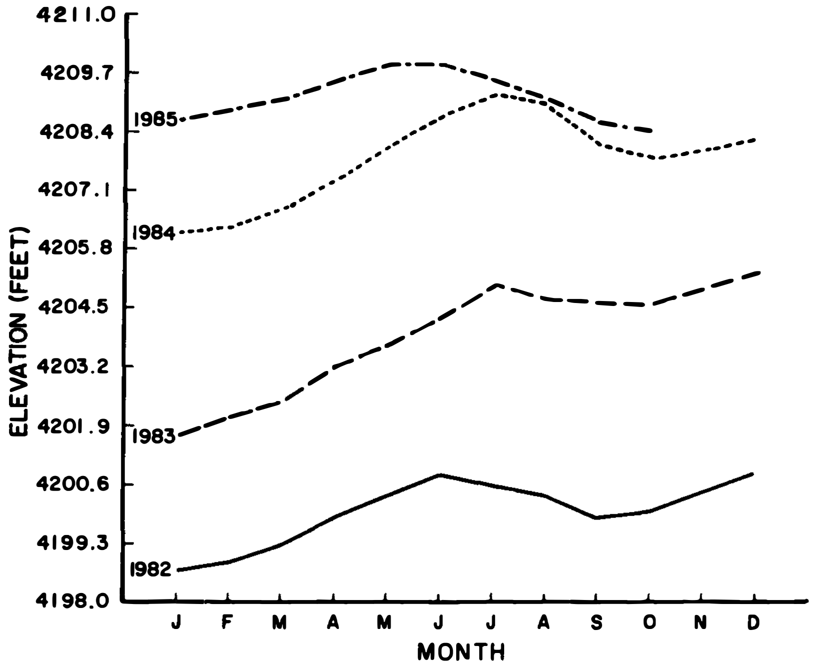

Figure 3. Recent monthly fluctuations in the level of Great Salt Lake.

diverse collection of species dominated by midges (Chironomidae) to only two or three species, although there are locally large numbers of Corixidae.

We believe that, as the GSL recedes, revegetation of the shallower margins will be rapid in areas where freshwater inflows keep salinities down and where surviving seed banks, roots, rhizomes, etc., can respond rapidly. Nearby surviving stands of macrophytes will be sources of seed for recolonization. We expect these two sources to allow a rapid recovery in tributary areas, with the extent and nature of vegetation response controlled primarily by salinity. In deeper areas subject to more prolonged flooding, the substrates are nearly devoid of residual propagules, so that when exposed, plant invasion and establishment will be slower. Again, salinity will be important, with the more salt–tolerant species such as pickleweed, salt grass and alkali bulrush, often being early invaders if a seed source is available. Species with wind–disseminated seed, such as cattail and salt cedar, may be among the first invaders—e.g., salt cedar in more–saline areas, cattail in freshwater areas. The task for marsh managers will be to rebuild dikes and control freshwater inflows so that salinity gradients can be managed to favor desired species. Where seed banks were lost, it may be desirable to resort to seeding of desired species or create barriers to seed dispersal.

Summary

Prior to modern development of the GSL marshes, marsh vegetation was confined to the deltas of freshwater rivers. Rich avifauna, fluctuating salt water levels, exploitation of freshwater supplies for irrigation, and avian botulism prompted establishment of refuges and public and private managed impoundments. The basic design of the GSL managed marshes followed the pattern of spreading freshwater from rivers over salt flats causing a freshening of the substrate and establishment of aquatic macrophytes. Initial productivity of these areas, as measured by waterfowl and wading bird populations, was high. However, with establishment of dikes and maintenance of stable water levels over time, cattail and reed became more abundant, and desired species decreased. Along with this successional change in marsh vegetation, there was a decline in waterfowl production. Declines in waterfowl production, drought, increased irrigation demands and resultant lowered river flows were of great concern in the 1960s and 1970s, and prompted habitat related research. Initial research efforts were aimed at marsh water requirements and salinity tolerance of marsh plants.

Continued low waterfowl production caused a shift in research that emphasized the use of disturbance as a management tool in the GSL marshes. Periodic disturbance is natural and essential for long–term productivity (in terms of wildlife populations) of marshes. Disturbance studies in the GSL were aimed at plant community changes using burning, cutting, flooding and salinity manipulation. After a disturbance that caused rhizome and vegetative propagule mortality in the rhizosphere, seed banks and/or dispersed seed determined subsequent plant response. Therefore, to understand the consequences of vegetation manipulation, it was necessary to study marsh plant life history strategies.

Since 1983, the level of the GSL has risen about 10 feet (3 m), inundating 90 percent of the managed marshes. The historic GSL high water level was 4,212.8 feet (1,283.7 m) in 1873 and recently peaked in the summer of 1985 at 4,209.95 feet (1,283.1 m). This resulted in a loss of 400,000 acres (160,000 ha) of constructed marshes through saltwater coverage and a loss of over $50 million. As lake levels recede and new dikes are constructed, plant succession will be determined by such environmental factors as sediment salinity, survival of seeds and underground plant structures, and dispersal of propagules into marsh areas.

Acknowledgments

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Urban Bird Habitat Relationships: Application to Landscape Design

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Studies over the last 20 years have shed light on the nature of urban environments and the wildlife that they support. Urban avifaunas, at least in eastern North America, are dominated by exotic species that achieve high densities, have comparatively few breeding species, few ground– or cavity–nesting species, few if any insectivorous migrant species, and high densities of seed–eater/omnivorous species (Walcott 1974, Erz 1966). All urban environments are not amenable to the enhancement of wildlife habitat values—city centers and associated intensively built areas are generally beyond the scope of wildlife habitat management. Wildlife habitat is more practically considered in suburban, urban residential and municipal/recreational environments—environments where wildlife habitat needs can be included in landscape design.

Two levels or scales of habitat analysis are considered here: a "fine scale" examination of the vegetation/structure associations of 12 example bird species; and a more broad association of larger landscape features with the breeding bird community as a whole.

Experienced naturalists can list the common bird species that could be expected to occur in a given habitat and, if required to find a given species, they know which habitats to search and can describe the structure of the habitat in general terms. But, identification of the key elements that the bird species perceive as habitat, such that they can be reproduced, is considerably more difficult.

This paper concerns itself with the practical problems of identifying groups of measurable habitat components that likely account for the distribution of birds in suburban and urban residential habitats. There is no biological necessity that the various bird species "select" these components or even perceive them. If these components can be shown to affect the species' distribution, then they are useful in landscape design.

A significant impact of urbanization is the removal, alteration or replacement of most natural vegetation. Urbanization typically changes the local species composition by favoring some native species at the expense of others and by adding a wide variety of exotic species, both intentionally as landscape plantings or unintentionally as "weeds." These activities have profound effects on wildlife, most noticeably birds. The identification of habitat characteristics that are important both to individual species and to the breeding bird community, and their pictorial display such that they are useful in landscape design, are steps toward the maintenance of diverse urban avifaunas.

Eastern North America contains more than 250 species of native land birds; woodlands and forest edges are the natural habitats of most of these species. Much woodland remains, but the trees and shrubs of urban and suburban environments differ from the predevelopment vegetation in several ways: species composition is altered; sterile varieties abound; and most striking, woody plants are sparsely distributed. In most cities and suburbs, trees cover a small fraction of the land surface and, instead of being clumped into naturalistic stands, are frequently scattered over the landscape in "specimen" plantings. This distribution provides to many human residents some of the benefits of forest vegetation—privacy, shade, visual amenities, etc. But this dispersal of vegetation, and thus resources, creates problems for many wildlife species.

Bird Habitat Associations

Even with birds' apparent mobility in the urban/suburban ecosystem, there are two basic sets of factors that determine whether a given species will breed in a given area. Many of the factors that ultimately determine reproductive success are not evident at the time of arrival or of habitat selection. Keys to these "ultimate" factors—for example, insect availability for nestlings—are perceived through psychological or "proximate" factors, usually aspects of the physical habitat, especially vegetation structure, and are generally considered important to many species. Ever since Lack (1933) propounded the idea that birds select breeding habitats by recognizing features that they do not generally require for survival, namely vegetation structure, many studies have been conducted to identify the features or pattern that bird species were "programmed" to seek. Beecher (1942) expressed a similar idea, and suggested that a bird did not "adapt" to a so-called new habitat, but occurred there because it could realize its preconceived perception of its habitat.

Breeding bird species occurring together in a given habitat may not necessarily have similar requirements for combinations of vegetation density and distribution. Bond (1957) showed that a continuum of bird species distribution was related to a forest continuum—the distributions of 25 or 27 species were related to the forest continuum, and the abundance of each species peaked at a different point along the continuum. Bond may have actually measured indirectly the structural vegetation "requirements" of birds and that several species can occur in the same habitat and not respond to the same set of habitat features.

The implied importance of layered vegetation was examined by MacArthur and MacArthur (1961), who demonstrated that the vertical complexity of forest vegetation (the diversity of vegetation heights and density of foliage at those heights) was associated with breeding-bird diversity. In the forest habitats studied, plant species composition was not useful in improving the relationships. Subjected to testing in many habitats, the relationships of bird species diversity to foliage height diversity has been supported in many cases (Karr 1968, Karr and Roth 1971, Willson 1974), but not others (Tomoff 1974).

James (1971), using principal component analyses, reconstructed ordinations of three-dimensional habitat relationships from basic field measurements. Important variables were the number of tree species, percentage canopy cover, number of small trees and canopy height. In forest recreation areas, in which the vegetation is somewhat analogous to that in suburbs, bird species richness was strongly related to canopy diversity—the mixture of conifers and hardwoods was about 12:1 (Hooper et al. 1973). In sum, the basic importance of vegetational layers to birds of forested regions has generally been established.

Horizontal diversity or patchiness is also important to breeding bird composition. Roth (1976) demonstrated that the number of bird species increased faster than the degree of species overlap in a series of habitats from grasslands to forests, and that horizontal habitat heterogeneity was a better predictor of bird species numbers than was vertical habitat heterogeneity.

From these studies, it is obvious that both vertical vegetation structure and patchiness are important to breeding bird communities. How do these concepts then relate to suburban habitats? Suburban habitats, at least in temperate forest regions, have breeding bird communities that are intermediate in species richness. They typically have many more species than urban residential habitats but considerably fewer than rural habitats (DeGraaf and Wentworth 1981). A common result of increased urbanization is a decline in the number of species and a simultaneous increase in total bird density as a relatively few species become very abundant. Habitat availability and complexity are important agents in these changes.

Habitat structure can be considered for individual species to reveal "fine scale" associations. The habitat components that are related to bird species richness—those that would tend to benefit the greatest number of species—can also be identified for suburban habitats.

Habitat Associations of Suburban Bird Species

Habitat relationships reported here are drawn from studies conducted in Amherst, Massachusetts, from 1973 to 1979, and include analyses of both breeding bird species (DeGraaf 1976) of the community as a whole (DeGraaf and Wentworth 1981, DeGraaf 1985, Goldstein et al. 1981, 1983).

The following individual analyses of the habitat associations of 12 bird species all consider vegetation volume in uniform layers. This approach is based on the importance of vertical vegetation structure to birds and the multivariate descriptions of bird habitat associations pioneered by Sturman (1968). Mawson et al. (1977) modified Sturman's equations for the calculation of canopy volumes in order to determine volumes of discrete five-foot (1.5 m) canopy layers. This procedure was modified to calculate canopy volumes in three layers: 0–5 feet (0–1.5 m), 5–15 feet (1.5–4.6 m) and greater than 15 feet (4.6 m). Methods for determining bird species habitat associations are in DeGraaf (1976) and Mawson et al. (1977). Landscape components that were correlated with each species' use of 56 0.5–acre (0.2–ha) plots are shown schematically below. Multivariate analyses of each species habitat associations are shown in Table 1. A key to features in the following species habitat analyses is provided in Figure 1.

Mourning dove (*Zenaida macroura*) occurrence was correlated with lower coniferous tree crown volume from ground level to a height of 15 feet (4.6 m) (Figure 2). Lower deciduous tree crowns were also shown to be important in multiple–regression analyses of mourning dove habitat in the breeding season; deciduous crown volume was approximately three times that of coniferous crowns at the same height. These results agree closely with Lucid's (1974) analysis of the species' suburban habitat in Virginia. Mourning dove occurrence was positively correlated with distance to the nearest woodlot, also in agreement with the birds' preference for open, sparsely wooded sites (Bent 1932:404).

Northern flicker (*Colaptes auratus*) use of suburban habitats is associated with large trees (Figure 3). Cavity trees *per se* were not included in this analysis, but large

Table 1. Ordination (multiple regression) of habitat components associated with breeding birds, Amherst, Massachusetts (DeGraaf 1976).

Species/habitat component	Multiple correlation coefficient	Simple correlation(r)[a]	Significance (F–test)[a]
Mourning dove			
Conifer tree crown vol. 5–10 ft.	.216	.465**	12.117**
Decid. crown vol. 5–10 ft.	.307	.269	5.667*
Decid. tree crown vol. 0–5 ft.	.405	–.045	6.915*
Distance to woodlot	.461	.084	4.280*
Northern flicker			
Conifer tree crown vol. 5–10 ft.	.492	.702**	31.045**
Decid. tree crown vol. 35–40 ft.	.570	.405*	5.573*
Distance to open field	.664	–.027	8.432**
Conifer tree crown vol. 10–15 ft.	.725	.566**	6.421*
Conifer tree crown vol. 20–25 ft.	.774	.593**	6.065*
Blue jay			
Conifer tree crown vol. 5–10 ft.	.317	.563**	23.713**
Decid. tree crown vol. 30–35 ft.	.442	.472**	11.203**
Building density	.490	–.059	4.567*
Lawn area	.563	–.351**	8.052**
Black-capped chickadee			
Conifer tree crown vol. 5–10 ft.	.741	.861**	114.284**
Decid. tree crown vol. 35–40 ft.	.786	.445	8.248**
Decid. tree crown vol. 60–65 ft.	.817	–.013	6.378*
Conifer tree crown vol. 25–30 ft.	.856	.671**	10.029**
Total conifer tree crown vol.	.887	.559**	9.760**
House wren			
Decid. tree crown vol. 20–25 ft.	.158	.397**	7.867**
Weedy vegetation	.277	–.305*	6.781*
Decid. shrub vol.	.350	.381**	4.482*
Brown thrasher			
Decid. tree crown vol. 5–10 ft.	.695	.834**	18.231**
Lawn area	.854	–.649*	7.649*
American robin			
Conifer tree crown vol. 5–10 ft.	.139	.373**	8.715**
Weedy vegetation	.223	–.336*	5.753*
Decid. tree crown vol. 5–10 ft.	.291	.067	4.928*
Cedar waxwing			
Conifer tree crown vol. 60–65 ft.	.399	.631*	7.290*
Decid. tree crown vol. 10–15 ft.	.577	.349	4.231
Weedy vegetation	.668	–.006	2.453
Conifer tree crown vol. 5–10 ft.	.772	.333	3.669
Decid. shrub vol.	.890	.364	7.520*
Red-eyed vireo			
Decid. tree crown vol. 35–40 ft.	.422	.650**	23.396**
Decid. tree crown vol. 60–65 ft.	.5622	.095	9.908**
Conifer tree crown vol. 20–25 ft.	.657	.385*	8.293**
Decid shrub vol.	.705	.593**	4.727*
Scarlet tanager			
Conifer tree crown vol. 30–35 ft.	.695	.833**	36.384**
Conifer tree crown vol. 55–60 ft.	.828	–.050	11.682**

Table 1. (*continued*)

Species/habitat component	Multiple correlation coefficient	Simple correlation(r)[a]	Significance (F–test)[a]
Decid. tree crown vol. 0–5 ft.	.867	.198	4.112
Conifer tree crown vol. 15–20 ft.	.895	.518*	3.461
Total conifer tree crown vol.	.934	.736**	7.179*
Lawn area	.965	−.398	9.428**
Decid. tree crown vol. 70–75 ft.	.978	.288	5.868*
Northern cardinal			
Conifer tree crown vol. 35–40 ft.	.378	.614**	20.620**
Weedy vegetation	.445	.397**	4.017
Decid. shrub vol.	.518	.187	4.848*
Chipping sparrow			
Lawn area	.133	.365*	4.604*
Decid. tree crown vol. 80–85 ft.	.250	.351*	4.516*
Conifer tree crown vol. 0–5 ft.	.369	.220	5.270*

[a]* = P < 0.05, ** = P < 0.01.

stubs or trees with central columns of decayed wood or large dead limbs—at least 12 inches (30.5 cm) in diameter—are required for excavation of the nest cavity. Multivariate analysis reveals the importance of open fields to flickers in suburbs (Table 1).

Blue jay (*Cyanocitta cristata*) breeding habitat use was correlated with deciduous-tree crown volume—both total crown volume and especially the layer at 20–45 feet (6.1–13.7 m) above the ground. Coniferous tree crown volume from ground level to

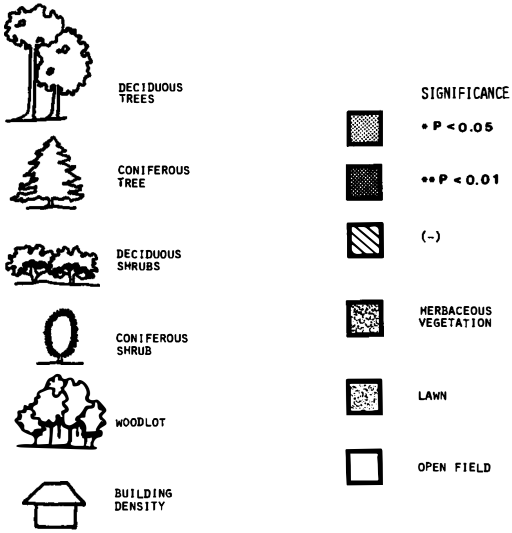

Figure 1. Key to habitat components used in schematics of suburban breeding bird habitat associations.

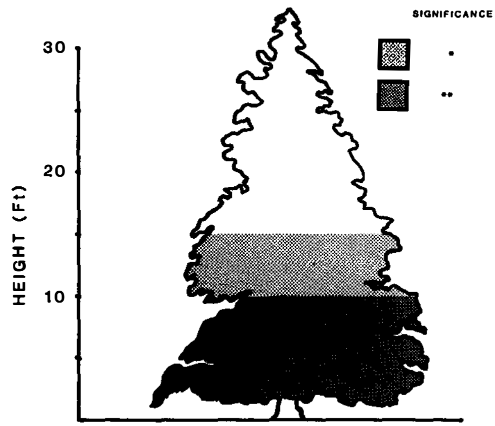

Figure 2. Schematic of breeding habitat for mourning dove.

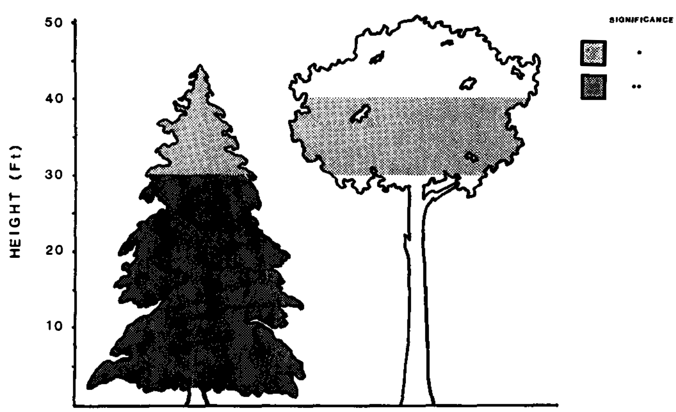

Figure 3. Schematic of breeding habitat for northern flicker.

a height of 35 feet (10.7 m) was important to blue jays, but the species' occurrence was inversely related to lawn area (Figure 4). This association with mixed, large suburban tree cover also has been observed in Virginia (Lucid 1974) and West Virginia (Goetz 1975). In the multiple–regression analysis, blue jay occurrence was shown to be inversely related to building density. Secretive during the breeding season, blue jays in suburban habitats prefer mixed tree cover with conifers in the lower canopy, small lawns and relatively low housing density.

Black-capped chickadees (*Parus atricapillus*) have breeding habitat associations similar to those of blue jays—mixed tree crown volumes and a small lawn area. In addition, black–capped chickadees show an affinity for woodlots, indicated by a negative correlation with distance to the nearest woodlot (Figure 5). Chickadees are cavity nesters, using either natural cavities or excavating nest holes in rotted stubs. Dead or dying trees should be retained where possible in suburban landscapes.

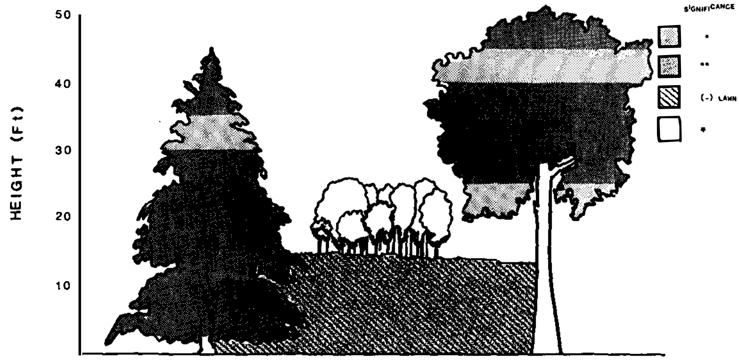

Figure 4. Schematic of breeding habitat for blue jay.

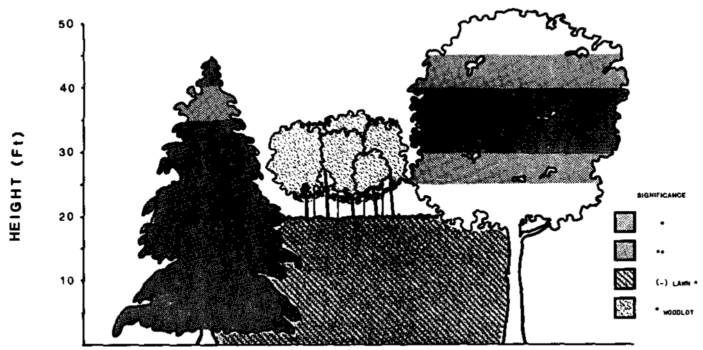

Figure 5. Schematic of breeding habitat for black–capped chickadee.

House wren (*Troglodytes aedon*) breeding habitat use was correlated with deciduous tree cover of midstory height and deciduous shrub volume (Figure 6). Hole nesters, house wrens use a variety of nest sites and habitats.(Stewart and Robbins 1953:231). In multiple–regression analysis, house wrens were shown to be associated negatively with tall herbaceous ("weedy") vegetation (Table 1).

Brown thrasher (*Toxostoma rufum*) suburban breeding habitat included a low–to–midstory deciduous tree canopy and a negative association with lawn area (Figure 7).

American robins (*Turdus migratorius*) occurred on all census plots, and their abundance was correlated with conifer crown volumes from ground level to 25 feet (7.6 m). Robins were negatively associated with tall weedy vegetation (Figure 8). Robins are typical in most temperate suburbs, and others have reported associations similar to those reported here (Lucid 1974, Thomas et al. 1976). Suburbs with lawn and shade trees appear to provide ideal robin habitat (Howell 1942). An adaptable species, the robin attempts to nest in many environments or habitats. Robin nesting success has been reported to be greater in suburban than in rural habitats (Klimstra and Stieglitz 1957) and low in urban residential habitats where, although the habitat appeared to be ideally composed of lawns and shade trees, predation from cats and

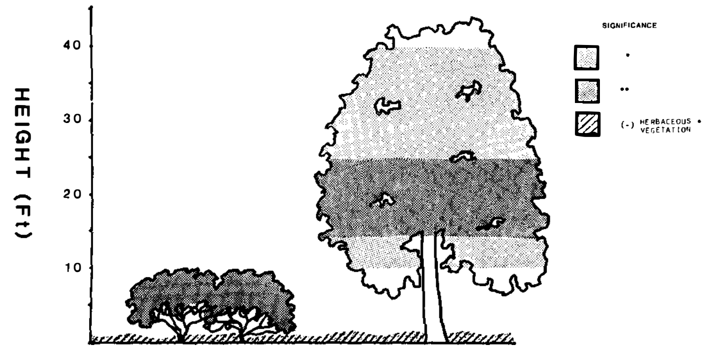

Figure 6. Schematic of breeding habitat for house wren.

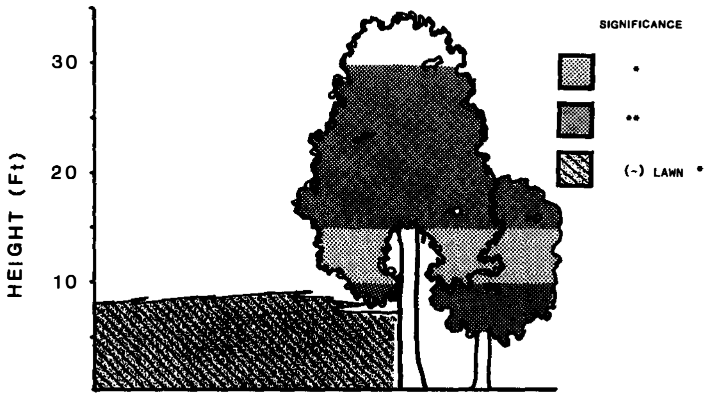

Figure 7. Schematic of breeding habitat for brown thrasher.

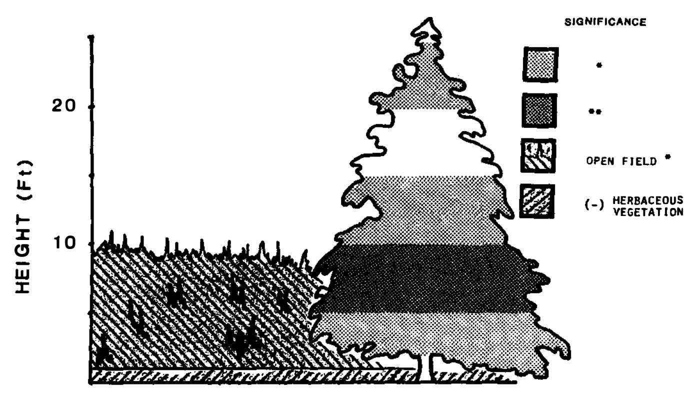

Figure 8. Schematic of breeding habitat for American robin.

crows rendered urban residential robin populations dependent on recruitment from more secure wooded habitats (Howard 1974). Early nests of robins are usually built in conifers, before hardwoods leaf out.

Cedar waxwing (*Bombycilla cedrorum*) breeding habitat use was associated with tall trees—both hardwoods and conifers—and open fields (Figure 9). These suburban habitat descriptions reflect those of the bird in natural environment—northern coniferous forests (McElroy 1974:63) and farther south, in orchards or lightly wooded country (Davison 1967:146). The bird nests in mixed shrubs and small trees.

Red-eyed vireo (*Vireo olivaceus*) suburban breeding habitat was primarily associated with tall deciduous trees—certainly in accordance with its wide distribution throughout the eastern deciduous forest. This species was also positively correlated with distance to the nearest five buildings, probably reflecting a preference for more natural or forested habitats (Figure 10).

Scarlet tanager (*Piranga olivacea*) breeding habitat was associated with mixed tall tree cover (Figure 11). In the multivariate analysis, a negative association with lawn area was shown (Table 1).

Northern cardinals (*Cardinalis cardinalis*) in suburban breeding habitats were correlated with upper deciduous–tree crowns, all coniferous tree crown layers and weedy vegetation (Figure 12). In multiple–regression analysis, deciduous shrub volume was also shown to be important. Cardinals need tall song perches, and nest in conifers or low thick tangles (Woolfendon and Rohwer 1968).

Chipping sparrow (*Spizella passerina*) occurrence in suburbs was correlated with two habitat components: lawn area and tall deciduous tree crown volume (Figure 13). Chipping sparrows occupy quite open or structurally simple habitats—elevated song perches and low, thick coniferous cover for nesting. Results of multiple–regression analysis showed this association with conifers (Table 1).

These examples serve to show the specificity that birds have for breeding habitat structure. These relationships do not need to be known for each potential breeding

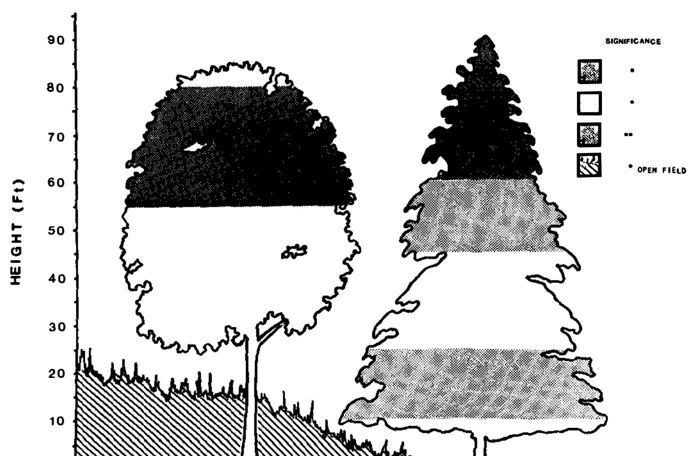

Figure 9. Schematic of breeding habitat for cedar waxwing.

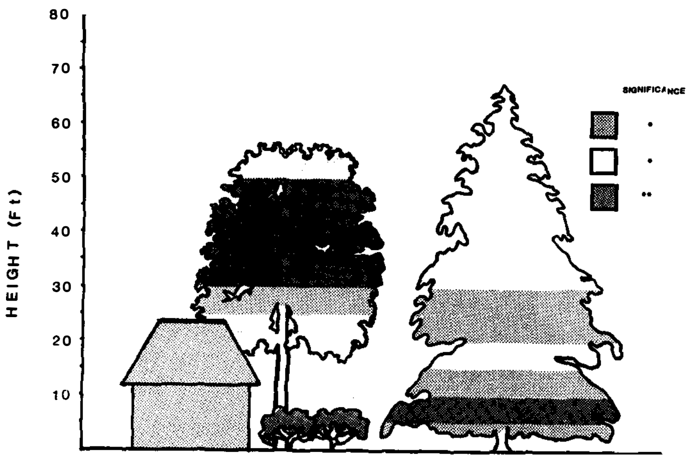

Figure 10. Schematic of breeding habitat for red–eyed vireo.

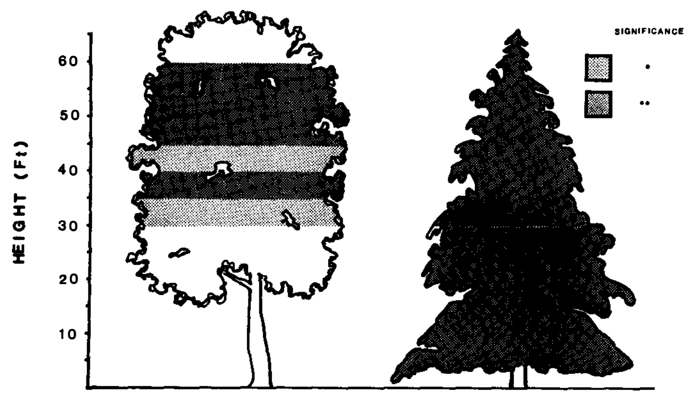

Figure 11. Schematic of breeding habitat for scarlet tanager.

species; vertical complexity of the foliage will provide the structure needed by a variety of species. The habitat features or components that were associated with 23 breeding birds in suburbs are shown in Table 2. When each species' habitat associations were analyzed separately, discrete layers of tree crown foliage or volume that were important to each were revealed. This technique is a useful way to examine the "fine structure" to which these birds respond when selecting their breeding habitats.

Habitat Associations of Urban/Suburban Avifaunas

Obviously, landscapes are not designed to produce vegetation that is distributed in discrete layers at specified heights. Plant materials are selected for a variety of reasons—form, texture, etc.—and their ultimate height is generally known. Bird species that realize their habitat image or proximate factors will attempt to reside within the landscape.

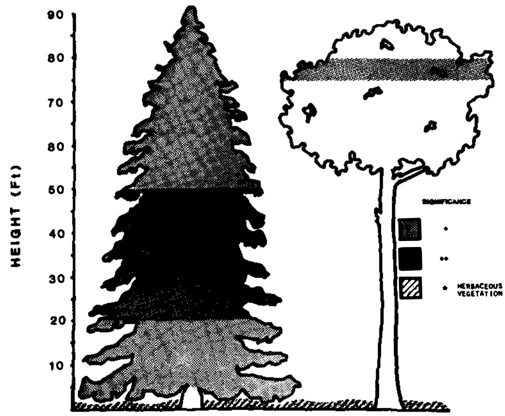

Figure 12. Schematic of breeding habitat for northern cardinal.

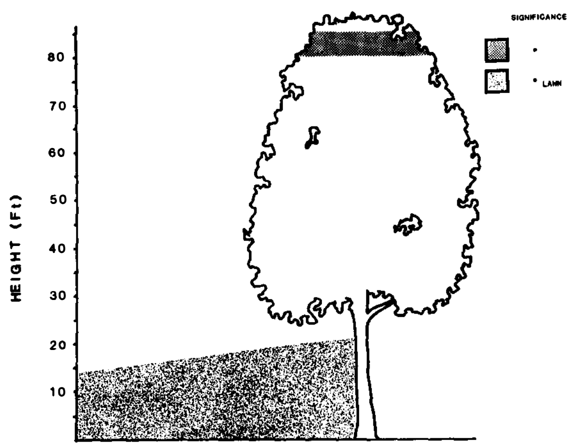

Figure 13. Schematic of breeding habitat for chipping sparrow.

When the bird species richness (the total number of species) of a given habitat is analyzed in view of habitat components, discrete layers of foliage volume do not appear to be important in suburban environments. Relationships have been demonstrated for forested habitats, where the foliage is arranged more or less in a continuum vertically and where tree crowns abut or branches overlap horizontally. But in suburban landscapes, most trees are dispersed as specimens. Thus, other measures of the landscape become important to the breeding bird community. The nearer a woodlot and open field, the smaller the lawn area, the more "weedy" vegetation is permitted, and the lower the building density, the greater the variety of the suburban breeding bird community (Table 3).

Breeding birds have been considered in functional units or guilds (Root 1967) to examine their distribution in suburbs. All insectivorous guilds except air screeners

Table 2. Correlation of habitat components and breeding bird densities in Amherst, Massachusetts.

	Deciduous tree				Coniferous tree										
	Crown height[a]			Vol.	Crown height[a]			Vol.	Shrub volume		Area		Nearness		Building density
Species	0–15	15–30	30+		0–15	15–30	30+		Deciduous	Coniferous	Lawn	Weedy	Field	Woodlot	
Mourning dove					+										
Northern flicker			+		+	+	+								
Eastern phoebe	+										–				
Eastern kingbird									+					+	
Blue jay			+		+	+					–			+	
Black–capped chickadee			+		+	+		+						+	
Tufted titmouse					+	+									
White–breasted nuthatch					+	+	+	+							
House wren		+							+			–			
Wood thrush			+		+	+								+	–
American robin					+							–	+		
Gray catbird									+						
Brown thrasher	+	+							+		–				
Cedar waxwing					+	+	+								
Red–eyed vireo			+			+			+						+
American redstart	+	+	+												
Scarlet tanager	+	+	+				+								
Northern cardinal			+			+	+					+			
Rufous–sided towhee			+												
Chipping sparrow			+								+				
Song sparrow		–		–											
American goldfinch			+			+			+		–	+			
House sparrow			+									–			

[a]In feet.

were associated with tree features, and most show an affinity for woodlot nearness (DeGraaf and Wentworth 1981). Woodlots are common in most suburbs, and likely account for the presence of bark gleaners and excavators there. Urban residential environments are poorly represented by insectivores.

So, two levels of concern or scale are involved when designing landscapes that will provide habitat for birds: (1) the planted component; and (2) the reserved or relict woodlot. A fairly large literature exists on the values of individual plants and their arrangement to attract birds, at least for residential grounds (Terres 1968, Davison 1967, Martin et al. 1951, DeGraaf and Witman 1979). The arrangement of plants that provide fruits and seeds, secure nest sites, and escape or protective cover can indeed attract many locally occurring species. A greater variety of birds can be maintained in the landscape as a whole if woods and fields—elements of the pre-existing landscape—can be retained.

Within woodlots, there are factors that affect birds, but size appears to be the characteristic most important to the breeding bird community (Figure 14). Based on this relationship, designs have been proposed for hypothetical small– (Goldstein et al. 1981) and medium–scale (Goldstein et al. 1983) residential developments that maximize the patch size of woody vegetation, theoretically to maximize the variety of the bird community.

Not all suburbs or residential cluster developments are built in landscapes that are mosaics of woodlots and open country. Does suburban development built in woodland, with minimal clearing for houses, have a high number of breeding bird species? The answer is essentially only among insectivores and cavity nesters (DeGraaf and Wentworth in press). Planted trees, no matter how mature or abundant, evidently do not replace natural forest stands as breeding habitat for insectivorous birds. Edge species will probably continue to thrive in suburbs, but for insectivorous migrant species, which have been used as measures of avifaunal quality (Walcott 1974), natural woodland must be retained where possible.

In the foregoing discussion, urban residential and suburban habitats have been considered together. Actually two characteristics of their respective trees are quite different. For a variety of reasons, urban residential environs do not contain trees in the larger size classes (Figure 15), and their crown bases are higher than those in suburbs (Figure 16). Both characteristics are important to the avifaunas that they support (DeGraaf 1985).

An important habitat consideration in urban/suburban environments is attractiveness or visual quality. Is bird species richness related to visual quality or scenic

Table 3. Correlation of breeding bird species richness and suburban landscape features in Amherst, Massachusetts.

Landscape feature	Simple correlation (r)	Significance[a]
Distance to woodlot	–	**
Distance to open field	–	*
Area of tall weedy vegetation	+	*
Area in lawn	–	*
Building density	–	*

[a]* = $P < 0.05$, ** = $P < 0.01$.

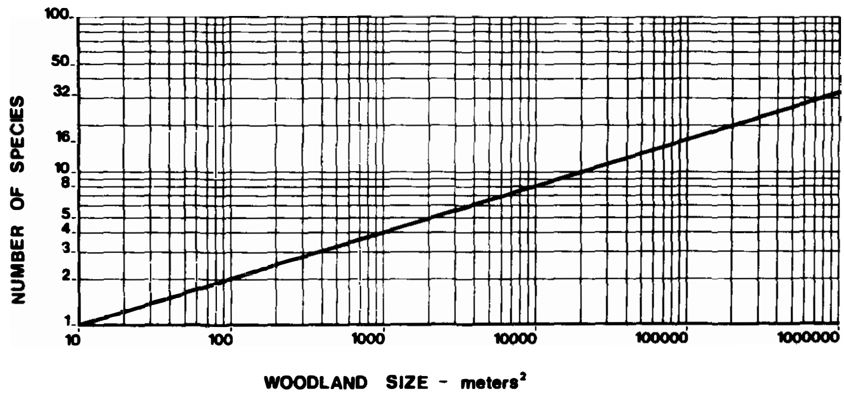

Figure 14. Theoretical maximum numbers of breeding birds in woodlots of different sizes (after Moore and Hooper 1975).

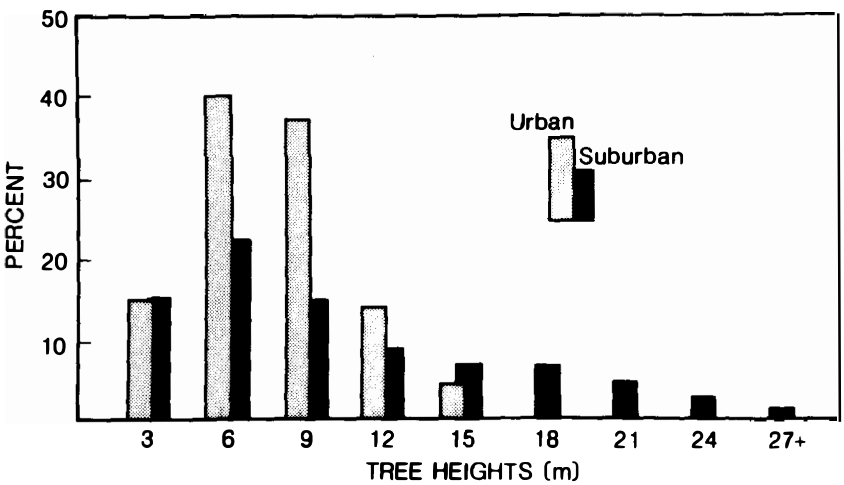

Figure 15. Distribution of the tree heights in urban Springfield and suburban Amherst, Massachusetts.

resource value? In a sample of 20 forest stands—ranging from open, regenerating hardwoods to closed–canopy woodlands—whose scenic qualities had been rated by Q–sort, I found no relationship between the number of breeding bird species and scenic resource value scores; views and bird censuses were restricted to the foreground by surrounding forest vegetation.

But, when bird censuses were conducted on 77 sites where landscape foreground, midview and background were visible in visually rated Massachusetts landscapes, correlation of breeding bird species richness with elements of six landscape dimensions were found. In the landform dimension, the number of breeding bird species was related to relative relief and mean elevation. In the land–use dimension, naturalism index (a measure of site naturalness) and percentage tree cover were strongly

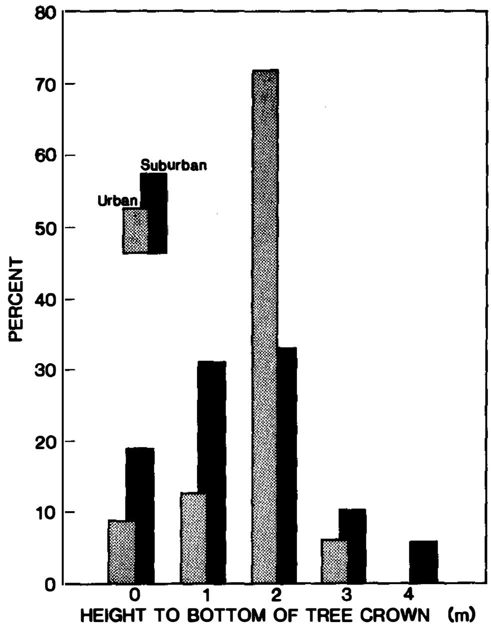

Figure 16. Crown positions of trees in urban Springfield and suburban Amherst, Massachusetts.

correlated with breeding bird species. In the land–use edge dimension, (a measure of the number of different land uses in view), land–use compatibility (visual congruence of adjacent land uses) was similarly correlated. In the land–use contrast dimension, both spacing contrast and grain (size of elements) contrast were negatively related to breeding bird species richness. Water area was negatively correlated, and area of view positively related to bird species richness (DeGraaf et al. 1976). These preliminary relationships suggest that retention of landscape features, as measured by the naturalism index and percentage tree cover, and approximately equal proportions (in the viewed landscape) of compatible land uses, produces the greatest variety of bird species, while juxtaposition of many small patches of contrasting land uses—as measured by spacing and grain contrast—has the opposite effect.

These relationships need to be studied further in other regions. If significant associations exist between scenic value and bird habitat quality, and if they can be convincingly documented, critical landscape elements can be retained or rearranged in landscape design.

Conclusions

The general effects of urbanization on breeding birds are fairly well known: edge species fare well, and forest species generally decline; overall densities rise as the avifauna is dominated by a relatively few abundant (often exotic) species. Insectivores, cavity– and ground–nesters also decline. These general effects can likely be offset in urban residential and suburban environs if avian habitat needs are considered in landscape design. Literature to document the importance of vegetation structure and related habitat components to breeding bird species is provided. Examples of the habitat components that are important to 12 breeding birds in suburbs are presented to show the range of factors involved.

Individual species habitat analyses, while they show "fine scale" habitat perception, are not in themselves useful to enhance or maintain a diverse urban/suburban avifauna. Landscape features such as woodlots—the bigger the better—open fields, relatively small lawn area and low building density are important to high bird species richness. The overall landscape must support a rich avifauna from which to attract the greatest variety (or selected species) to smaller sites.

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Design Considerations for Wildlife in Urban Stormwater Management

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Introduction

The burgeoning worldwide human population is increasing stress on the earth's land and water resources. Therefore, continued improvement in the management of natural resources is imperative to maintain habitat quality for both humans and wildlife. Water resources are especially important, because all life processes depend on good water quality and quantity.

Conservationists and others are concerned about the continuing loss of wetland habitat in the United States and elsewhere. Estimates indicate that the U.S. had about 215 million acres (87 million ha) of wetlands at the time of colonial settlement. Less than half that amount remains today. Between the mid-1950s and the mid-1970s, annual wetland losses averaged 458,000 acres (185,490 ha) (Tiner 1984). Agricultural development involving drainage was responsible for 87 percent of those losses, while urban and other development caused 8 percent and 5 percent of the losses, respectively. These losses are tragic because wetlands have many benefits. Acre for acre, they are the most productive habitats for wildlife. They help to control floods and erosion, purify water, recharge groundwater supplies, and they have recreational and aesthetic values.

On a more positive note, Tiner (1984) reported that two wetland types—inland flats and ponds—experienced gains between the mid-1950s and mid–1970s. Two hundred thousand acres (81,000 ha) of unvegetated wetland flats and 2.1 million acres (850,500 ha) of ponds were created. Pond acreage nearly doubled from 2.3 million acres (931,500 ha) to 4.4 million acres (1.8 million ha), primarily due to farm pond construction in the Central and Mississippi flyways. Most of the pond acreage came from former uplands, although 145,000 acres (58,725 ha) of forested wetlands and 385,000 acres (155,925 ha) of emergent wetlands were changed to open water.

When land is cleared for development, the resulting buildings, pavement and loss of vegetation reduce the ground's natural storage capacity for water. Thus, after a heavy rainstorm, more water will flow quickly into nearby waterways. If uncontrolled, this "stormwater runoff" can lead to increased downstream flooding and pollution, diminished groundwater supplies, increased erosion and sedimentation, extensive alteration of stream channels, and damage to aquatic wildlife or wildlife habitat.

Engineers and planners have widely used two basic structural designs in recent years to control runoff from urban developments. Detention basins have been constructed to slow runoff from developed sites during and immediately following major storm events. And retention ponds (and lakes) have been constructed for the same purpose. Retention ponds differ from detention basins in that the former maintain permanent–water pools. In addition to retention ponds, there is growing interest in the use of marshes and other wetlands, both natural and manmade for controlling urban runoff. However, the design of manmade urban impoundments for multipurpose stormwater control and *wetland wildlife enhancement* has received little attention. The purpose of this paper is to explore the potential for creating wetland wildlife habitat in urban and urbanizing areas, in connection with modern stormwater–management practices and to discuss the importance of urban stormwater control to regional watershed management.

Facility Design and Wildlife Use

In 1982, the National Institute for Urban Wildlife initiated a study of wildlife use of different stormwater–control facility designs and the design features particularly beneficial to wildlife in the developing city of Columbia, Maryland. Thirty-four stormwater–control facilities were studied, including nine detention basins, 22 retention ponds and three lakes. Data were collected on a variety of wildlife species using these areas, including amphibians, reptiles, birds and mammals.

The Institute's investigation of wildlife use of urban stormwater–control facilities was expanded in 1984–85 through a study of waterbird use of a manmade wetland system constructed in Coyote Hills Regional Park, Alameda County, Fremont, California. The research/demonstration facility was developed by the Oakland–based Association of Bay Area Governments to evaluate its potential for water quality enhancement. The system is approximately 40 acres (16 ha), featuring three distinct but contiguous subsystems. These consist of ponds in various configurations, overland flow with considerable shallow water and mudflat areas, and restricted and unrestricted channels. Waterfowl and other waterbird use of the facility was monitored from January 1984 through June 1985 and compared with bird use of a control marsh also located within Coyote Hills.

Birds

In the Columbia study, bird use of retention impoundments—shallow ponds, deep ponds and lakes—was more extensive than use of detention basins. In addition to numerous songbirds recorded around the edges of permanent–water impoundments, 32 species of waterfowl and related species, marsh birds, shorebirds, swallows and swifts were observed.

Breeding waterfowl in Columbia preferred (on a per–acre basis) smaller retention ponds to lakes. Except for one pair of Canada geese (*Branta canadensis*), one wood duck (*Aix sponsa*) brood and a pair of introduced mute swans (*Cygnus olor*), the only waterfowl species recorded breeding in Columbia was the mallard (*Anas platyrhynchos*).

Use of shallow ponds (average depth 2.3 feet or 0.7 m, with gently sloped sides) by breeding pairs of mallards was about 2.4 times greater than use of deep ponds (average depth 6.8 feet or 2.1 m, with steep side slopes) and about 3.2 times greater than use of lakes (Adams et al. 1985a). Also, mallard broods preferred shallow ponds to deep ponds and lakes. Shallow ponds provided better feeding sites and cover than did deep ponds, and the former more closely resembled shallow–water marsh habitat of natural wetlands. Almost 80 percent of the shallow ponds contained sediment bars at stream inlet channels. Mallards made extensive use of the mudflats and shallow–water edges associated with these sediment deposits. Only 15 percent of the deep ponds had sediment bars extending above the water surface.

Unlike during the breeding season, when waterfowl use was heaviest on Columbia's ponds, migrating waterfowl concentrated on the lakes. The large water surface areas of Columbia's three lakes attracted numerous waterfowl and related species, with the mallard dominating. Mallards made up almost 90 percent of the total observations. However, a variety of other species (16 recorded) also used the lakes as resting and feeding sites during this time period. Most notable of the species wintering in the area, or those using the lakes as stop–over sites during migration, were Canada geese, blue–winged teal (*Anas discors*), ring–necked ducks (*Aythya collaris*), canvasbacks (*Aythya valisineria*) and lesser scaup (*Aythya affinis*). All species were observed resting and feeding in the lakes. We believe Columbia's lakes are most attractive to waterfowl and related species during the winter and migratory seasons.

The impoundment features described above also were considered important for the recorded greater use of shallow ponds by other wetland birds (Adams et al. 1985b). In addition to waterfowl and related species, other wetland birds recorded using permanent–water impoundments in Columbia were: great blue (*Ardea herodias*) and green–backed (*Butorides striatus*) herons; killdeer (*Charadrius vociferus*); common snipe (*Capella gallinago*); spotted (*Actitis macularia*), solitary (*Tringa solitaria*) and least (*Calidris minutilla*) sandpipers; yellowlegs (*Tringa* spp.); and red-winged blackbirds (*Agelaius phoeniceus*). During migration, these species preferred shallow ponds to deep ponds by more than 3:1; shallow ponds were preferred to lakes by more than 46:1. A similar preference was shown for shallow ponds during the breeding season.

Waterbird use of the manmade wetland system at Coyote Hills, California, was similar to waterbird use of the control site (Duffield in press). Forty-eight species of waterfowl and other waterbirds were recorded during the study. Within the manmade system, the overland flow subsystem (pond–overland flow–pond subsystem) with shallow water and mudflat areas attracted the greatest diversity of waterbirds. The gently sloping sides of this subsystem provided feeding areas for shorebirds, herons, egrets, coots and dabbling ducks. Deeper open water attracted diving birds, including cormorants and grebes. The deep water also created a yearly supply of water for mosquitofish (*Gambusia affinis*) and other fish species. The dry portions of the overland flow subsystem served as loafing spots for waterfowl, shorebirds, gulls and terns.

Bird use of detention basins in Columbia, Maryland, was low. Twelve species were recorded using basins without streams and 14 species were observed using basins with streams. These facilities provided little useful habitat. Detention basins without streams were consistently mowed throughout the growing season. However, they did provide feeding areas for some ground foraging species, most notably the starling (*Sturnus vulgaris*). Detention basins with streams generally had wet bottoms and, thus, were not mowed. Tall herbaceous vegetation was common and some wetland plants were present. The song sparrow (*Melospiza melodia*) was the most–abundant species in these basins and showed an affinity for the water's edge. We also noted high use by song sparrows of lake and pond edges.

Other Wildlife

Amphibians and reptiles recorded using Columbia's stormwater–control facilities included: American (*Bufo americanus*) and Fowler's (*B. woodhousei fowleri*) toads; gray treefrog (*Hyla versicolor*); spring peeper (*H. crucifer*); bullfrog (*Rana catesbeiana*); green frog (*R. clamitans*); painted turtle (*Chrysemys picta*); and snapping turtle (*Chelydra serpentina*) (Adams et al. 1983, Bascietto and Adams 1983). Few snakes were recorded in the study area—the most–common being the northern water snake (*Natrix sipedon sipedon*)—and none was identified as poisonous. Most observations of amphibians and reptiles were recorded at permanent–water impoundments.

Schlauch (1976) noted that the construction of deep–water ponds on Long Island, New York, for recreational and other purposes probably resulted in more habitat for species like the painted turtle and the snapping turtle. We believe the same is true for Columbia, Maryland.

Our census methodology in Columbia, except for an evening call count survey of frogs and toads, was restricted to daytime visual observations of wildlife use of stormwater–control facilities. The technique was most appropriate for determining bird use of the facilities. Thus, although we know of the presence of many mammals in Columbia, we collected little quantitative data in the study. The muskrat (*Ondatra zibethicus*) was the most–common mammal observed, and all observations were recorded at permanent–water impoundments. The species made greater use of shallow ponds than deep ponds or lakes. One occupied beaver (*Castor canadensis*) lodge was located in downtown Columbia at the upstream end of one of the three lakes. Other mammals noted in the study included the gray squirrel (*Sciurus carolinensis*), eastern cottontail (*Sylvilagus floridanus*) and woodchuck (*Marmota monax*). Tracks of white-tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) were seen.

Facility Design and Water Quality Enhancement

Poertner (1974) indicated that on–site detention for stormwater control was relatively widespread and had been in general use for at least 15 years. Early detention basins were designed to reduce flood hazards downstream by temporarily detaining stormwater in the basin and slowly releasing it over an extended period of time. Such basins have been, and still are, effective in flood control.

Currently, there is increased interest in controlling both the quantity *and* quality of stormwater runoff from urban areas. Interest in water quality was heightened when the U.S. Environmental Protection Agency (EPA) initiated its Nationwide Urban Runoff Program (NURP) in 1978. NURP was designed to evaluate water quality of stormwater drainage from urban areas and various means of enhancing the quality of such runoff (EPA 1983a). Twenty-eight study locations were selected throughout the U.S. Detention basins, retention ponds (and lakes) and natural wetlands were evaluated for their pollutant–removal capabilities.

NURP identified four types of pollutants as the "standard pollutants" characterizing urban runoff: (1) sediment and other solid particles, resulting primarily from accelerated soil erosion during construction activities; (2) oxygen–demanding constituents; (3) the nutrients nitrogen and phosphorus; and (4) heavy (trace) metals.

Investigators suggest that *physical entrapment* and *biological incorporation* are perhaps the two most–important mechanisms for enhancing the quality of urban runoff with detention basins or retention ponds. Sedimentation is the most–important physical–entrapment process. Biological incorporation is a more–complex mechanism. Of primary importance is the fact that phytoplankton and rooted aquatic vegetation can utilize, through normal metabolic processes, trace metals, oxygen–demanding organic substances and nutrients dissolved in the water. Available data to date indicate that retention ponds are superior to detention basins with respect to both physical entrapment and biological incorporation. Although detention basins provide some degree of physical entrapment, an inherent problem with these facilities functioning as pollution–control structures is the potential for settled pollutants to become resuspended and washed from the basin with the next storm flow. The best–documented removal rates of pollutants by detention basins were 14 percent for suspended solids and less than 20 percent for nutrients (Lynard et al. 1980, COG 1983a). Because of their relatively poor performance in removing pollutants, the EPA does not recommend detention basins for water quality improvement of urban runoff.

Retention ponds have demonstrated removals of more than 90 percent of the suspended particles and lead, 69 percent of total phosphorus, and about 50 percent of the biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogen, copper and zinc from urban runoff (EPA 1983a). Available data suggest that larger impoundments remove pollutants more effectively than do smaller impoundments. Large impoundments, with their corresponding larger storage capacity, retain runoff waters for a longer period of time, thus facilitating both physical entrapment and biological incorporation. Thus, based on its own work and other published literature, the Metropolitan Washington Council of Governments (COG 1983a) concluded that, if management of nutrients or organic oxygen–demanding material is a primary objective, the retention pond must be considered a better design alternative than the detention basin.

In addition to retention ponds, there is growing interest in the use of marshes, both natural and manmade, and other wetlands for water pollution control of urban runoff. Only a few documented studies have been reported, but consistent reductions have been shown for BOD (54–89 percent), suspended solids (94–99 percent) and heavy metals (up to 97 percent) (Chan et al. 1981).

We must caution that the biological processes involved in the natural treatment of urban runoff in retention ponds and other wetlands are not well–understood. Researchers are continuing to learn more about these processes. For example, the sediments in wetlands have been called "phosphorus sinks" by various investigators (see Chan et al. 1981). On the other hand, Richardson (1985) concluded that terrestrial soils, with large amounts of aluminum and iron oxides found in conjunction with aerobic soil conditions, were much better phosphorus sinks than wetlands. Through the use of controlled experiments, he demonstrated that microbes and plants in wetlands initially removed dissolved phosphorus from the water. However, within a few years, unless significant amounts of iron and particularly aluminum were present in the soil, the wetlands became saturated and released excessive quantities of phosphate into the downstream ecosystem. Richardson did not recommend the use of natural freshwater wetlands for removing and storing phosphorus from wastewater.

Cost Comparisons for Detention Basins and Retention Ponds

Research conducted by the Metropolitan Washington Council of Governments (COG), as part of the EPA's Nationwide Urban Runoff Program (NURP), documented construction costs for detention basins and retention ponds. Construction cost projections were derived from an extensive unit cost survey of local stormwater–management agencies and private firms involved in the design and construction of stormwater–management projects throughout the metropolitan region (COG 1983b). COG found that, for 20–acre (8.1 ha) developments, detention basin construction costs amounted to about $230 per dwelling unit for a medium–density single–family development (four dwelling units per acre: 10 per ha) and about $110 per dwelling unit for a townhouse/garden apartment development (10 dwelling units per acre: 25 per ha). For 100–acre (40.5 ha) developments, detention basin construction costs were about $110 per dwelling unit for a medium–density single–family development, and about $50 per dwelling unit for a townhouse/garden apartment development.

Construction costs for retention ponds were estimated to be 26 to 46 percent more than costs for detention basins, primarily due to additional excavation needed to achieve the permanent–pool area in addition to the area needed for detaining runoff following major storm events. However, COG listed the following four factors that might make retention ponds an attractive alternative to developers, despite the additional cost of retention ponds:

1. Some sites might contain a natural depression to facilitate ponding without requiring extensive additional excavation;
2. Initial excavation costs to achieve permanent–pool storage may be offset later by a reduced need for periodic sediment removal (i.e., reduced operation and maintenance costs);
3. A developer may be able to realize additional profits on the sale of units fronting on a retention pond that serves as a visual amenity to the development; and
4. Retention ponds may produce significant water quality benefits not attainable with detention basins.

With respect to factor No. 1, it should be noted that shallow–water ponds would require less excavation than deep ponds.

With respect to factor No. 3, Mr. Bernard Hankin, a developer in eastern Pennsylvania, told two of us (LWA and TMF), on a field trip in August 1982, that, although initiallv it will cost slightly more to construct a retention pond, such cost is more than compensated for by future benefits. Mr. Hankin stated that houses located near ponds sell first, and new residents in a development attract other buyers. Also, enhanced aesthetics please residents who often recommend his community to additional buyers. According to Mr. Hankin, "Good stormwater control is good business. It's good for the community, and it's good for the builder. If you have animals, it's terrific."

Although Mr. Hankin does not charge more for houses located near retention ponds, we are aware of a 62–unit townhouse development in Columbia, Maryland, where original owners of houses with a view of two retention ponds paid $5,000 more for their homes than did owners of the same house design but whose homes did not overlook the ponds.

As part of its NURP study, COG (1983b) also obtained information on operation and maintenance costs of detention and retention facilities. This was done through a literature survey and by direct discussions with private– and public–sector individuals involved in stormwater–management planning. COG reported that annual operation and maintenance costs (including cost for periodic sediment removal) in the range of 3 percent to 5 percent of estimated basin or pond construction costs might be appropriate for planning purposes. Routine maintenance items included site inspections, grass maintenance, bank stabilization, debris and litter removal, algae and weed control, fence repair, and insect control. These maintenance items agree well with those documented by a 1980 American Public Works Association survey of 219 public agencies (APWA 1981). Nonroutine maintenance items identified by COG included structural repairs and replacement, and sediment and debris removal.

With respect to weed control, COG suggested that a careful distinction be made between objectionable plants and more–desirable species with valuable aesthetic or other beneficial properties. According to COG, respondents in Winnipeg, Canada, reported that a group of residents demanded a halt to periodic harvesting of cattails growing in city–controlled ponds, asserting that the plants were desirable and provided waterfowl habitat. We find such a remark encouraging indeed.

Public Attitudes Toward Urban Stormwater–control Facilities and Associated Wildlife

To determine peoples' attitudes toward different types of urban stormwater–control basins and the wildlife resource associated with those facilities in Columbia, Maryland, the National Institute for Urban Wildlife surveyed over 600 homeowners in the city (Adams et al. 1984). The majority of respondents (98 percent) said they enjoy viewing birds and other wildlife that make use of the city's impoundments. Respondents clearly preferred permanent–water impoundments (75 percent) to dry detention basins (17 percent), and agreed (94 percent) that it would be desirable to design and manage future stormwater–control basins for fish and wildlife, as well as for flood and sediment control if this was feasible from technical and economic standpoints. Perhaps most importantly, 75 percent of the respondents felt that permanent bodies of water added to real estate values, and 73 percent said that they would pay more for property located in a neighborhood with stormwater–control basins designed to enhance fish or wildlife use. Although residents had some concerns about nuisances, hazards and maintenance of these structures, they overwhelmingly considered benefits to outweigh undesirable features.

Urban Stormwater Runoff and Regional Watershed Management

To illustrate the importance of urban stormwater control to regional watershed management, we will briefly discuss two examples—one from the East Coast and the other from the West Coast of the U.S. Historically, both watersheds and their associated estuaries have been highly productive fish and wildlife habitats, and both have been heavily impacted by urban and other development.

Chesapeake Bay

The Chesapeake Bay is the largest estuary in the United States and is widely recognized as the most-productive estuary in North America. It provides habitat to waterfowl and related species, yields millions of pounds of seafood annually, serves as a commercial shipping center and offers outstanding recreational opportunities for sport fishing and wildlife enjoyment.

Over one-half million migratory waterfowl winter along the Chesapeake. Chesapeake Bay is the single most-important wintering ground in North America for tundra swans (*Cygnus columbianus*) (Bellrose 1976), and large numbers of Canada geese, canvasbacks, black ducks (*Anas rubripes*) and other species winter there. In addition, the Bay region provides important breeding habitat for numerous wildlife species, including the endangered bald eagle (*Haliaeetus leucocephalus*) and the osprey (*Pandion haliaetus*).

Within the Chesapeake Bay watershed, the human population grew 49 percent between 1950 and 1980, and is projected to grow an additional 15 percent by the year 2000, to a total of 14.6 million. The percentage of land in urban and residential use in the Bay basin has increased 282 percent since 1950 (Macknis 1985).

The health of Chesapeake Bay has been in a state of decline for many years, due to a combination of natural and man-caused problems. Among man-caused stresses, urban runoff is recognized as contributing to increased turbidity and sedimentation, nutrient overloading and chemical pollution.

In September 1983, the EPA (1983b) published the major research findings and recommendations of a seven-year study of Chesapeake Bay. Three months later, a conference on the Bay was convened by the governors of Maryland, Pennsylvania and Virginia, the Mayor of the District of Columbia, the EPA Administrator, and the Chesapeake Bay Commission. Among the actions taken by the convenors was the signing of the Chesapeake Bay Agreement of 1983. The Agreement commits the federal government, the states of Maryland, Pennsylvania and Virginia, and the District of Columbia to the restoration and protection of Chesapeake Bay. It pledges the signators to prepare and implement a coordinated plan to restore and protect the waters and the living resources of the Bay. The stated purpose of the plan is, "To improve and protect the water quality and living resources of the Chesapeake Bay estuarine system so as to restore and maintain the Bay's ecological integrity, productivity and beneficial uses and to protect public health."

Control of urban stormwater runoff is a recognized important component of this comprehensive plan (Chesapeake Executive Council 1985). The District of Columbia and the State of Maryland have initiated progressive programs to control urban nonpoint source pollution problems. The District is developing regulations requiring best management practices (BMPs) at construction sites, a BMPs manual and a homeowner's BMP guidebook. Maryland has initiated projects to treat urban stormwater through infiltration, by diverting it to remote park areas. And it is demonstrating how to retrofit existing ponds in developed areas to reduce sediment loads. Using innovative regulations, Maryland is encouraging establishment of stormwater infiltration and retention ponds rather than detention basins. Further, the Department of Natural Resources is developing criteria to assist developers in designing shallow marshes and retention ponds for water quality improvement. We believe that expanded use of urban wetlands to ameliorate effects of urban stormwater runoff and to provide habitat should be an important element of this comprehensive strategy to restore the Chesapeake Bay to a more–healthy condition.

San Francisco Bay

San Francisco Bay and its adjacent wetlands covered a 713–square mile (43 km^2) area before 1850 (Wakeman 1982). Traditionally, the Bay region has been an important wintering area for waterfowl, especially tundra swans, pintails (*Anas acuta acuta*), shovelers (*A. clypeata*), canvasbacks, scaup (*Aythya* spp.) and ruddy ducks (*Oxyura jamaicensis*). About 25 percent of the continent's population of tundra swans winters there, as does roughly 40 percent of North America's ruddy ducks (Bellrose 1976).

Historically, more than 200,000 acres (81,000 ha) of coastal marshes existed in the San Francisco Bay region. Less than 20 percent remain (U.S. Fish and Wildlife Service and California Department of Fish and Game 1979, as reported in Tiner 1984). Most of the original wetlands were filled for urban and industrial development, and many tidal marshlands were diked to create salt–evaporating ponds.

In addition to contributing to the loss of wetlands in the Bay region, urban development (as in the Chesapeake Bay watershed) has contributed to lower water quality through increased turbidity and sedimentation, nutrient overloading and chemical pollution. In June 1980, the California Water Resources Control Board included urban runoff as a priority water–quality problem. Awareness of the need to control surface runoff led to creation of the Water Quality Management Plan for the San Francisco Bay Area (California Resources Agency and California Regional Water Quality Board 1982). Part of that plan requires the development and implementation of a program to control surface runoff. If the pilot research–demonstration wetlands system constructed by the Oakland–based Association of Bay Area Governments proves useful in enhancing the quality of stormwater runoff, additional systems may be constructed within the San Francisco Bay watershed for stormwater control. In addition to helping control stormwater runoff, such manmade wetlands may help to mitigate past loss of natural wetlands in the San Francisco Bay Area.

Design Recommendations for Wildlife

We believe that manmade wetland habitat can and should be created in many urban and urbanizing areas, in connection with modern stormwater management practices. We encourage biologists to work closely with engineers, landscape architects, planners, developers, governmental officials and others to create and manage such habitat.

Experiences in the Chesapeake Bay and San Francisco Bay watersheds and elsewhere are demonstrating that use of urban wetlands can play an important part in controlling stormwater quantity and quality. Innovative efforts have recognized these opportunities and implementation strategies are in force in the Bay regions. Positive results likely will expand as design guidelines become readily available to developers, thus facilitating the incorporation of wetland impoundments into residential, commercial and industrial projects. We recommend that other local and state agencies seriously consider the establishment of guidelines and regulations that promote the design of permanent–water impoundments as multiple–benefit structures in urban and urbanizing areas to control water quantity, improve water quality, create wetland wildlife habitat, and provide ecologically oriented educational and recreational opportunities. We believe that, by doing so, agencies can significantly improve the quality of life for citizens who reside in urban areas and for those who will benefit from a healthier downstream environment.

To optimize the value of manmade urban stormwater control ponds or other wetland impoundments for wildlife, the following design guidelines are recommended for consideration. The guidelines are based on our own work and work of others as indicated; see also Adams and Dove (1984) for further considerations related to the planning process.

- Impoundments with gently sloping sides (on the order of 10:1) are preferable to impoundments with steep slopes. In our Columbia study, ponds with average side slopes of 16:1 were superior to ponds with average side slopes of 3:1. Gently sloping sides will encourage the establishment of marsh vegetation. Vegetation will provide food and cover for wildlife and help to enhance water quality. Impoundments with gently sloping sides also are safer than steep–sided ponds for children who might enter the impoundments.
- Water depth should not exceed 24 inches (61 cm) for 25–50 percent of the water surface area, with approximately 50–75 percent having a depth not less than 3.5 to 4 feet (1.1–1.2 m). A greater depth may be advisable for more northern areas subject to greater ice depths.
- An emergent vegetation/open water ratio of about 50:50 should be maintained (Hobaugh and Teer 1981, Weller 1978).
- For larger impoundments (approximately 5 acres: 2 ha or more), one or more small islands are recommended. The shape and position of islands should be designed to help direct water flow within the impoundment. Water flow around and between islands can help to oxygenate the water and prevent stagnation. Water quality can be enhanced by a flow–through system where water is continually flushed through the impoundment (Harris et al. 1981). Islands should be gently sloped, and the tops should be graded to provide good drainage. Appropriate vegetative cover should be established to prevent erosion and provide bird nesting cover. Consideration should be given to including an overland flow area in the design of large impoundments. In our California study, the overland flow subsystem (pond–overland flow–pond subsystem) with shallow water and mudflat areas attracted the greatest diversity of waterbirds.
- Impoundments should be designed with the capability to regulate water levels, including complete drainage, and with facilities for cleaning, if necessary.
- Locating permanent–water impoundments near existing wetlands generally will enhance the wildlife values of impoundments.

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Public and Private Rangeland Management

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Public and Private Rangeland Management: An Overview

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No more timely topic than "Public and Private Rangeland Management" could be discussed at the 51st North American Wildlife and Natural Resources Conference—especially with the increasing public awareness of rangeland issues and the great national debate over the recently expired "Public Rangelands Improvement Act" being considered for renewal by Congress. Also contributing to the topic's timeliness is the fact that this conference is being held within the confines of the Great Basin that so well reflect the control geologic, climatic and grazing events have over rangeland resources.

Throughout North America, the many rangelands, including their streams and adjacent riparian habitats, have lost much of their biotic productivity. Two centuries of human consumptive land uses have brought about many changes. In the West, where public lands are so important, appraisals by the U. S. Forest Service and Bureau of Land Management show that substantial acreage is still in need of improved management for fisheries, wildlife (Almand and Krohn 1978, Owen 1979) and other resources.

Historic Perspective

Before white settlers moved into North America, large numbers of wild ungulates grazed the natural ecosystems. The American bison, which was so numerous in the mid- to short-grass prairies to the east, had not taken hold in the Great Basin and had mainly withdrawn from the area long before historic times (Hornaday 1889). The rangelands of the Great Basin supported relatively few large herbivores during the time span of Indian culture. The main herbivores that did exist (pronghorn, bighorn sheep and deer) were selective feeders that distributed themselves widely, in small scattered groups, in order to find dispersed browse and forbs (Platou and Tueller 1985). The sagebrush–steepe rangelands did not favor large numbers of generalist grazers such as buffalo.

Europeans soon recognized the potential of using the Great Basin for livestock production. Processes were initiated that would increase the production of domesticated "red meat." In the following years, the Indians were confined to reservations, the few bison were annihilated, and the rangelands were set up for use by the domestic livestock operator.

It was about 1840 that the ability of the Great Basin's ranges to support large numbers of livestock became recognized, and the immense "seas of grasses" found in many areas were soon being consumed by cattle and sheep (Cottam 1961). In the beginning, few considered that the Great Basin could not continue forever to support all the livestock that could be introduced.

But even the immense resources of the Great Basin were limited. Within a brief span of 25 years (1875 to 1900), the once–empty rangelands of the Great Basin, thought to be inexhaustible, had been overfilled with domestic livestock. The introduction of livestock had more effect on Great Basin environment than any other event in at least the previous 1,000 years (Davis et al. 1977).

It wasn't until the 1930s, with federal government intervention, that controls needed for improved rangeland management were initiated. This control started degraded rangelands on their long road to improvement.

Today's Perspective

Currently, the grazing pressure from all domestic livestock and populations of big game animals on Great Basin ranges is much more than when Europeans first settled America (Platou and Tueller 1985, Young and others 1976). The need is still as great as ever to manage rangelands properly—especially because livestock, particularly cattle, are attracted to the stream–riparian rangeland types. Even though many upland ranges have improved since the 1930s, riparian types have not had this same response. It is probable that stream–riparian areas are as badly deteriorated today as they have been at any other time during modern history in the Great Basin (Platts 1979, Platts et al. 1985).

The Future Perspective

The recent climatic past, which is used to predict the future, forecasts that climatic changes will come again to the Great Basin. The past geoclimatic record supports this, and even on–going changes demonstrate it. Since 1961, Great Salt Lake has risen 14 feet (4.3 m), covering thousands of additional square miles of land. Carson Sink, NV, almost dry in 1963, now spreads over 100 square miles (259 k^2). Between 1966 and 1980, the northern hemispheres seasonal snow cover has increased by 1,555,000 square miles (4,027,450 k^2), with snow falling earlier and melting later. In recent years, the Great Basin has had above normal precipitation and snowpacks, especially during the winters of 1983 and 1984. These heavy snowpacks led to some of the highest streamflows on record and had great impacts on Great Basin aquatic habitats (Platts et al. 1985). Thousands of wild ungulates died as a result of habitats that were constricted by heavy snowpacks. Even larger storm and drought events in the future would put Great Basin wildlife and fisheries habitats under even more stress.

The earth's atmospheric CO_2 content has been rising steadily over the past quarter-century and will double again by the year 2065 (Idso 1984). Based on this rise, some research models predict a rise in the earth's temperature; other models predict a lowering of the earth's temperature. One recent research report predicts streamflow rates will be reduced, while another report shows they will be increased 40-90 percent (Idso 1984). What this tells us is that, regardless of whose model is correct, changes are inevitable. Great Basin geologic history has well–demonstrated that nothing stays static for long, and that changes are sure to follow and even be accelerated under human influences. Thus, future storm events will place the Great Basin and the nation's rangelands under continuous stress. Only healthy, well–managed rangelands will be able to withstand these climatic influences without undue damage to rangeland resources.

These are encouraging times, as rangeland research and management are moving ahead and the public is becoming more aware that well–conditioned rangelands will produce much–needed resources. Multiple–use demands on rangelands will certainly continue to increase. Rehabilitation of rangelands is the most efficient way to increase wildlife and fish in the western United States. Research shows that livestock grazing, under well–managed grazing strategies, can be compatible with other rangeland uses. We need to develop further and use these compatible uses and move toward their acceptance in rangeland management. The key is the speed in which the move to sound rangeland management can be made. Constant headway will come about through sessions like this, which bring the state–of–the–art in front of the scientific and management communities for assimilation and discussion, and which provide a basis for future direction.

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Effects of Grazing Management on Streambanks[1]

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Introduction

The relationship between streambank stability and aquatic and riparian habitats has attracted attention in recent years. Streambank shape and channel geometry influence stream temperature, velocity, sediment input, cover and the amount of water space suitable for fish habitat (Morisawa 1968, Platts 1976, Berry 1979, Brown 1980, Platts 1981). These characteristics determine the composition of aquatic life (Bowers et al. 1979, Reiser and Bjornn 1979). At the same time that the importance of streambanks came into focus, interest in the effects of livestock grazing on streambanks also began to grow. Although grazing effects may be subtle, accumulating over many decades, they are generally recognized as an increase in summer stream temperatures and an alteration of channel geometry—the latter related to soils, substrate and gradient (Behnke and Raleigh 1978, Platts 1981, Kauffman and Krueger 1984). It is also thought that these changes result from trampling and vegetation removal. However, throughout the literature, "streambank stability" tends to be ill–defined and often implies immobility rather than the maintenance of the integrity of a reach.

The case study reported here sought to compare bank stability under five different grazing options. The study was instructive in several ways. First, it indicated that the amount of streambank retreat differs statistically between ungrazed treatments and those grazed by livestock and big game, but does not differ significantly among grazing systems. It suggested that bank retreat increases with animal use. The study also brought attention to some of the hydrologic activities that work on the channel. Lastly, it advanced our understanding of methodology for streambank studies.

Site Description

Meadow Creek is located in the Starkey Experimental Forest and Range, about 35 miles (56 km) southwest of La Grande, Oregon. The study area included approximately 5 miles (8 km) of stream coursing through a ponderosa pine (*Pinus ponderosa*) / Douglas fir (*Pseudotsuga menziesii*) forest and bordered by small meadows. Meadow Creek is a second–order stream, draining approximately 38 square miles (98 square km) and dropping an overall average of 48 feet per mile (16.24 m/km).

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The streambanks are variable—sloped and vegetated, sloped and bare, straight, and undercut are all represented, and both gravelly and loamy consistencies are present. It is estimated that the flow generally ranges between 1 and 300 CFS (0.03 and 6 CMS), but the gaging station operated only in 1978 and 1979. After 1979, the only discharge records are occasional hand–gauged measurements. However, almost a 100–fold increase in flow can be expected from the season's low in August to the peak in March or April. High runoff also often occurs in December or January. Ice floes do occur. Average annual precipitation is about 19 inches (48cm), falling primarily as winter snow, and as fall and spring rain.

During the first part of this century, the Meadow Creek drainage was logged (which included construction of a splash dam and roads) and grazed abusively. In about 1940, the U. S. Forest Service dedicated the Starkey Forest for research purposes, but utilization in the stream bottoms remained high. At the time of the study, Rocky Mountain elk (*Cervus elaphus nelsoni*) used the area primarily as spring and fall range, and mule deer (*Odocoileus hemionus hemionus*) were present much of the year.

Objectives and Methods

The primary objective of this study was to compare the amount of bank retreat among five commonly used grazing management systems. The systems studied were season–long, four–pasture rest rotation, two–pasture deferred rotation, late–season (high–intensity, short–duration, October/November rotation) and no–grazing. Within this main objective, the effect of big game and the cumulative effects of rest and season–long grazing were also investigated.

Although small contiguous pastures were fenced along the stream in 1975, complete data sets are available only for 1977 through 1981, and only those years are reported here. All treatments were ungrazed in 1975 and 1981. The pastures were stocked with yearling heifers at the rate of 8 acres per AUM (3.2 ha/AUM), with the intention of achieving 70–percent utilization. However, utilization approached 70 percent only in the first year of the study; by Year 4 it was down to 40–45 percent, despite consistent stocking (Thomas 1985). Small pasture sizes limited the number of livestock to 2–20 heifers, depending on the management system (Table 1). No–grazing, rest–rotation, deferred–rotation and season–long grazing systems were installed in two blocks and grazed according to prescription, June through October; one block was surrounded by a game–proof fence and the other block was left open to big game use. The actual level of big game use was not documented. The big game access block extended upslope quite a bit farther than the other pastures. Both late season pastures also had big game access. One other series of pastures was grazed season–long after a period of rest ranging from 0 to 4 years. These pastures also had big game access.

The distance from permanent reference points (single metal stakes) to the closest bank edge was recorded after each winter period and each grazing period, to document movement of the bank's edge. Sixteen sample points were established in each treatment. A multiple regression test found that bends in the stream channel significantly affected bank retreat, so only sample points on straight reaches were used to

Table 1. Grazing treatment, stocking rate and length of stream associated with study pastures.

Grazing treatment	Approx. pasture size (ha)	No. of animals	Stocking rate[a]	Approx. length of stream (m)	Meters of stream/animal
Season–long					
1 year	2.9	10	3.2 ha/AUM	523	52
2 years	1.1	(Stocked intermittently		382	38
3 years	3.2	throughout season		318	32
4 years	4.0	until 70 percent		397	40
5 years	2.8	utilization was		381	38
		achieved.)			
Big game access					
Rest–rotation	73.8	20 or 0	3.2 ha/AUM	544	27
Deferred–rotation	82.0	20	3.2 ha/AUM	444	22
Season–long (5)	56.6	10	3.2 ha/AUM	409	41
Rest–rotation	61.2	0 or 20	3.2 ha/AUM	538	27
No–grazing	49.0	0	None	352	—
Big game–proof					
Rest–rotation	5.7	4 or 0	3.2 ha/AUM	238	60
Season–long (5)	4.7	2	3.2 ha/AUM	206	103
Deferred–rotation	4.7	4	3.2 ha/AUM	174	44
Rest–rotation	4.1	0 or 4	3.2 ha/AUM	257	64
No–grazing	4.0	0	None	248	—
Late season					
September	6.2	12	0.85 ha/AUM	648	54
October	5.7	12	0.77 ha/AUM	397	33

[a]Stocking rate to achieve 70 percent utilization.

compare treatments. The mean bank retreats and accompanying confidence intervals (0.05) were used to compare treatments, because it is a conservative method for testing data with wide ranges of variances.

Results

Treatment Differences

Numerically, more bank retreat occurred in the grazed treatments than in the ungrazed treatments, with the most occurring under deferred–rotation grazing and five–year season–long grazing (Figure 1). These were statistically significant differences where big game had access but not where they were excluded. Late–season grazing was not statistically different from the other treatments. Among the grazed treatments, the bank retreat tended to be numerically greater where the big game had access than where they were excluded. These pastures extended farther upland than the game–proof pastures, and so were stocked with more cattle per length of stream to achieve the pastures' stocking rate. Therefore, in addition to big game use, the streambanks in these treatments also had more livestock use. In other words, the set

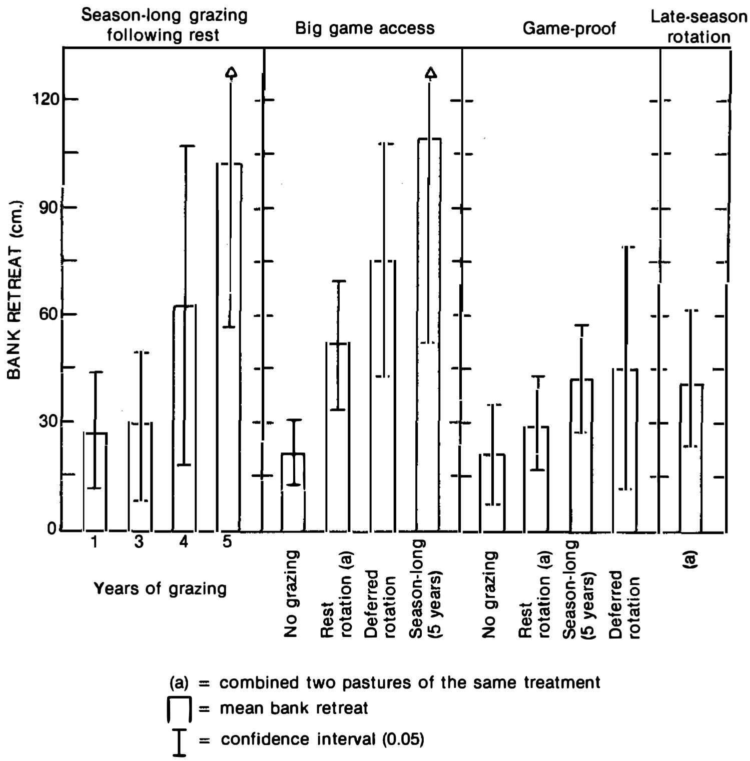

Figure 1. Bank–edge retreat on Meadow Creek between 1977 and 1981.

of treatments that had more animals per length of stream had numerically more streambank retreat, as did the treatments in which livestock grazed for longer periods overall (season–long and deferred–rotation).

Examination of the cumulative effects of rest and season–long grazing also supports this apparent pattern. The treatment with three years rest followed by two years of grazing was not included in the analysis because the stream was extremely sinuous through that area. As years of grazing increased, streambank retreat also increased. Five years of season–long grazing with no rest had significantly more bank retreat than one year of grazing after four years of rest.

Seasonal Differences

An interesting suggestion that arose early in the study was that a significant amount of bank disturbance might be occurring from October through May, from ice floes and spring runoff. After the first two grazing seasons on Meadow Creek (1976 and 1977), it appeared that more streambank retreat occurred in the winter than in the summer (Buckhouse et al. 1981). At the close of 1981, the data were reanalyzed for seasonal differences by analysis of variance with a randomized block design (years = blocks) and a year by season error term. That analysis showed only 4 of 16 total treatments had significantly more streambank retreat in the winter than in the summer. All four treatments were grazed season–long for three, four or five years with big game access. These treatments were scattered throughout the study area, and all season–long treatments with three or more years of grazing and big game access were significant. No other treatments showed significant seasonal differences. On another stream in northeastern Oregon, no significant differences were reported in overwinter bank retreat between late–season grazing treatments and no grazing (Kauffman et al. 1983).

Each individual sample point was then tested for seasonal differences. Of the 256 sample points tested, 6.6 percent had significantly more bank retreat in winter, and 3.5 percent had more retreat during the grazing season. A total of 26 sample points demonstrated significant seasonal differences of any kind. Although ice floes appear to be a formidable erosive force, they generally did not cause any more retreat than did grazing during the course of this study.

Limitations of the Study

Because the experimental pastures were small, as few as two and never more than 20 cows were sufficient to achieve the forestwide stocking rate. This probably failed to simulate the impact on streambanks that cattle from hundreds of acres would exert when concentrated along the stream for water. These experimental pastures were, in this sense, very understocked, relative to real management situations. Small experimental pastures were not appropriate for this kind of streambank study. Animals per meter of stream may be a more realistic approach than is stocking rate for stream studies.

Monitoring only the rate of bank–edge retreat also limited the interpretive value of this study. Other features, such as bank shape or channel form, might better address ecological questions, such as impacts on fisheries or channel integrity (Bohn 1986). Besides monitoring only bank–edge retreat, the single–stake reference method allowed some variation in the exact point on the bank to which measurements were taken. One effect of varying the point of measurement was that the difference between the very first measure and the very last did not always equal the sum of the seasonal changes. Furthermore, this method cannot account for new channels or braiding.

It is also noteworthy that the limited hydrological data makes it difficult to place these data (and many other riparian studies) in perspective in terms of flow–years or return intervals. This was an unreplicated case study that provided some interesting and provoking observations regarding a specific study site at a specific point in time.

Summary

Despite certain limitations imposed by methodology, the Meadow Creek streambank study produced some valuable insights into the complex relationship of streambank dynamics and grazing management. It indicated that streambank retreat may increase as animal use increases, both in numbers and in years. There was significantly more bank–edge retreat on grazed treatments with big game access than in ungrazed treatments. There was numerically more bank retreat on treatments that had big game access and higher livestock numbers. However, the small experimental pastures required very few animals to achieve the stocking rate and, therefore, may not be representative of the real–world situation. We suggest that animals per meter of stream would be more appropriate for stream studies.

Ice–related or runoff–related bank disturbances occurred during the study and appeared to be linked to season–long grazing. This is a poorly understood phenomenon that invites ecosystem–oriented research. Occasionally, ice jams do develop on Meadow Creek, and the hydraulic force of the released water is capable of carving spur channels. Evidence of this was observed in the spring of 1981. However, the critical questions are whether ice–related disturbance alters the form or function of the stream, as grazing can, and if land management perhaps alters the native patterns of ice formation and movement. Ice and animals appear to exert very different forms of disturbance on the channel walls and geometry.

Some of the most important lessons from Meadow Creek concern methodology. The one–stake method of monitoring bank retreat is of limited value because it allows some variarion in the exact point of measurement on the bank, and because it does not document the formation of new channels or important changes in channel geometry. It is likely that cross–sectional and longtidunal profiling would provide more appropriate data. Interpretation was also limited by the paucity of flow data.

Bank loss appears to be a complex process that was not fully addressed in this experimental design. However, the possible patterns in the data, as well as an increased understanding of methodology, suggested useful avenues for study and, possibly, for management.

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Economic Issues of Grazing and Riparian Area Management

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Introduction

Riparian areas are important components of western rangelands because they are highly productive and perform important hydrologic functions. Current use of these areas for grazing follows a long history, and such use on public lands has been encouraged and permitted by the federal government. Several economic issues associated with possible changes in emphasis of riparian area use might adversely affect livestock grazing. Livestock permittees are concerned with possible decreases in ranch income and values due to reduced use, increased costs or lower livestock performance. Land managers are concerned with the costs of rehabilitating streams and riparian areas. The general public is concerned with how benefits and costs are distributed (who gains and who loses). Information basic to making sound economic analysis depends on the ability of economists to estimate economic values properly and the biologists to estimate properly the physical impact of alternative management schemes.

Management of riparian areas is of great concern because of the important role these areas play both alone and in association with the aquatic environment to which they are tied. While many activities influence the health and functions of riparian areas, this paper deals only with livestock grazing on western rangelands, because this is a problem of current concern and examples of the problems are close at hand.

Of western rangelands, riparian areas, as noted, have the highest production of vegetation and perform important hydrologic and watershed functions. Indeed, most water within a watershed moves through a riparian area before reaching a stream channel. Livestock prefer riparian areas because they generally provide green forage for a longer period than do surrounding upland areas. Also, water is available, shade is generally close by and the terrain is more favorable for easy movement (Heady 1975, Stoddard et al. 1975).

The areas immediately adjacent to the water are critical because of the interrelationships of terrestrial and aquatic ecosystems. Streamside vegetation influences several aquatic system features, such as water temperature, light intensity, insect populations and aquatic species (Platts 1981). Streambank vegetation also affects such stream characteristics as velocity, organic debris loading, food quality, food storage and sediment loading (Gifford 1976, Satterlund 1972).

Livestock grazing on streambanks can cause several types of stress to the aquatic system. Trampling can cause banks to fall into the stream, which, with water and ice erosion, causes the stream to widen (Platts 1981). Also, the mechanical compaction of wet soils can occur (Bohn and Buckhouse 1985). Livestock fecal material can directly enter the aquatic system and alter stream chemistry and fertility. Grazing can cause changes in the plant community structure and may, in time, eliminate some plant species (Meehan and Platts 1978).

Management actions lead to environmental impacts that have social and economic implications. If the social or the economic impacts differ from what is desired, a problem or issue exists. If there is a clear legal basis for mandating needed changes, the issue could be resolved by administrators. Otherwise, political actions to provide for the enactment of legislation may be needed, and regulations must be written and implemented. New actions could then be taken and the cycle begun again. For example, an action (grazing and trampling) leads to *environmental impacts* (bank failure, erosion, aquatic failure in the aquatic system), which leads to *social and economic impacts* (loss of fish, loss of recreation, higher water costs, reduced ranch income), which leads to *problem or issue* (how to increase ranch income, improve water quality, increase fishing), which leads to *solution* (change grazing system, channel structures, or political action and new laws, regulations).

Three major management concerns emerge from a look at grazing in riparian areas—watershed conditions, fisheries habitat impacts and level of livestock production. These concerns are broad and involve many professions, and all resolutions have economic implications. While economics may not be the sole decision criterion, the major issues and problems should be addressed from an economic perspective.

Issues and Concerns

In the case of grazing on riparian areas on public lands, the action (livestock use of riparian areas) has taken place over a long time and been permitted and encouraged by government policies and actions. The environmental impact (bank failure, for example) may have taken place over so many years that the change was difficult to see, or it may have happened so long ago that no one can remember how things were originally. Because most western livestock owners are economically tied to public land grazing, changes in the permitted level or grazing system used will have direct impact on them. This happens because actions to improve aquatic habitat and watershed conditions often involve investments in structural measures and more–intensive management. A summary of the issues and concerns follows.

1. Decreased ranch income and ranch property values due to reductions in levels of permitted grazing.
2. Increased livestock owners' operating expenses due to added livestock–control structures—installation and maintenance.
3. Increased costs of livestock handling and management, required by more–complex grazing systems.
4. Reduced livestock performance due to elimination of choice forage areas or changed time of use, or both.
5. High costs of using structures for rehabilitation of stream habitats and adjacent areas.
6. Who pays the rehabilitation and higher management costs, and who receives the benefits?

7. What are benefits from riparian stream rehabilitation?
   a. Soil/water.
   b. Fisheries.
   c. Nongame species.
   d. Grazing.
   e. Recreating.
8. Sufficiency of information available about:
   a. values of nonmarket economic factors;
   b. biological and physical data base;
   c. economics of structural improvements; and
   d. magnitude of problem.

Economic Implications

For each of these eight issues or concerns, there are economic implications ranging from negligible to catastrophic, depending on one's perception and degree of involvement.

1. If a reduction of public land grazing is made, there will be an adverse effect on dependent rancher income, and this may lead to a reduction in ranch property values. The degree of impact varies among ranchers and depends on such factors as the availability of substitute forage, forage cost and forage quality. Also important is the financial capability of the ranch to acquire substitute forages through purchase, lease or development of forage on other lands by range improvement. The degree of dependency of western ranchers on public range forage varies greatly from 0 to 70 percent. Studies have reported the impact that reductions in permitted use and increased costs of using public lands would have on ranch incomes (Bartlett et al. 1979, Gee 1981, Neilsen 1982).

2. Among the obvious resolutions of the grazing issue is the exclusion of livestock from riparian areas. A more–moderate position is to control grazing more closely in these areas. Corridor fencing to control grazing is an option, but it is expensive and may not be economically feasible, particularly as a general solution over broad areas (Platts and Wagstaff 1984). Any fence construction and maintenance by the livestock permittee will increase ranch operating costs and reduce income unless there are compensating increases in livestock production. Again, the degree of economic impact varies depending on the amount of investment per animal unit month (AUM) of grazing. On allotments with a high proportion of riparian areas needing protection, the cost of building and maintaining corridor fences may exceed the value of grazing on the remaining areas.

3. Grazing systems calling for more–intensive livestock management may prove to be the most–effective way of managing grazing on some riparian areas. This may be particularly true when good riparian conditions exist and where grazing can be useful in managing riparian vegetation. Intensive–grazing systems will increase livestock management costs by requiring more labor for herding and moving livestock. The more–intensive management of livestock use may have a positive effect on total forage production and permitted use.

4. Livestock performance may be adversely affected by totally or periodically restricting grazing in riparian areas when lush vegetation is available. The impact from this factor would be greatest in the later portion of the growing season, when the

upland vegetation matures and dries and the riparian vegetation is critical in maintaining livestock weight gains. In some cases, the total available forage may be increased through better management, but the timing of use would still reduce levels of livestock performance below these possible under season–long use.

5. Costs for rehabilitating damaged streams and their watersheds are high if structural works are needed. If natural processes can correct the situation, expenses would be much less. It is certain that fencing will be needed in a lot of cases to control livestock. In some allotments, artificial revegetation will be needed where a source of desirable vegetation is not present or natural processes are too slow. More research is needed to find cheaper methods of rehabilitation.

6. The costs of rehabilitating streams and riparian areas have been paid for by public agencies funding the initial treatments and ranchers absorbing the losses of reduced grazing or increased livestock operating expenses. Maintenance costs of allotment fencing are typically the responsibility of the grazing permittee. An argument could be made that if grazing has caused or contributed to the damage, the permittees should pay all rehabilitation costs. A counter–argument is that those who will also receive benefits from rehabilitation (fisheries, wildlife, water users, etc.) should pay a portion of the rehabilitation costs.

7. Identifying the benefits from riparian area rehabilitation will require careful research over many years. Initial conditions or benchmarks must be established where such information does not now exist. In the meantime, planning for and implementation of rehabilitation measures must proceed on the basis of known and expected results. The main categories of benefits from riparian rehabilitation will be soil and water quality improvement, increased range forage, higher numbers of fish and wildlife, and increased recreational use. Range forage production will also improve as water tables are raised to where they will again support west meadows in areas where erosion has degraded stream channels. Fencing and more–intensive grazing systems may also lead to increased levels of livestock grazing.

Fisheries will benefit from better streambank, riparian and water column conditions. Decreases in stream temperature by increasing streambank cover will vastly improve aquatic habitat on many streams. Salmonids will usually increase with the return of shade and cover and the lowering of water temperatures to more natural levels (Platts 1981).

Wildlife dependent on more lush vegetative conditions for nesting, cover or food will increase as riparian areas are artificially rehabilitated or naturally return to a better condition. Many areas will have an increase in species of wildlife as well as an increase in population numbers. Some species, such as beaver, will require added management and control because they can be a problem in certain management situations. For example, failure of abandoned beaver dams on small creeks can release damaging flows of water and debris.

Recreation use will increase due to return of fisheries and also because of increased nonconsumptive uses of more plentiful wildlife.

8. Is enough information available? This is always a concern, but because decisions must be made, we should find and use the best information available, identify gaps and take steps to improve our information base.

Four areas of concern arise about our current economic information base. First is the improvement of the estimation of economic benefits and costs, where much depends on estimating values for nonmarket goods and services. The value of recrea-

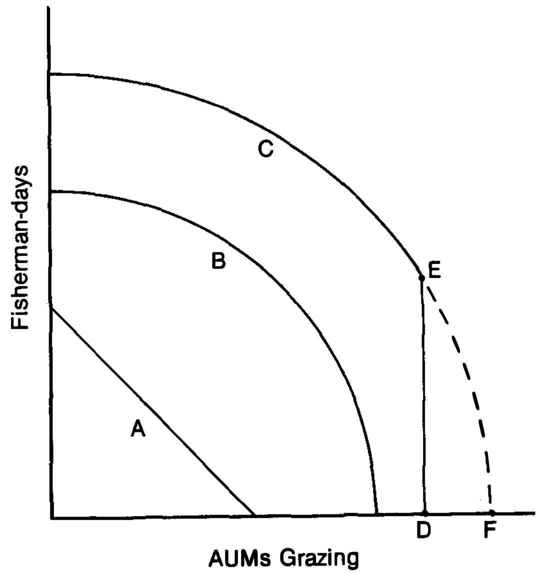

Figure 1. Hypothetical rates of substitution or production of grazing and fisherman–days.

tion, fishing, birdwatching and other factors not traded in markets is estimated using various techniques. The federal agencies managing rangelands generally use the values suggested by the U. S. Water Resource Council (1983) or values they have developed for planning (USDA 1982). Value estimations of these nonmarket factors set the limits for one part (benefits) of the analysis process.

A U. S. Forest Service Handbook (USDA 1982) gives fisherman–day values of $14.70 for the Intermountain Region and a regional average AUM value of $10.99 for use in allotment–management plans. Without challenging the appropriateness of the values, it does fix the relative proportion of the two activities and suggests a value trade–off of 1.3 AUM's per fisherman–day.

The second concern about the information base is that the accuracy of the economic analysis rests on the physical or biological data base. Because AUM's and fisherman–days were used previously, a simple graph can be constructed to show the importance of physical data. Figure 1 shows, for a sample area, hypothetical production of fisherman–days on one axis and AUM's on the other. The form of the relationship of these two uses is critical. Form A of a production–possibilities function suggests a smooth and uniform trade–off of one fisherman–day for one AUM; Form B shows that, after a point, production of another AUM requires that more than one fisherman–day be given up (increasing rate of substitution); Form C suggests an increasing trade–off rate to a point (E) and then a collapse of the aquatic system's capability to produce fisherman–days of recreation. Grazing use could then be increased without further loss of fishing (D to F), because there is no fishing due to failure of the aquatic system.

Figure 2 shows the economic interpretation of this information by developing a price ratio line (value per fisherman–day/value per AUM) and putting it on the curves

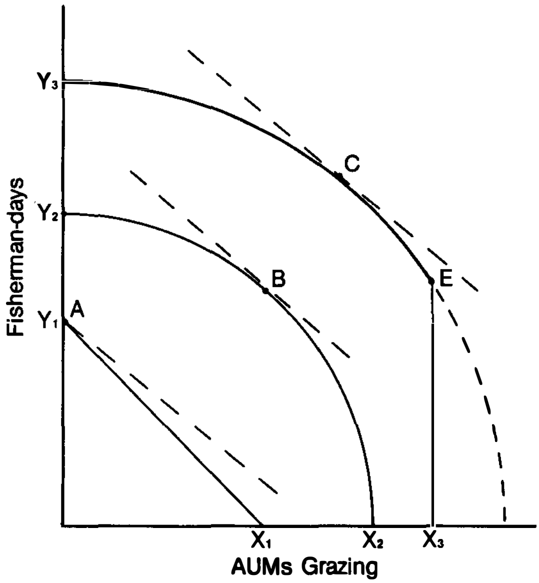

Figure 2. A hypothetical example of combinations of fisherman-days and grazing that maximizes net values.

of Figure 1. Economic theory tells us that maximum net revenue or benefit will occur where the slope of the production possibilities or benefits line and price ratio line become tangent (are of equal slope). We can see graphically that when the rate of substitution is 1 to 1 (line Y_1, X_1), maximum benefits at this price relationship would occur by having maximum fisherman–days and no grazing (point A). The logic of this becomes clear when the values of AUMs and fisherman–days cited earlier are used because giving up $14.70 (fisherman–day benefit) would yield a gain of $10.99. When increasing ratio of substitution occurs, as represented by line (Y_2, X_2), a combination of uses would maximize benefits; the amount is B. This is where the value given up—say, the $14.70 (one fisherman–day)—would equal $14.70 (1.3 AUMs) gained in grazing. Line (Y_3, X_3) shows that maximum benefits would occur at point C, and that beyond a certain level (point E), grazing would not be economically feasible unless (and only unless) fisherman–days had no value. This means that pushing a system to aquatic collapse makes no economic sense if fishing has any value. This illustration points out the importance of determining the physical factors of the problem.

The third concern about the information base centers on the effectiveness of in-channel structure. The economic efficiency question hinges on establishing the linkage between structures and production of fish or changed water quality, or both.

The fourth and perhaps most–surprising concern is the lack of information for public lands on how much riparian area exists and its present condition (USDI 1985).

Summary of Implications

A shift in the allocated use of riparian areas from primarily grazing toward other uses, such as fisheries, wildlife and watershed condition, appears certain to continue. Whether livestock grazing will continue and, if so, at what level are pressing questions. If grazing is to continue in important riparian areas, suitable grazing management systems must be developed. Grazing must be done in a manner that will not unacceptably damage riparian areas by altering streambank vegetation or physical structure or by preventing rehabilitation.

Livestock grazing may be limited to levels below that of the past. If so, dependent ranch incomes may be reduced. Some of this negative impact might be mitigated by improvement and development of substitute forage or intensive grazing systems, but these would be costly. Improved management, better livestock control, fencing and other measures will be needed to keep livestock grazing at desirable levels in riparian areas. These things will increase livestock owners' expenses and management requirements. The public will also be faced with increased costs due to more intensive land–use management.

Positive economic effects from the improved conditions may be felt in the recreation industry. Where commercial fisheries are involved, they may be benefited by larger catches. By and large, fisheries benefits are difficult to measure in the market value sense. This makes evaluation and comparisons difficult and less than certain, but it must be done.

Irregularities will be perceived by the many interests involved in riparian habitat management. Many of the perceived problems will lead to costly litigation and social disharmony. But, reasoned approaches could lead to a greater net social benefit level than currently exists. Gains and losses could exist with no current mechanisms for direct compensation. This is true because there is a readily identifiable party or group on one hand (livestock owners) and a large undistinguishable group on the other (recreationists, water users, public). Government agency policies, regulations, management practices and laws, both past and present, give a framework within which solutions can and must be forged. The issues and problems will not become simpler or easier to solve. Because of political and social forces, economics alone cannot resolve the problem, but it is helpful in putting the problem in perspective.

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Concepts in Stream Riparian Rehabilitation

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The purpose of this paper is to discuss interrelationships between riparian systems and the hydrologic and geomorphic processes operating in the associated stream channels. We show how the proper hydrologic function of the floodplain, stream–dependent water table, and stream channel erosion and deposition processes are all necessary for a healthy riparian ecosystem. These factors and interrelationships are brought to bear in a discussion of rehabilitation principles and approaches for use on degraded riparian areas. We introduce and discuss two types of channel conditions—incised streams and laterally unstable streams—which are commonly associated with degraded riparian areas. Proper identification of the causes of degradation and stage of channel evolution is required before developing a rehabilitation plan. We stress that stream riparian systems undergoing major geomorphic or hydrologic adjustments should not be treated with habitat improvements until the channel has reached a new dynamic equilibrium. We consider the stream riparian zone to be the entire active channel area, including that portion of the floodplain that supports a riparian vegetation community.

Riparian Zones: Geomorphic and Hydrologic Function

Stream riparian zones have important geomorphic and hydrologic roles that support their high level of biological productivity. The most–productive stream riparian zones often are associated with alluvial stream systems. That is, they are deposition zones and occur in fluvial sediments transported and reworked by the stream. A major role of the riparian zone is to function as a floodplain and dissipate stream energies associated with high flows. This, in turn, permits sediments to deposit and continue development of the alluvial valley floor.

Alluvial riparian zones also function as shallow aquifers that recharge at high flows and drain at low flows. This interaction between surface flows and groundwater storage results in moderated high flows and enhanced or prolonged base flows. The shallow aquifer condition also creates the moist soil conditions for plant growth, which characterize riparian zones.

Thus, it is the geomorphic and hydrologic characteristics of riparian zones that establish the basic components of biological habitat, including wet soils and instream structural features such as pools, riffles, gravels and streambanks. The vegetation that thrives in riparian zones, in turn, contributes to their proper geomorphic and hydrologic functioning. Disruption of normal geomorphic or hydrologic function, or the vegetation on which it depends, usually results in impairment to overall riparian resource values.

Stream Channel Adjustments and Riparian Condition

Stream channels, in association with adjacent riparian zones, adopt forms and normal modes of function that allow water and sediment to be discharged efficiently (Leopold and Langbein 1962, Yang 1971). Stream channel form, in turn, contributes to the physical and biological makeup of the riparian system (Brussock et al. 1985). Variables such as channel slope, channel and floodplain shape, and hydraulic geometry reflect long–term watershed conditions, but adjust continuously in response to changes in controlling factors such as discharge, sediment delivery, or changes in channel bed or bank conditions (Schumm 1971). Three classes of channel adjustments influence riparian conditions:

Channel evolution. Channel evolution refers to channel adjustments, usually at the geologic time scale, that occur as part of overall landscape evolution (Schumm 1956, Strahler 1968). In an analysis of rehabilitation potential, it is important to relate channel and riparian conditions to their evolutionary status and to identify potential threshold conditions (Bull 1979).

Rapid channel response. Rapid channel response refers to channel adjustments that occur rapidly in response to sudden changes in the long–term equilibrium condition of controlling factors, or to the exceedence of critical geomorphic thresholds. For example, sudden changes in discharge, sediment delivery or channel/floodplain conditions may initiate periods of excessive channel instability and adjustment (Heede 1980, Harvey et al. 1985). Also, more gradual changes resulting from channel evolution eventually may cause exceedence of a stability threshold for slope or base–level elevation that, in turn, initiates periods of rapid adjustment—for example, downcutting—throughout the channel network (Schumm 1977, Bull 1979). Instream structures associated with stream riparian rehabilitation projects may establish new critical or threshold conditions that may initiate adjustments within the channel system (Heede 1986).

Normal channel dynamics. Normal channel dynamics refers to adjustments that occur as part of normal channel/riparian function under dynamic equilibrium conditions. Channels and adjacent riparian areas continuously undergo incremental or periodic adjustments under normal high flow conditions (Heede 1975, Jackson and Beschta 1982). This is because the main external factors acting on the system—discharge and sediment delivery rates—are highly irregular over short time frames, even though long–term average conditions of discharge and sediment delivery may be fairly stable. Channel adjustments associated with conditions of dynamic equilibrium include incremental bank cutting, cycles of streambed scour and fill, and adjustments to normal inputs of large organic debris. In addition, flood flows and riparian areas interact to cause sediment deposition on floodplains. Many biological systems are dependent on normal channel and floodplain adjustments associated with dynamic equilibrium systems (e. g., Coats et al. 1985). Thus, it may be important to avoid excessive rigidity in rehabilitating stream riparian systems.

Most channel adjustments involve interactions with stream riparian zones. Normal adjustments associated with dynamic equilibrium processes may serve to enhance or rejuvenate riparian conditions. Excessive adjustments, associated with rapid response to changes in controlling factors, may temporarily or permanently impair normal riparian conditions.

Rehabilitation Approaches

Stream riparian rehabilitation requires (a) description or classification of riparian area degradation, (b) identification of the cause(s) of impaired riparian conditions, and (c) formulation and implementation of riparian rehabilitation objectives and strategies that allow reestablishment of a viable and sustainable riparian condition. This last requirement may be especially challenging since the rehabilitation objective—especially in the case of large, incised channels or arroyos—may not be to reestablish the former riparian situation, but to establish a new equilibrium condition that supports a viable riparian zone.

In general, impairment of riparian condition is characterized by either excessive channel incision and the subsequent dewatering of the riparian zone, or direct destruction of riparian vegetation with the subsequent loss of channel bank and floodplain integrity and the acceleration of lateral channel adjustments. The nature of riparian impacts and the concepts in riparian rehabilitation are different for these two classes of impaired riparian function.

Impaired Water Table Function: The Case of the Incised Channel

Deeply incised drainages occur throughout the world and are particularly common in arid and semiarid deserts and rangelands. In the western United States, large gullies and arroyos commonly occur in fine–grained, deep alluvial deposits, and are characterized by unresistant beds and steep fine–grained banks. Incised channels result from either downstream base–level lowering or localized gullying initiated by increased runoff rates or lowered resistance to erosion. In semiarid regions, gully initiation occurs when the erosional threshold is exceeded—usually at the steepest portion of the valley (Schumm 1969). When base–level lowering is triggered in a stream system, channel incision progresses upstream into all tributaries, unless stopped by a resistant geologic structure (Heede 1981a). Channel incision produces two important changes that affect the associated riparian system. Advancing gully systems increase peak discharge (Wallace and Lane 1976), making the stream very efficient at scouring channel beds and banks, and transporting sediment. Channel bed degradation produces a drop in the local water table and imposes a subsequent water stress on the riparian vegetation (Groeneveld and Griepentrog 1985). A loss of riparian vegetation, in turn, produces additional hydrologic changes—lowered resistance to flow and, therefore, higher flow velocities during flood events (Schumm and Meyer 1979). Channel incision, then, often leads to impaired hydrologic function of the stream system, as well as impaired resource values of the riparian ecosystem.

While small gullies may undergo cycles of cutting and filling, large gullies and arroyos undergo a more complex evolution (Harvey et al. 1985). The evolution of medium–to–large gullies and arroyos is depicted in Figure 1. Properly analyzing where a gully or incised channel is in its cycle of development helps considerably in the assessment of management alternatives. Also, a gully that develops in response to a general base–level adjustment is more difficult to control than a discontinuous gully that is reacting to local watershed conditions.

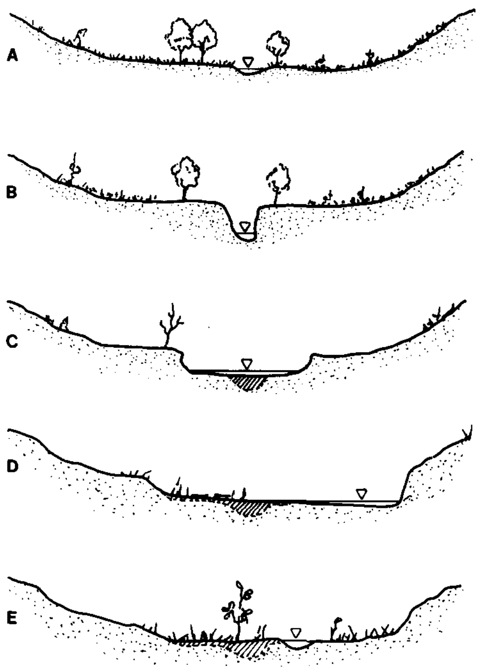

Figure 1. Hypothetical sequence of arroyo evolution (after Elliott, 1979).

Referring to Figure 1, channels in Condition A are not incised and often support a productive riparian resource. The key to the management of Condition A channels is to determine their susceptibility to incision (Schumm 1969, Harvey et al. 1985), then manage land uses to prevent incision. Management may be best accomplished in these situations by controlling intensive land uses, such as concentrated livestock grazing, in the riparian zone as well as contributing upland areas. Low (flush with the bed) instream base control structures or upstream detention structures (combined with improved upland watershed management) can contribute to the stability of Condition A channels. Also, proper management of large organic debris in the riparian zone can contribute to the maintenance of proper channel slope and instream sediment storage (Heede 1985, Swanson and Lienkaemper 1978). If incision is likely to occur as a result of base–level adjustment, a barrier dam or drop structure may be necessary to stop headward migration of the incision. Generally, prevention of incision is a very cost–effective stream management practice (Heede, 1986).

Condition B channels are recently incised and are characterized by narrow, steep banks. If the gully is small, appropriate land–use management may allow reestablishment of a Condition A channel. Combining land–use management with installation of gully plugs may hasten the recovery of small Condition B channels (Heede 1981b). If the gully is large, and especially if it has not reached a firm or resistant bed level, properly designed structures will be very expensive to install, and the feasibility of returning to a Condition A channel is greatly reduced. Furthermore, large Condition B channels will be the least responsive of all incised channel condi-

Figure 2. Inappropriate design and placement of a low check dam in a Condition C channel.

tions to improved land–use management, including rest from livestock grazing.

Condition C channels are in the early stages of widening—a prerequisite to stabilization and reestablishment of a riparian resource. In essence, they are midway between the stable conditions exemplified by Conditions A and E. If a resistant base level has been reached, a reasonably stable channel condition may be achieved simply by promoting establishment of a dense cover of bank vegetation. If livestock grazing is limiting riparian vegetation establishment, intensive management must be applied, such as the creation of riparian pastures or the implementation of grazing systems that favor riparian vegetation maintenance. Flood flows, however, will still erode the upper banks until a stable flood–flow channel can be established. While bank controls, such as jacks or loose rock revetments, could be used at critical situations in Condition C channels, they would be resisting natural widening tendencies and may not be cost effective. Base controls would have to be designed and installed carefully to confine flood flows or they would be breached at the ends (Figure 2). Furthermore, a reestablished riparian resource in a Condition C channel may have less ultimate value than a riparian resource reestablished in the more naturally stable Condition D or E channel. A final alternative for Condition C channels would be to try to return them to Condition A, if the resource values justified it. Although it would be expensive, barrier dams or base controls could be considered.

It may be possible to establish beaver in Condition C channels. Beaver translocating has been used to restore riparian conditions in southwestern Wyoming (Brayton 1984).

The most effective management strategy for Condition D and E channels is to allow passively for vigorous reestablishment of streambank and riparian vegetation. Some upper floodplain control on point bars or in abandoned flood–flow channels,

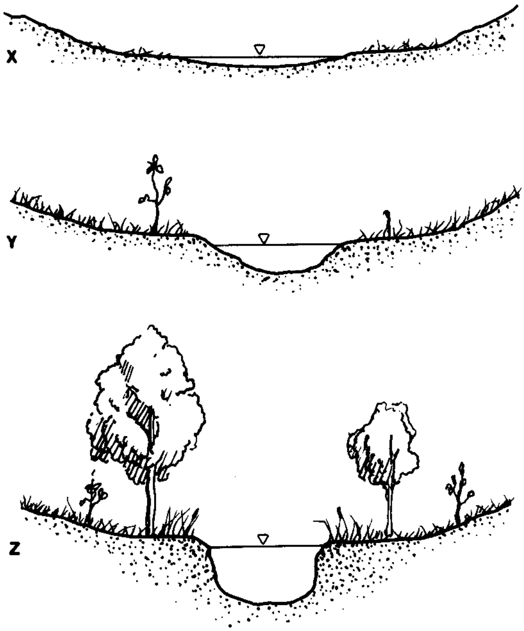

Figure 3. Hypothetical sequence of non-incised stream channel evolution from laterally unstable (X) to laterally stable condition (Z).

or bank control on outer meander banks may be justified in certain situations in Condition D channels. Generally, structures—except possibly those for fish habitat improvement—would not be warranted in Condition E channels. Management of land use in Condition D and E channels will often be a very cost-effective treatment.

Impaired Channel Bank and Floodplain Function: The Case of the Laterally Unstable Channel

The second type of impaired riparian function occurs on streams with relatively stable beds, when streamside riparian vegetation is directly impacted by land use in the riparian zone. Changes in vegetative composition and reductions in vegetative cover, vigor or production—which may result from concentrated livestock grazing, timber harvesting or road construction—directly alter the structural integrity of streambanks and floodplains. This, in turn, encourages excessive channel adjustments that further impact the riparian zone. Unlike channels in fine, deep alluvium that are prone to incision, coarse alluvial channels or channels with structurally controlled beds tend to respond to direct riparian impacts by becoming wider and shallower with less–steep banks (Figure 3) (Kauffman et al. 1983, Duff 1977, Platts 1981a, Platts 1981b). In addition to possessing poor aquatic habitat attributes (Kauffman et al. 1984, Platts 1981b, Platts 1981c), channels impacted in this way may become less capable of conveying high flows and may directly impact riparian areas by bank cutting or channel realignment during high–flow periods. Riparian area problems caused by this type of channel condition are aggravated by increased instream sediment loads resulting from upstream erosion (Jackson and Beschta 1984).

Riparian zones characterized by widened channels, frequent channel realignments, and poorly vegetated banks and floodplains generally can be rehabilitated rapidly by revegetation of the riparian streamside zone, provided that soil water in the riparian zone has not been affected by excessive channel incision. The management objective in this case is almost always to establish a Condition Z channel (Figure 3). For stream riparian areas impacted by livestock grazing, for example, elimination or reduction of livestock grazing in the riparian zone generally results in quick and dramatic recovery (Platts and Rinne 1985)(Figure 4). Other potentially effective riparian–management strategies include implementation of deferred–grazing systems, adjusting season of grazing use, creation of riparian pastures, development of off–site water sources and construction of drift or corridor fences.

Restoration of riparian vegetation through land–use management is the preferred method for rehabilitating this class of impaired stream riparian area. However, more active management may be required in certain circumstances. This is particularly true when riparian conditions are no longer amenable to rapid revegetation by passive means—either because the soil resource has been removed, normal sources of large debris are absent or the stream system itself has become too unstable to permit successful revegetation within an acceptable time frame. In this situation, structural techniques, including channel bank erosion controls and proper grading of floodplains, may contribute to improved conditions for revegetation. In the extreme case, channels may actually be reconstructed using proper hydrologic, hydraulic and geomorphic criteria to establish conditions conducive to establishment of vigorous vegetation (Jackson and Van Haveren 1984, Orsborne et al. 1985). The objective in any sort of structural solution should always be to provide the conditions necessary for natural revegetation and evolution so that the stream riparian system can quickly function properly and stably on its own, independent of rigid manmade structures.

Management Considerations

The overriding consideration in planning a riparian–rehabilitation program may be to determine the rehabilitation potential of the target area and identify the root causes of the degraded riparian condition. If the causes are due to upstream watershed disturbances, those areas should be stabilized so that riparian rehabilitation can proceed without interference (Jackson and Van Haveren 1984). If the disturbance is due to land–use management conflicts, those conflicts must be resolved before an improvement project is initiated. Stream riparian rehabilitation should not be used to circumvent the real causes of stream degradation (Platts and Rinne 1985).

In addition, we cannot overemphasize the need to understand and work with the natural recovery processes operating in a stream riparian system (Cairns et al. 1979). Rehabilitation should strive to establish the physical and biological conditions that favor rapid recovery by natural processes (U. S. Department of Transportation 1979, Jackson and Van Haveren 1984, Platts and Rinne 1985, Hasfurther 1985). Finally, stream riparian systems undergoing major adjustments should not be treated with habitat improvements until the channel has reached a new dynamic equilibrium.

Once it is determined that conditions warrant a rehabilitation program, rehabilitation objectives need to be carefully formulated. The objectives should consider existing and future watershed condition, hydrologic regime and the desired rate of recovery. If time is not an important consideration, and watershed and channel sta-

Figure 4. Rest from livestock grazing restored a Condition Z channel.

bility are favorable, then a passive approach to rehabilitation—simply letting nature take its course—may be the best alternative.

Generally, three questions should guide the formulation of recommendations for the use of structures in channel/riparian–restoration projects. First, will the structure permit the system to reach a condition of natural stability more rapidly than can be achieved passively (i. e., without structures)? Second, are the benefits achieved by accelerated rehabilitation sufficient to justify the costs? Third, will the achieved condition be self–sustaining instead of being dependent on the integrity of the structure? In most cases, the answer to all three questions should be yes.

Summary and Conclusions

Because all stream riparian systems are unique, stream riparian rehabilitation should be approached systematically using problem–solving techniques. The specific causes of riparian degradation should be ascertained. We believe that riparian degradation is generally associated with one of two different types of channel conditions—lateral instability or stream incision. These conditions must be identified and dealt with first in any proposed rehabilitation project. Treatment methods should work with, not against, the natural channel–adjustment processes. If the stream channel is evolving towards a new stage of dynamic equilibrium, and watershed condition is static or improving, riparian rehabilitation may simply involve no more than waiting for the natural healing processes to work.

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Options for Managing Livestock in Riparian Habitats

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When livestock were introduced into the Southwest in 1540, it was never conceived that they would be the first of many that would be overstocked and mismanaged on western rangelands. The adverse effects of livestock mismanagement on the once–abundant riparian habitat and herbaceous forage have been recognized for over 100 years. Yet even with problem recognition and the increased emphasis on riparian habitat awareness for the past two decades, the problem persists. On many grazing allotments, the management choice continues to be livestock mismanagement.

Most areas bear little resemblance to historic habitats. In some cases, the deteriorated riparian habitat is accepted as the norm, without any idea of what it could or should be. Yet this does not have to be the case. As the title of this paper implies, there are choices that can be made that will solve the problem.

The Habitat and Its Demise

The literature is replete with data that describe the healthy riparian habitat of the past. Although, in many cases, it is described in general qualitative rather than specific quantitative terms, these descriptions can serve as sources of enlightenment to all but those with the most–myopic viewpoint.

Today, there are few areas that can be used as standards of the past, but we can gain insight from those who observed such conditions firsthand.

Rusby (1889) described the area in northern Arizona, stating ". . . everywhere through the forest we encountered beautiful open parks . . . The grasses are taller, often nearly two yards high and of different species."

In 1853–54, Bigelow (1856) wrote of Arizona: "The banks of all the streams that we crossed produced cottonwood and mesquite . . . in great abundance."

Later records of an expedition in the late 1880s by Mearns (1907) indicated: "The streams are regularly lined with trees of which the Fremont cottonwood, black willow, box elder, walnut, sycamore, oak, mulberry, ash, and wild china trees are usually the most abundant. Of these, the cottonwood and willow are almost certain accompaniments of every permanent stream. . . ."

Accounts of former riparian habitat are descriptive and numerous, and so are accounts of what happened to this habitat.

Hastings and Turner (1965) reported that the Territory had about 35,000 head of livestock in 1880; in 1891, the governor wrote that the number was 1.5 million.

The time of reckoning arrived. Overstocking of the range destroyed the grass to the point that severe summer drought resulted in a heavy mortality among cattle (Wagoner 1952).

In 1926, Fred Croxen[1] gave accounts of the history of grazing on the Tonto National Forest, which were taken from interviews with original settlers still living on the land.

Croxen wrote: "Tonto Creek was timbered with local creek bottom type of timber from bluff to bluff, the water seeped rather than flowed down through a series of sloughs and fish over a foot in length could be caught with little trouble. Today this same creek bottom is little more than a gravel bar from bluff to bluff. The old trees are gone. Some were cut for fuel, many others cut for cattle during droughts and for winter feed, and many were washed away during the floods that rushed down the stream nearly every year since the range started to deplete. The same condition applies to practically every stream of any size on the Tonto."

Over eighty years ago, Griffiths (1901) wrote: "The free range system has led to the ruthless destruction of the native grasses which once covered the magnificent pasture lands of the west, and the time has now come when active measures need to be adopted to remedy the evils that have resulted from overstocking and mismanagement. It is evident that laws for the proper control and preservation of the ranges are not only essential to the stock interests, but also to the general welfare of the country."

H. C. Hooker, proprietor of the Sierra Bonito Ranch, described the range condition of the San Pedro Valley in 1870 as an abundance of willow, cottonwood, sycamore and mesquite timber, with large beds of saccaton and grama grasses (Griffiths 1901). The river bed was shallow and grassy, with its banks beautiful with luxuriant growth of vegetation. In December 1900, Hooker said that the river had cut 10 to 40 (3–12.2m) feet below its banks with its trees and underbrush gone, and the mesas were grazed by thousands of horses and cattle.

C. H. Bayless (in Griffiths 1901) of Oracle, Arizona, described the same valley as very fertile lands, with beaver dams that checked the flow of water. Trappers exterminated the beavers, and less grass on the hillside permitted greater erosion until, within four or five years, channel depths to 20 feet (6.1m) were cut almost the entire length of the river: "The valley is a sandy waste from bluff to bluff. The very roots were trampled out by the hungry herds that constantly wandered to and fro in search of enough food. Vegetation does not thrive as it once did, not because of drought, but because the seed is gone, the roots are gone, the soil is gone. Object lessons of this kind will prove conclusively that overstocking, not drought, had made our country a desert."

So it was, and so it continues today. The once–healthy riparian habitat continues to decline. It occupies only a token part of its original density, range and composition. Too many riparian zones can be described as having a few overmature and decadent trees, with nothing to indicate a hundred years of reproductive effort. Along some drainages, it is easier to count trees per kilometer than trees per hectare. Although regeneration has been established many times, it has been unable to withstand the grazing pressures.

Instead of this regeneration being the hope of a healthy riparian habitat for the

[1]Presented by Senior Forest Ranger, Fred W. Croxen, at the Tonto Grazing Conference in Phoenix, Arizona, November 4–5, 1926. On file at Supervisor's Office, mimeograph report 11pp.

future, it is nothing more than the cow feed of today. In most cases, the deterioration has not been rapid or dramatically obvious. It happened one bite at a time, until the reproduction was gone and the mature trees died and were washed away by the resulting floods. Without reproduction, the riparian habitat that once was, is no longer in a desirable, productive condition.

In addition to historic accounts, efforts have been made in recent years to document the adverse impacts of livestock mismanagement and the unacceptable condition of the riparian habitats and aquatic systems.

Platts (1981) stated that the effects of cattle grazing first appear on the streambanks and riparian vegetation. Behnke and Raleigh (1978) reported that typical stream habitat changes resulting from overgrazing of riparian vegetation, trampling of streambanks and increased erosion included widening and shallowing of the stream, stream channel trenching or braiding, silt degradation of spawning and invertebrae food–producing areas, loss of streamside and instream cover, increased water temperatures and velocities, decreased terrestrial food inputs, and a three– to four–fold decrease in trout biomass. Other effects include changes in width, depth, meander pattern or longitudinal profile (Platts et al. 1985). Szaro et al. (1985) even reported significantly higher numbers of wandering garter snakes (*Thanmophis elegans vagrans*) where grazing had been excluded from a thin–leaf alder–willow riparian community in northern New Mexico.

Data are voluminous documenting the adverse impacts that livestock and livestock mismanagement have had on riparian habitat and the biotic and abiotic components associated with it. Additional research could be conducted on every biotic and abiotic factor associated with the riparian ecosystem, and I am confident that it will find that, when the system as a whole is adversely affected, the dependent components comprising the system are also adversely affected. Data are important to give us insight and awareness, but data alone will not solve the problem.

There may be many reasons or excuses for continuation of the problem. These may include inadequate personnel and funds, personal values, priorities, politics, confusion, or even the failure to recognize that a problem exists. Regardless, the end result is the same.

Management Options

One of the first steps to solving this or any problem is to realize that a problem exists. Once the problem is recognized and a solution desired, resource managers can trade livestock and livestock mismanagement for other management options. But even after the problem is recognized and a solution is desired, selecting the most–appropriate solution may not be an easy task. On the surface, the solution may appear simple. If overgrazing is a problem, then control or remove the livestock. Yet the complexity of the relationship between livestock and the riparian habitat can be overwhelming to those looking for a single, simple answer. Data may even seem confusing or contradictory, thus a decision may be made to do little or nothing, in contrast to trying something that may not work.

Livestock or Riparian Habitat Management

Managers have the options to manage riparian areas with or without livestock. To exclude livestock from riparian areas can be referred to as a choice of livestock habitat management *or* riparian habitat management, whereas to include livestock is both.

Often when the problem is recognized and the decision is made to trade livestock mismanagement for other management options, drastic measures are necessary. Under these conditions, solutions may involve excluding livestock through the use of protective fencing, protective non–use or allotment closure.

Protective fencing is relatively fast and successful. It is a means of giving natural or planted regeneration a chance to respond. Fencing is supported by many. The need and positive benefits of protective fencing in many cases is recognized and justified.

Protective fencing is successful, but does not treat deteriorated watershed conditions and may be considered as treating the symptoms rather than the problem. As a result, the problem remains ever–present. Fences are expensive to maintain, and when watergaps are washed out or vandals cut the fences, livestock can destroy in a short period of time the habitat gained over months of protection.

Fencing is not the only option that amounts to a choice between livestock or riparian habitat. Livestock non–use, whether for permittee convenience or for resource protection, can provide some of the rest needed to initiate resource response. When in the elementary stages of resource recovery, and an optimistic objective is to get regeneration above the reach of livestock, the resource rest provided by non–use may be a start.

When given the choice of livestock or riparian habitat management, riparian habitat management is not always the selected alternative. In some cases, grazing allotments have been and are being closed for resource protection. But usually when the resource has deteriorated to the level to justify allotment closures, the resource and everyone involved loses.

The choice of livestock or riparian habitat management can be used to benefit riparian habitat recovery. This may not, however, be the most desirable alternative because of construction and maintenance costs, vandalism and political influences, but it should be used when necessary.

Livestock and Riparian Habitat Management

The choice of managing livestock and riparian habitat simultaneously can succeed or fail depending on the techniques and system selected. Serious consideration must be given, however, to the existing condition of the habitat. A solution that may provide resource improvement for an area that has been under yearlong grazing and little management may not improve or even maintain habitat that is in good or pristine condition. I believe successful solutions are those directed at the problem. I do not believe that any solution will be completely successful without first placing the grazing allotment under a resource–sensitive level of stocking and management and management intensity.

Too often techniques and systems are used to treat the symptoms rather than the problem. Token efforts and band–aid treatments may be used to postpone the inevitable reduction and management. These efforts not only fail to protect and restore the resource, but contribute to the loss of resource manager and agency time, money and management credibility.

Management Systems

Specialized grazing systems have been developed to manage a diverse combination of resource situations. These systems are an improvement over continuous yearlong grazing and are designed to deal with one or more variables, including stocking rates, time (season) and duration of use.

Riparian habitats are sensitive, relatively small in area, and usually provide water, shade and other elements attractive to livestock. A system that is good for the perennial herbaceous forage on the uplands may or may not provide the desired rest and results in riparian areas.

Possibly the most–common management after fencing a riparian area is to use it as a seasonal pasture. The strategy is to provide use during the time of year when riparian species are less vulnerable. This may be during plant dormancy or during periods when other forage is more enticing. With a seasonal pasture, the stocking rate, time and duration of use are relatively set. This system may not have the time flexibility of others, and may prove harmful to other forage species.

The gathering pasture concept usually evolves after livestock has been fenced from an area for a length of time. As the riparian habitat begins to improve, management options begin to change. The operator may be permitted to use the pasture as a gathering or holding trap, while moving livestock from one area to another. The stocking level and duration are variable, and the season is usually set, but may vary depending on the associated management system and pasture design. The pasture is used, thus reducing the anxieties of an area not being used.

The riparian pasture concept may vary from a narrow area placed under protective fencing to that of a pasture that encompasses the entire watershed. The appropriate number and class of livestock are cut from the main herd and then moved back at a specified time. At times, the layout of the riparian zone and its respective pasture fences make it difficult to distribute and manage livestock.

The riparian pasture is used with a set or variable stocking rate, a set duration, and a variable season of use. The stocking and season depend on the desired usable forage. Riparian habitat protection and recovery are provided, but may be at the expense of permittee convenience. The permittee may find it cumbersome to cut out a specific number of livestock and move the animals back and forth. But this system does provide the treatment of the pasture as a distinct use area and the opportunity to control use.

A rest–rotation system is based on a concept of providing rest, to meet the physiological needs of the plants. In management of riparian habitat, the rest must be adequate to provide plant establishment and growth beyond the reach of livestock, while under proper stocking and a proven management system.

The disadvantages of a rest–rotation system are mostly economic. It requires three roundups per year rather than two, often a reduction in the calf crop the first two years, usually a reduction in permit number and value, and expenditures for improvements.

This system, however, provides riparian habitat and watershed improvement, an improved calf crop after three years, improves long–term viability of the operation, an opportunity for a higher percentage and uniform calf crop, and it permits the regulation of calving to a specific time of year.

Management Techniques

In addition to selecting an appropriate management system, management techniques can be used to enhance management success further. One technique is the use of enticements to lure and disperse livestock away from riparian areas. Enticements include protein, mineral and diet supplements, salting, shade construction, water developments, revegetation, and prescribed burning. Although enticements are being used with varying degrees of success, the benefits to riparian or aquatic habitat are not well-documented.

Livestock selection is another technique. Some livestock operators cull livestock that exhibit undesirable behavior patterns, while others select and breed cattle that exhibit upland home range patterns (May and Davis 1980). A change in the class of livestock may provide improvement to the riparian and aquatic resource. Steers may exhibit different consumptive and behavior patterns than a cow–calf operation. Sheep have a different physical structure and habits, and are said to inflict less damage to the vegetation and streambanks than do other classes of livestock.

Herding and trailing are also used to protect the resource. A dedicated commitment from an operator to physically herd livestock and relocate stock driveways and trailing areas away from riparian, aquatic and other sensitive habitats can achieve positive results. The human variable of compliance is, however, a weakness in this technique.

Habitat Enhancement

Riparian habitat recovery can be accelerated through the augmentation of management systems and techniques by planting cottonwood poles or seedlings, using drip irrigation, gabion structures and check dams and, in some cases, through reintroduction of beaver.

The use of cottonwood poles is a revitalization of a concept described by Aldo Leopold (1924). He discussed the use of poles to create living fence rows. Living fence rows have been used for years by residents along the Rio San Miguel, Sonora, Mexico. These people have used cuttings from cottonwoods and willow to establish living fence rows to protect and revitalize theie agroecosystem and enhance floodplain farming (Nabhan and Sheridan 1977).

Gabion structures and check dams can be used to speed riparian habitat recovery. These structures reduce erosion, trap sediment for vegetation establishment and increase water retention. All of this benefits the healing process.

Similar benefits can be achieved through reintroduction to beaver. Caution should be taken, however, in assessing the use of beaver. In some cases, beaver can be detrimental to meeting specific objectives. A case in point is Canyon Creek—a trout fishery on the Tonto National Forest. The objective was to reduce water temperature by increasing stream shading. Livestock were placed under proper stocking and management, and cottonwood and willow regeneration responded significantly, only to be cut continuously by beaver. The most realistic solution to the problem in this case was to control the beaver until the vegetation met the shading objective and a level that could support beaver.

In 1979, resource managers on the Tonto National Forest took action to resolve the livestock–riparian habitat conflict. Within its almost 3 million acres and 103 grazing allotments, the Forest contains diverse riparian habitats, a broad range of grazing allotment sizes, historic management practices, and climatic and political influences. These variables provided management challenges that required a mix of management options.

In an effort to protect and restore the resource, the Forest has successfully used protective fencing, resource protection and permittee convenience non–use, allotment closure, change in livestock class, pole planting, drip irrigation, rest–rotation, and proper stocking and management. All of these efforts have been successful to varying degrees in re-establishing riparian habitat.

Today, 50 allotments have been placed under proper stocking and management. On several grazing allotments, modification of the three pasture Santa Rita rest–rotation system, along with proper stocking, has been successful in establishing cottonwood and willow regeneration. This approach provides high–intensity, short–duration livestock grazing, with each pasture receiving spring–summer rest, back to back, two years out of three.

In 1978, the Sedow allotment on the Globe Ranger District was placed under this system after the permitted 11,125 animal unit months (AUM's) were reduced to 5,800 (Davis 1981). When the system was initiated, the Walnut Spring area of the Storm Canyon pasture did not have cottonwood or willow between 0.25 and 25.9 inches (0.1–10.2 cm) in diameter. Today, with rest and livestock use, the area supports over 1,000 cottonwoods and 3,200 willow per hectare in this size class.

Riparian habitat on the Roosevelt grazing allotment improved even with an increase in the stocking rate from 2,612 to 3,315 AUM's. Cottonwoods increased from 20 per hectare in 1978 to 2,020 per hectare in 1984. Willow increased from 28 to 225 per hectare in the same period. Similar results are being seen on the Winters and Superior grazing allotments.

The rest and livestock control permitted riparian habitat to respond under favorable climatic conditions, with the healing process appearing first in the upper reaches of the riparian and aquatic systems.

Conclusion

The mismanagement of livestock continues to have adverse impact on riparian habitat. The literature is replete with data describing the riparian habitat that once existed, how it was lost, the unacceptable conditions of the present, and the adverse impacts that have been incurred on the various components of the riparian and aquatic ecosystems.

Still, there are solutions to the problem for those willing to recognize that a problem exists and to accept the responsibility for solving it by implementing the solutions.

Managers have choices of livestock and livestock mismanagement, livestock or riparian habitat management, or livestock and riparian habitat management. There are numerous management systems, techniques and enhancement efforts that can be selected to solve the problem.

It is up to us as resource management professionals to maintain an acute sense of resource awareness and urgency. We must remember that published data alone or proof that the riparian habitat is worth saving will not in themselves solve the problem. The critical element is for us to select or create and implement solutions that will provide livestock control and total resource restoration.

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Texas Creek Riparian Enhancement Study

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Introduction

A significant amount of interest has developed in the past several years concerning the impact of livestock grazing on riparian areas. Alteration of riparian habitat and deterioration of trout stream productivity are occurring on the majority of public lands presently grazed by livestock. Numerous publications relating to this subject are available, with references to various areas of the western United States.

In 1976, an inventory was initiated to evaluate spawning habitat conditions for brown trout (*Salmo trutta*) in the tributaries of Arkansas River drainage. This inventory was conducted on trout streams under multiple–use management of the U. S. Bureau of Land Management (BLM), Canon City District, Colorado. Within several of the streams, the quality of habitat was limiting the success of the spawn and limited the streams' ability to sustain a "wild" trout population. Texas Creek was one stream identified as having spawning habitat, but lacking adult habitat to sustain a "wild" trout population. This provided an opportunity to assess quantitatively riparian and trout habitat response to selected stream treatments and manipulation of livestock grazing.

One-half mile (0.8 km) of Texas Creek was selected as a study site, to collect information and demonstrate treatments that could be used to enhance aquatic and riparian habitat in response to different management strategies.

Study Site

The study area is located approximately 2.5 miles (4 km) south of Texas Creek, Colorado, on public lands administered by BLM. Texas Creek originates in the Sangre De Cristo Mountains at an elevation of 12,300 feet (3,750 m). It flows for approximately 24.5 miles (39.4 km), where it enters the Arkansas River at the town of Texas Creek, Colorado. The mean annual flow from 1976 to 1985 was 18.5 cfs (0.5 m^3/sec).

The study area was divided into three segments (Figure 1): Segment A has deferred seasonal livestock grazing with no habitat treatment; Segment B excludes livestock grazing with intensive habitat treatment; and Segment C excludes livestock grazing with no habitat treatment. Intensive habitat treatments include the placement of five gabion drop structures, planting of 382 willow cuttings, and resloping and placing rip–rap along approximately 100 feet (30.5 m) of streambank. Livestock grazing was excluded in Segments B and C by the construction of approximately 1 mile (1.6 km) of fence. All construction activity was concluded by March 1980.

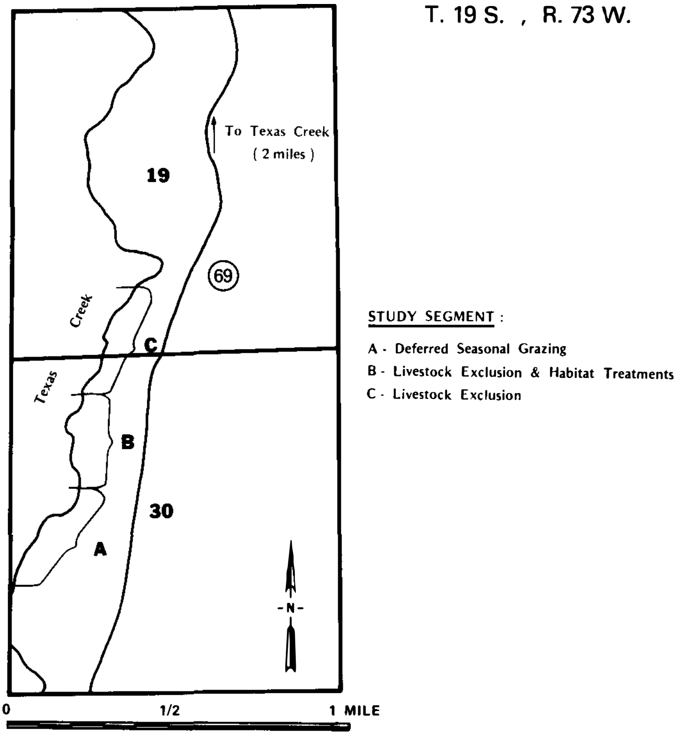

Figure 1. The Texas Creek study area.

Methods

Baseline data were collected in 1976, and riparian and aquatic monitoring studies were conducted from 1980 through 1985 after spring run-off. The BLM–Colorado State Office, manual transmittal sheet "6671–Stream Surveys" and the "Stream Habitat Inventory Profile Scorecard" (USDI 1980) were used. The Colorado State Office "6671–Stream Surveys" corresponds to a level–three inventory as described in BLM Technical Note No. 283. Information collected from permanent study stations includes bank cover, stream bank stability, pool/riffle ratio, stream width, pool quality and stream bottom substrate. These features are used in the numerical rating of the "Stream Habitat Profile Scorecard." The scorecard categories and numerical ratings are: excellent (17 points); good (14–15 points); fair (10–13 points); and poor (5–9 points).

Trout population sampling was conducted in the fall of 1976 and 1982, utilizing the Seber–LeCren double–sampling procedure. Two nets are set 500 feet (152.4 m) apart. The catch effort is started at the lower net, working upstream toward the upper net, with a sweeping back and forth action of the electrodes. Fish captured from the first pass are removed and placed in a live car. The sample area is rested for one–half hour before the second pass is made to allow fish "spooked" to return to their previous unguarded and catchable condition.

The food standing crop was determined by using the "Aquatic Ecosystem Inventory, Macroinvertebrate Analysis" developed by the U. S. Forest Service (Winget and Mangum 1979). Sample sites were selected in each segment that represented the typical substrate. A specially designed Surber Net was placed over the rubble substrate, and rocks are scrubbed, allowing the macroinvertebrates to be swept into the net by flowing water. The substrate underlying the rubble is stirred to a depth of 3 to 4 inches (7.6–10.2 cm). After the water is drained from the net, it is inverted into an aluminum pan containing saturated saltwater. The insect samples are strained and bottled in an alcohol solution. The samples are analyzed by the Forest Service's Aquatic Ecosystem Analysis Lab in Provo, Utah.

Results

The "6671–Stream Surveys" and "Stream Habitat Inventory Profile" rating conducted in 1976 showed that the quality of habitat in study Segments A, B and C were virtually the same. The scorecard rating was poor (less than 9 points). The average stream width was 18.0 feet (5.5 m). Stream banks consisted of scattered grasses, forbs and small shrubs, and were classified as totally unstable. As a result, the stream channel showed extensive lateral movement. Existing bank cover provided less than 10 percent shading (cover) to the stream. Areas of slow, deep water were nonexistent. The pool/riffle ratio was 1:9. Existing pools were shorter and narrower than the average stream width, completely exposed, with a depth of less than 1 foot (0.3 m). Approximately 80 percent of the stream substrate was made up of coarse gravel 1 to 3 inches (2.5–7.6 cm) and small rubble 3 to 6 inches (7.6–15.2 cm).

Segment A

Since the initial inventory, study Segment A has shown significant improvement. In 1985, the stream Habitat Profile Rating was good (15 points). The left streambank was totally stable, and 50 percent of the right streambank was totally stable. This stability has reduced the lateral movement of the stream channel and decreased the average stream width by 3.8 feet (1.2 m). With streambank stability, the vegetative response of grasses and forbs provided more cover along the stream. The bank cover was rated at 80 percent, which is an 800–percent increase in the percent of the stream shaded. Areas of slow, deep water are now present, and the pool/riffle ratio has improved to 1:5. The types of substrate (coarse gravel, small rubble, etc.) have remained much the same as was found in 1976.

Segment B

Like Segment A, study Segment B has shown significant improvement. The Habitat Profile Rating in 1985 was 17 points (excellent). Streambanks were found to be totally stable and composed of medium–to–heavy cover of trees and/or tall shrubs. Bank cover or percent–of–stream–shaded measured 70 percent. The stability of the streambanks has reduced the average stream width from 18.0 feet (5.5 m) to 15.0 feet (4.6 m). The pool/riffle ratio is 1:1. With this improvement in the number of pools, areas of slow, deep water are common. All pools are longer and wider than the average width of stream, exceed three feet (0.9 m) in depth and have abundant cover. One unique feature that developed is the exceptional undercutting of banks along the pools. The stream substrate has changed from small rubble and coarse gravel to a mixture of small and large rubble. Large rubble is defined as 6–12 inches (15.2–30.5 cm). At the tail of each pool, small rubble has been deposited in such a manner that these areas have become very productive redds for brown trout.

Segment C

Study Segment C has shown the least amount of improvement. The Habitat Profile Rating is fair (12 points). The left streambank is totally stable and composed of medium–to–heavy grasses, forbs and a few small shrubs. Eighty percent of the right streambank is totally stable, but 20 percent still remains less than 50–percent stable. Scattered grasses, forbs and small shrubs are found on this section of stream bank. Bank cover remains at 10 percent. The stream now has an average width of 15.6 feet (4.8 m). The pool/riffle ratio is 1:7. The stream substrate remains unstable, and composition changes each year.

Trout Population

In 1976, the brown trout population in all three study Segments averaged 13 trout per 500 feet (152.4 m) of stream. The average size fish captured was just under 8.0 inches (20.3 cm) in total length. Ninety-eight percent of the fish inventoried were brown trout, with the remaining two percent being brook trout (*Salvelinus fontinalis*).

In 1982, with the assistance of the Colorado Division of Wildlife, study Segments A, B, and C were electrofished. Segment A contained a population of 54 trout per 500 feet (152.4 m) of stream. Brown trout made up the total population, and averaged 8.5 inches (21.6 cm) in length. Eight fry and two trout over 10 inches (25.4 cm) were captured in the sample. An average of 71 brown trout per 500 feet (152.4 m) of stream were captured in Segment B. The average size trout captured was the same as Segment A. Fifteen percent of the population exceeded 10 inches (25.4 cm) in length. Three times as many fry were found in Segment B as in Segment A.

As in Segments A and B, brown trout were the only species captured in Segment C. They averaged eight and one-half inches (21.6 cm) in total length. Forty–three trout were captured per 500 feet (152.4 m) of stream. One percent of the population exceeded 10 inches (25.4 cm) in total length, and 2 percent were fry.

Macroinvertebrate Population

The aquatic macroinvertebrate community in study Segments A, B and C from the 1976 inventory showed that Texas Creek was completely dominated by taxa tolerant to organic enrichment and particularly to sedimentation. The observed lack of shredders often indicates heavy impacts in riparian habitat. This observed community structure is often found where plants have been severely grazed. The standing crop averaged 0.07 ounces per square yard (2.3 gm/m^2). Twenty–nine species were present and included but not limited to the Orders of Ephemeroptera (mayfly), Plecoptera (stonefly), Odonata (damselfly) and Diptera (two-winged flies).

In 1982, all segments showed a slight shift from taxa tolerant to sedimentation and organic enrichment to clean water species. As the number of shredders increased, it resulted in an increase in the standing crop. In Segment A, the total was 0.13 ounces per square yard (4.5 gm/m^2). In Segment B, the standing crop increased to 0.14 ounces per square yard (4.8 gm/m^2). In Segment C, the standing crop was 0.09 ounces per square yard (3.2 gm/m^2).

Discussion and Conclusion

This study shows that enhancement of riparian habitat can occur with: (1) deferred livestock grazing; (2) protective fencing; and (3) extensive habitat treatment, but the level of improvement varies. Study Segment A—deferred seasonal livestock grazing with no treatment—has improved in its quality of habitat from poor to good. Measured improvements were noted in streambank stability, bank cover and number of brown trout. Segment B—intensive habitat treatment and no livestock grazing—improved from poor to excellent. Attributes are in streambank stability, bank cover, pool/riffle ratio, spawning habitat, and number and size of brown trout. In Segment C—no livestock grazing and no treatments—the habitat quality improved from poor to fair. The only significant changes occurred in streambank stability and number of brown trout.

The most–noticeable improvement occurred in Segment B. The treatments were designed to correct deficiencies noted in the initial inventory. Gabions instantly improved the pool/riffle ratio, began to develop well–defined redds at the tail of each pool, and greatly enhanced the recovery of vegetation by subirrigation. This quick recovery of vegetation resulted in stable banks in three years, well–developed undercuts in five years, and heavy bank cover of medium–to–tall trees and/or shrubs in six years. The accelerated establishment of woody riparian vegetation was augmented by willow planting and streambank stabilization. Platts and Rinne (1985) reported similar responses in their evaluation of enhancement techniques in restoring riparian habitat and stream rehabilitation.

It appears that Segment A was more productive for enhancing bank cover conditions than was Segment C. In reality, they probably are the same. If Segments A and C were reversed, as per location, the numerical ratings would have been similar. Stream treatments in Segment B seem to have influenced the watertable upstream more so than downstream. The numerical rating of Segment A shows the upper half with a profile rating of fair (13 points), while the lower half had a rating of excellent (17 points). The increase in watertable in Segment B appeared to influence the lower half of Segment A, through saturation of the streambanks. The vegetation response resulted in a higher index rating for streambank stability and cover.

All three study segments showed an increase in the number of brown trout, with Segment B showing a wider range in trout size, which relates directly to habitat treatments. Trout 12 inches (30.4 cm) and larger were found in the quality pools that have developed below the gabion drop structure. Trout of that size were not found in Segments A and C.

The food standing crop of macroinvertebrates increased in all study segments. Segments A and B showed the most–noticeable increase, probably as a result of the stream treatments in Segment B. However, the amount of macroinvertebrates found in all three study segments could not be directly associated with the presence or absence of treatments and livestock–exclusion areas.

Throughout the western United States riparian and aquatic resources have suffered from a low level of management. There are many management alternatives to improving these conditions, but not all these alternatives will produce optimum habitat. The identified impact may be livestock, but removing livestock may not always produce the desired results. In many cases, adjustments in grazing strategies may do as much for the resource as complete removal (Platts 1981). In other cases, the only way to produce optimum habitat is to do extensive treatment. This is true for Texas Creek. Without extensive treatment, the Habitat Profile Rating would probably always remain in a fair rating.

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Stocktanks: An Underutilized Resource

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Introduction

Stocktanks or ponds are common throughout the West and were one of the first management tools used by the ranching industry. They usually are created by excavating and placing an earthen embankment for the catchment and storage of surface water. Most tanks have less than five surface acres. Their uses include water for livestock, irrigation, fish production, wildlife habitat and recreation (Soil Conservation Service 1982).

On the Tonto National Forest, tanks were built primarily to provide water for livestock. Many are fenced into what are commonly called "water lots." A tank is enclosed in a small pen or pasture for the purpose of working livestock, holding horses or sick animals, etc. Stocktanks have been valuable for wildlife in providing water where there was none before. However, there has been little or no attempt to manage ponds as riparian habitat. Rarely are embankments or shorelines protected from livestock grazing or trampling. Therefore, the dams and shorelines are often devoid of any vegetative cover. In several studies, grazing has been found to be detrimental to wildlife habitat by removing shoreline vegetation around ponds and potholes (Bennett 1937, Bue et al. 1952, Shearer 1960, Kirch 1969, Gunnell and Smith 1972, Whyte and Cain 1981).

An artificially created stocktank is considered an induced riparian ecosystem built for a particular purpose (i. e., livestock water). Management for each tank is on an individual basis, and riparian policy guidelines do not necessarily cover stocktanks. Tanks can be used for other purposes (i. e., wildlife habitat), providing they do not preclude the use of the tank for its original purpose (USDA Forest Service Manual 2526).

Importance of Stocktanks

Generally speaking, the more arid the region, the more important are the marsh and aquatic habitats in it (Martin et al. 1951). An estimation of the amount of riparian habitat in Arizona's and New Mexico's national forests is 285,350 acres (115,480 ha) (LaFeyette 1984). This amounts to only 1.3 percent of the national forests' land base.

There are over 89 wildlife species and 26 fish species that commonly use stocktanks (Table 1). Two wildlife and one fish species are federally listed as threatened and endangered. Eight wildlife and one fish species are listed by the State of Arizona (Arizona Game and Fish Commission 1982). Another 31 species of wildlife, such as the indigo bunting (*Passerina cyanea*), could use stocktanks if the right structure of riparian habitat was present. It is unusual to find developed riparian communities on stocktanks, therefore these species are not commonly found.

The Gila topminnow (*Poeciliopsis occidentalis occidentalis*) is an "endangered"

Table 1. Fish and wildlife species found on the Tonto National Forest that would directly benefit from the improvement of riparian habitat on stocktanks.

Amphibians

bullfrog (*Rana catesbeiana*)
toad, red-spotted (*Bufo punctatus*)
salamander, tiger (*Ambystoma tigrinum*)
spadefoot, western (*Scaphiopus hammondii*)

Reptiles

skink, Gilbert's (*Eumeces gilberti*)[a]
skink, great plains (*E. obsoletus*)
skink, many-lined (*E. multivirgatus*)
snake, blackneck garter (*Thamnophis cyrtopsis*)
snake, checkered garter (*T. marcianus*)
snake, common garter (*T. sirtalis*)
snake, Mexican garter (*T. eques*)[a]
snake, ringneck (*Diadophis punctatus*)
turtle, sonoran mud (*Kinosternon sonoriense*)turtle, yellow mud (*K. flavescens*)[a]

Birds

bittern, American (*Botaurus lentiginosus*)
bittern, least (*Lxobrychus exilis*)
blackbird, brewer's (*Euphagus cyanocephalus*)
blackbird, redwinged (*Agelaius phoeniceus*)
blackbird, yellow-headed (*Xanthocephalus xanthocephalus*)
black-hawk, common (*Buteogallus anthracinus*)[a]
bufflehead (*Bucephala albeola*)
canvasback (*Aythya valisineria*)
coot, American (*Fulica americana*)
cormorant, double-crested (*Phalacrocorax auritus*)
dowitcher, long-billed (*Limnodromus scolopaceus*)
duck, ring-necked (*Aythya collaris*)
duck, ruddy (*Oxyura jamaicensis*)
egret, great (*Casmerodius albus*)[a]
egret, snowy (*Egretta thula*)[a]
falcon, peregrine (*Falco peregrinus*)[b]
gadwall (*Anas strepera*)
goldeneye, common (*Bucephala clangula*)
goose, Canada (*Branta canadensis*)
goose, greater white-fronted (*Anser albifrons*)
goose, snow (*Chen caerulescens*)
grackle, great-tailed (*Quiscalus mexicanus*)
grebe, eared (*Podiceps nigricollis*)

Birds, con't.

redhead (*Aythya americana*)
sandpiper, least (*Calidris minutilla*)
sandpiper, solitary (*Tringa solitaria*)
sandpiper, spotted (*Actitis macularia*
sandpiper, western (*Calidris mauri*)
scaup, lesser (*Aythyua affinis*)
shoveler, northern (*Anas clypeata*)
snipe, common (*Gallinago gallinago*)
sora (*Porzana carolina*)
sparrow, Lincoln's (*Melospiza lincolnii*)
sparrow, song (*Melospiza melodia*)
stilt, black-necked (*Himantopus mexicanus*)
swallow, bank (*Riparia riparia*)
swallow, northern rough-winged (*Steigidopt serripennis*)
swallow, tree (*Tachycineta bicolor*)
swallow, violet-green (*T. thalassina*)
swan, tundra (*Cygnus columbianus*)
teal, cinnamon (*Anas cyanoptera*)
teal, green-winged (*A. cyanoptera*)
tern, black (*Chlidonias niger*)
turkey, wild (*Meleagris gallopavo*)
waterthrush, northern (*Seiurus noveboracen*)whistling-duck, black-bellied (*Dendrocygna autumnalis*)[a]
wigeon, American (*Anas americana*)
wren, marsh (*Cistothorus palustris*)
yellowlegs, greater (*Tringa melanoleuca*)
yellowlegs, lesser (*T. flavipes*)
yellowthroat, common (*Geothlypis trichas*)

Mammals

beaver (*Castor canadensis*)
muskrat (*Ondatra zibethica*)
raccoon (*Procyon lotor*)
skunk, striped (*Mephitis mephitis*)
skunk, western spotted (*Spilogale putorius*)
weasel, long-tailed (*Mustela frenata*)

Fish

bass, largemouth (*Micropterus salmoides*)
bass, smallmouth (*M. d. dolomieui*)
bluegill (*Lepornis macrochirus*)
bullhead, black (*Ictalurus melas*)
bullhead, yellow (*I. natalis*)
carp (*Cyprinus carpio*)
catfish, channel (*Ictalurus punctatus*)
crappie, black (*Pomoxis nigromaculatus*)
guppy (*Lebistes reticulatus*)
minnow, fathead (*Pimephales promelas*)

Table 1. (*continued*)

grebe, pied-billed (*Podilymbus podiceps*)	molly, sailfin (*Poecilia latipinna*)
grebe, western (*Aechmophorus occidentalis*)	mosquitofish (*Gambusia affinis affinis*)
harrier, northern (*Circus cyaneus*)	mouthbrooder, Mozambique (*Talapia mossambi*)
heron, great blue (*Ardea herodias*)	perch, yellow (*Perca flavescens*)
heron, green-backed (*Butorides striatus*)	pike, northern (*Esox lucius*)
ibis, white-faced (*Plegadis chihi*)	pupfish, desert (*Cyprinodon macularius*)[a]
killdeer (*Charadrius vociferuss*)	shiner, golden (*Notemiqonus crysoleucus*)
kingfisher, belted (*Ceryle alcyon*)	sunfish, green (*Chaenobryttus cyanellus*)
mallard (*Anas platyrhynchos*)	sunfish, redear (*Lepomis microilophus*)
merganser, common (*Mergus merganser*)	topminnow, Gila (*Poeciliopsis o. occidenta*)[b]
moorhen, common (*Gallinula chloropus*)	trout, Arizona (*Salmo apache*)
nighthawk, lesser (*Chordeiles acutipennis*)	trout, brook (*Salvelinus fontinalis*)
night-heron, black-crowned (*Nycticorax nycticorax*)[a]	trout, brown (*Salmo trutta*)
phalarope, wilson's (*Phalaropus tricolor*)	trout, rainbow (*S. gairdneri*)
phoebe, black (*Sayornis nigricans*)	walleye (*Stizostedion v. vitreum*)
pintail, northern (*Anas acuta*)	warmouth (*Chaenobryttus gulosus*)
rail, Virginia (*Rallus limicola*)	
rail, Yuma clapper (*R. longirostris yumaensis*)[b]	

[a]State threatened and endangered list.
[b]Federal threatened and endangered list.

fish. Primary reasons for its decline are habitat destruction, and predation by and competition for habitat with nonnative fish (Arizona Game and Fish Commission 1982). Stocktanks are providing critical habitat to separate the topminnow from nonnative fish. Sixty-four sites (22 ponds) were stocked on four national forests in Arizona in 1982. Another 24 sites were stocked in 1983. An analysis of the sites stocked in 1982 revealed the success rates of introductions into springs and ponds (stocktanks) were the highest of all introduction sites, with the success rate for ponds (70 percent) being slightly higher than springs (65 percent). Aquatic plants were an important component of habitats with successful introductions. Trampling by livestock was one of the reasons for failure (Brooks 1985). Stocktanks could also be a key in the recovery of the desert pupfish (*Cyrinodon macularius macularius*)[1]. The pupfish is proposed for federal listing and already recorded as threatened by the state (Arizona Game and Fish Commission 1982).

Another example of stocktanks being critical to a threatened species is the black–bellied whistling duck (*Dendrocygna autumnalis fulgens*). This species is not on the federal list but is included by the state. It breeds in southeastern Arizona and, following the decline in natural marshes, is dependent on manmade ponds (Arizona Game and Fish Commission 1982).

Most of the amphibians and reptiles dependent on riparian ecosystems are threatened, as is the ecosystem. Local extirpations of obligate riparian reptile species have

[1]Gary Bell, personal communication, Forest Service Zone Fisheries Biologist for Arizona.

been progressing in Arizona for about 20 years, but they are essentially unrecorded (Lowe 1985). There are 10 species of obligate riparian amphibians and reptiles listed as threatened in Arizona (Arizona Game and Fish Commission 1982). Lowe (1985) recommended the addition of five more species. Many of these species now use stocktanks and associated riparian habitats. For example, the yellow mud turtle (*Kinosternon flavescens*) primarily occurs in widely scattered ponds and stocktanks in semidesert grassland in southeastern and southcentral Arizona (Arizona Game and Fish Commission 1982). As the riparian habitat further declines in quantity and quality, artificial riparian habitats (stocktanks) will become increasingly more important. There is an "opportunity" for stocktanks to provide quality riparian habitats widely distributed throughout the range of many of these threatened species.

Opportunities for Enhancing Riparian Habitat

There are opportunities to enhance the amount of riparian habitat by increasing riparian plant communities around stocktanks. The Tonto National Forest encompasses nearly 3 million acres (1.2 million ha) and includes a variety of ecosystems from the desert communities at lower elevations to the mixed conifer at higher elevations. There are over 1,275 stocktanks scattered throughout. The tanks vary in size from 0.01 to 4.5 surface acres (0.004–1.8 ha) and average 0.3 surface acres (0.12 ha). Combined, the shoreline available would be over 83 linear miles (134 km).

Management of Stocktank Riparian Habitats

Riparian habitat associated with stocktanks will depend on the site, zonation of vegetation and fluctuation in the water level. Berg (1956) found that water fluctuation had a dramatic effect on aquatic vegetation. Where grazing occurs, riparian habitat will also depend on management of livestock, stocking rates and on the resistance of plants to grazing. With proper management, bare shorelines can be eliminated. Grazing management on the Tonto has changed in the last 10 years. Improved management has been implemented on one-half of the allotments (1.5 million acres: 0.6 million ha) with a reduction of approximately 60,000 AUMs. This has resulted in upward range trends on many allotments.[2] Many stocktanks, however, still have bare shorelines, heavy sedimentation and low associated wildlife populations.

Submergent vegetation is impacted very little by livestock grazing (Whyte and Cain 1981), but emergent vegetation is highly vulnerable because it is associated with water, limited in its distribution and remains succulent when upland herbaceous vegetation has cured during the dry, summer season. Many of the emergent aquatic species are high in protein when the upland species are not (Patton and Judd 1970). To maintain an emergent aquatic plant community, it is necessary to restrict grazing. Fencing is one means of doing this.

Shaw (1985:270) and Robinson and Bolen (1984:199) suggested the use of fences for wetland protection. Tanks can be totally fenced with water being piped or siphoned to an outside trough, or they can be partially fenced. Partial fences can exclude livestock from the shallow end while allowing livestock access to the deepest

[2]Dave Stewart, personal communication, Forest Range and Wildlife Staff, Tonto National Forest.

section of the pond (Whyte and Cain 1981). Fencing is expensive in the initial construction and requires periodic maintenance, and it is not feasible to fence every tank because of a low benefit–cost ratio.

A reasonable program would be to prioritize the stocktanks by their potential for contributing to the riparian habitat. Evaluation and ranking of stocktanks should be based on water dependability, surface area, water volume, water level fluctuation, and the permittee's attitude and cooperation. In general, the larger the tank, the shallower the water area it has, and the more constant its water level, then the higher it would rank in its potential to produce a wetland habitat. Each tank should have definite objectives.

If the objective is to create a marsh, then a pond completely choked with cattail (*Typha* sp.) or covered by a woody overstory would not be desirable. Just because a tank is fenced does not mean cattle would be permanently removed. Grazing is a proven method for setting back succession and should be used to maintain the desirable riparian habitat. Grazing as a tool has been reported as being beneficial to improve nesting habitat for upland nesting waterfowl, primarily in the control of dense stands of emergent aquatics such as cattails (Bennett 1937, Bue et al. 1952).

Maintenance of fences around stocktanks would quickly make the whole concept impractical for most land management agencies. They rarely receive budgets that include significant funds for maintenance. Nor do these agencies maintain fence crews. This is why it is essential that the attitude of the permittee be included in any ranking of stocktanks for the purpose of improving riparian habitat. The rancher will receive many indirect benefits, such as higher water quality and less sediment, and therefore less maintenance. Enhancing riparian habitat does not directly benefit the permittee's livestock operation. However, the land management agencies are required by law to manage the range on a multiple–use basis. Perhaps the best strategy would be for the original construction of the fence to be the responsibility of the land management agency. During use of the range, it is not unreasonable for the permittee to do routine maintenance for the protection of an established range improvement. This is one feasible way improvements involving fencing could work on a scale large enough to make a contribution to the amount of riparian habitat and its associated wildlife.

Summary

There are many stocktanks available that are now providing only a limited riparian habitat resource. Stocktanks are not normally considered as riparian and are not managed as such. As the riparian habitat declines further, many obligate riparian species will come to depend more heavily on stocktanks as their primary habitat. There is an opportunity to enhance the riparian habitat associated with stocktanks through the use of fencing. Stocktanks can become truly "multiple use" without detracting from the tank's original function, which is to provide water for livestock. On public land, it will be essential for any type of riparian enhancement program to include the permittee (rancher) as an active participant.

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Wildlife Use of Lowland Meadows in the Great Basin

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Introduction

Early settlers of the arid Great Basin homesteaded in the vicinity of lowland streams, springs and river courses. These areas provided not only water, but climate and topography more tolerable than that of the surrounding mountains, and comparatively lush forage for livestock. In Nevada, although 86 percent of the land area is in public ownership, the lowland riparian areas are still predominately in private ownership. Compiling figures from several land management agencies, we estimate that at least 85 percent of Nevada's lowland meadow habitat is privately owned.

Wildlife inventory and research on two ranches in northern and central Nevada between 1978 and 1985 revealed that the privately owned lands were of critical value to many wildlife species. The value of this region's privately owned land to wildlife was not a function of quantity (acreage), but rather of quality (i. e., type of land involved).

Our use of the term "lowland meadows" is meant to be descriptive of the wetland and/or riparian vegetation we encountered on our study areas. It includes meadows along both standing–water (lentic) and running–water (lotic) areas. It also includes those areas that may be considered marshland. Trees were not a dominant form on the habitats we studied, although willows (*Salix* spp.) were often present in lotic areas. Because grass or grasslike vegetation was the common denominator, the term "meadow" has been used. We do not include montane meadows, thus the use of "lowland" to make the distinction. Because, by definition, these habitats were riparian or wetland habitats, we compared our observations with available literature on riparian and wetland communities. Thomas et al. (1979) emphasized the value of riparian zones to wildlife in the northern Great Basin, and Dealy et al. (1981) reported that little information was available on such communities in this region.

Study Areas

The Saval Ranch is located in northeastern Nevada, approximately 40 miles (64 km) north of Elko. The ranch unit, including federal grazing lands, consisted of 49,105 acres (19,888 ha), of which 1,708 acres (692 ha) were privately owned irrigated meadow (Torell et al. 1985). These large lowland meadows, located along three perennial watersheds, were irrigated by natural stream flow, flood irrigation and diversion ditches, and were cut for hay production. Elevation of the Saval Ranch unit varied from 5,800 to 8,500 feet (1,700–2,600 m). Mean annual precipitation at the elevation of lowland meadows was 12 inches (30 cm).

Meadow vegetation was highly variable, consisting of a variety of grasses, sedges, rushes and forbs. Common species were bluegrass (*Poa secunda*), Douglas sedge (*Carex douglasi*) and wiregrass (*Juncus balticus*), as well as interspersed willow. Vegetation adjacent to lowland meadows consisted of a big sagebrush/alkali sagebrush (*Artemisia tridentata*/*A. longiloba*) mosaic with a variety of grasses and forbs.

The Gund Research and Demonstration Ranch (owned by the University of Nevada-Reno) is located in central Nevada, 40 miles (65 km) northeast of Austin. The ranch unit consisted of 95,000 public and private acres (38,500 ha), of which 700 acres (280 ha) were lowland meadow. In contrast to the Saval Ranch, meadows at the Gund Ranch were located near the edge of a playa, rather than along perennial streams. Gund Ranch elevation ranged from 5,600 to 9,150 feet (1,700–2,800 m). Mean annual precipitation at the elevation of lowland meadows was 9 inches (23 cm).

Major meadow species included saltgrass (*Distichlis stricta*), alkali sacaton (*Sporobolus airoides*) and Great Basin wildrye (*Elymus cinereus*). The wettest areas were dominated by wiregrass and saltgrass, with some extensive patches of wildrye. Other areas were dominated by alkaligrass (*Puccinellia* spp.) and alkali ivesia (*Ivesia kingii*). A variety of forbs was also present in these areas (Roundy 1980). Native hay meadows were irrigated primarily by water from geothermal springs and, to a lesser extent, from intermittent mountain streams via diversion ditches. No perennial streams were present on this site. Vegetation on adjacent uplands consisted of greasewood (*Sarcobatus vermiculatus*) and big sagebrush, with varying understory constituents.

Methods

During 1978–1980 (inventory phase), wildlife populations in representative habitats at each ranch were sampled for the purpose of evaluating changes brought about by livestock grazing management and range improvement practices. From 1981–1985 (research phase), sampling methods were modified somewhat to accommodate more intensive research objectives. In addition to quantitative data, field notes of animal sightings and animal signs (fecal droppings, tracks, etc.) were kept by both permanent and seasonal personnel. Emphasis was placed on compiling a complete species list of vertebrate terrestrial wildlife and their habitat affinities.

Birds

Bird–count transects were conducted in the various habitats during the breeding season. Transects were conducted for three consecutive days and consisted of 10 five–minute listening stations 1,000 feet (300 m) apart. At each stop, the "unlimited–distance count" method was used (Blondel et al. 1981), with all birds seen and heard recorded. Data from these counts provided relative–abundance estimates (number of birds observed per transect–day), as well as species composition and species richness, for each habitat sampled. Major habitats were sampled at least twice during each year of sampling.

Mammals

During the inventory period, rodent populations were sampled with live–trap lines consisting of 25 trap stations spaced 50 feet (15 m) apart. We placed one Sherman mouse trap at each station and one Tomahawk squirrel trap at alternate stations. All animals caught were ear–tagged, sexed, weighed, and released. Trap–line data provided information for relative–abundance estimates (numbers of rodents per 100 trap nights) for each species, as well as species composition and richness for each habitat sampled.

Density estimates of rabbits and hares were determined by walking strip–census transects 3 miles (4.8 km) in length through the major vegetation types. The method was a modification of the technique used by Gross et al. (1974). Perpendicular flushing distance was recorded for each animal flushed. Density for each transect was determined by: density $= n/lr$, where n = number of animals flushed, l = length of transect and r = mean flushing distance.

Results and Discussion

Birds

Low–elevation meadows on both ranches harbored diverse bird communities. Of the 80 species at the Saval Ranch and 75 species at the Gund Ranch that were associated with lowland meadows, 28 and 25 species, respectively, were considered obligates of this habitat (Table 1). An additional 10 species were considered "preferential lowland meadow" species. These birds nested in habitats including but not limited to the lowland meadows, but were more abundant in the lowland meadow habitat. Twenty-six bird species utilizing lowland meadows were considered general riparian habitat associates since they were found in high–elevation riparian habitats as well as in the lowland meadows.

Total bird abundance was typically greater in lowland meadows than in adjacent upland habitats. At the Gund Ranch, for example, mean total bird abundance for the irrigated lowland meadow type was approximately twice that determined for adjacent greasewood/sagebrush habitat. Of the six most abundant meadow nesting species, only two were observed on upland habitat transects (Table 2).

Lowland meadow habitat was obviously of critical importance to the birds that

Table 1. Comparative avian use of lowland meadow habitat versus adjacent rangeland habitats on two northern Nevada ranches, 1978–1985.

Ranch	Habitat	Number of species[a]	Type of use	
			Obligatory[b]	Preferential[c]
Saval	Lowland meadow	80	28	10
	Sagebrush	32	6	5
Gund	Lowland meadow	75	25	10
	Greasewood/sagebrush	33	7	5

[a]Total number of species associated with a habitat; a complete list of species is available from the senior author.
[b]Species nesting only and/or observed only in a specific habitat.
[c]Species nesting in several habitats, but most abundant in one habitat.

were considered obligates of this habitat. Included among these species were several that were unique because of their aesthetic value and/or population status. A few greater sandhill cranes (*Grus canadensis*)—as evidenced by their arrival time in March, courtship display and appearance of juveniles in August—were nesting annually at the Saval Ranch in the large hay meadows that contained some interspersed willow cover. Sandhill cranes require lowland meadows with willows for successful nesting and rearing of young (Nevada Department of Wildlife 1983). Most of this habitat in Nevada is in the northeastern part of the state (Elko County), where the Saval Ranch is located. This species occurred only as a migrant at the Gund Ranch, where no willow cover was available for nesting.

Long–billed curlews (*Numenius americanus*) nested on both study areas. However, this species was more abundant at the Gund Ranch where the low growth form saltgrass meadows were interspersed with irrigated hay meadows and greasewood habitat. This species has been shown to have a nesting affinity for short grass areas (Allen 1980), such as provided by saltgrass.

Nine waterfowl species were observed in the lowland meadow areas. Most of these were summer residents nesting in the vicinity of the perennial streams at the Saval Ranch and irrigation ditches on both ranches.

In addition to providing nesting habitat, the lowland meadows of both ranches also provided stop–over habitat for a number of migrating bird species, including the lark bunting (*Calamospiza melanocorys*), bobolink (*Dolichonys oryzivorous*), snowy egret (*Leucophoyx thula*), American avocet (*Recurvirostra americana*), white–faced ibis (*Plegadis chihi*) and white pelican (*Pelecanus erethrorhyncos*). The importance of "wetlands" and riparian habitat for migrating birds has been emphasized by Sprunt (1975) and Stevens et al. (1977). Irrigated lands that are partially flooded to provide shallow water or muddy flats are particularly attractive to shorebirds (Sprunt 1975).

Table 2. Relative abundance of the six most–abundant bird species in an unmowed (at time of sampling) irrigated lowland meadow during nesting season compared with relative abundance of the same species in adjacent upland habitat, Gund Ranch, 1979–1980.

	Relative abundance (number observed/transect–day)[a]	
Species	Irrigated meadow	Greasewood/sagebrush
Savannah sparrow (*Passerculus sandwichensis*)	54.8	0.0
Western meadowlark (*Sturnella neglecta*)	53.7	19.2
Red–winged blackbird (*Agelaius phoeniceus*)	72.7	0.0
Brewer's blackbird (*Euphagus cyanocephalus*)	12.2	0.3
Long–billed curlew (*Numenius americanus*)	20.8	0.0
Killdeer (*Charadrius vociferus*)	8.5	0.0
Total[b]	238.0	118.6

[a]Both values for all species identified are significantly different (t test, $p < 0.05$).
[b]Includes other species not listed in table.

Raptors observed hunting in the lowland meadow areas on a regular basis included the Swainson's hawk (*Buteo swainsoni*), red–tailed hawk (*B. jamaicensis*), American kestrel (*Falco sparverius*), prairie falcon (*F. mexicanus*) and great-horned owl (*Bubo virginianus*) during summer, the rough-legged hawk (*Buteo lagopus*) during winter and the golden eagle (*Aquila chrysaetos*) year–round. The primary value of meadows to most avian predators was the production of their prey base, but northern harriers (*Circus cyaneus*) and short–eared owls (*Asio flammeus*) nested in lowland meadow habitats at both ranches. Herron et al. (1985) noted that lowland meadow habitats, including wetlands, were essential for nesting populations of these species.

Sage grouse (*Centrocercus urophasianus*) used lowland meadows from mid- to late summer. Meadow habitats in Nevada have been shown to be important sources of insects and succulent forbs for sage grouse broods (Savage 1968, Oakleaf 1971, Klebenow 1972). Eng (1952) and Rogers (1964) found greatest use of low–elevation irrigated meadows when green vegetation was lacking in upland habitat.

Riparian habitat typically supports the most abundant and most diverse avifaunal communities (Carothers et al. 1974, Jahn 1977, Johnson et al. 1977, Odum 1978). A general correlation exists between elevation and the dependency of birds on riparian, marsh and other types of wetlands. Although riparian habitats at higher elevations are important, generally the lower the elevation the larger the percentage of nesting avian species that are associated with the riparian habitat, with water being the limiting factor that determines this phenomenon (Johnson 1978), at least during the nesting season.

Mammals

We recorded use of lowland meadows by 18 mammal species at the Gund Ranch and by 24 species at the Saval Ranch; 4 were considered meadow obligates (Table 3). Although rodent populations were variable from year to year, the highest populations were typically recorded in the lowland meadow type. In 1983, when mountain voles (*Microtus montanus*) reached a cyclic peak, total rodent abundance in lowland meadows was significantly greater (*t* test, $p < 0.001$) than in adjacent upland habitat at Saval Ranch. This was a four–fold difference between habitats. The importance of lowland meadows as mountain vole habitat was also obvious from examination of cumulative trapping records at the Saval Ranch. During 39,200 trap–nights over an eight–year period, voles were only captured in habitats other than lowland meadows during the peak year of the cycle and only in habitats adjacent to the meadows. Other studies have also documented the affinity of mountain voles for meadow habitat (Feldhamer 1979, Clark 1973). Voles constitute an important food item in the diet of many predators. At the Gund Ranch, mountain voles were a preferred prey item of great horned owls (Longland 1983). Other raptors often include vole species in their diets (Marti 1976, Baker and Brooks 1981, Herron et al. 1985).

Deer Mice (*Peromyscus maniculatus*) were the most–abundant rodent during a five-year sampling period at the Gund Ranch. They inhabited both irrigated Great Basin wildrye (*Elymus cinereus*) meadows and adjacent greasewood/sagebrush lands. However, they were significantly more abundant (*t* test, $p < 0.001$) in the unmowed (at the time of sampling) meadow habitat, outnumbering those in upland habitat almost three to one.

Long–tailed shrews (*Sorex* spp.) were trapped incidentally in rodent traps at the

Table 3. Mammal species trapped or observed in lowland meadow habitat on two northern Nevada ranches, 1978–1985.[a]

Species	Ranch[b] Gund	Saval	Species (continued)	Ranch[b] Gund	Saval
Merriam shrew (*Sorex merriami*)	pb	P	Great Basin pocket mouse (*Perognathus parvus*)	OH	OH
Vagrant shrew (*S. vagrans*)	O	O	Beaver (*Castor canadensis*)	NR	P
Montane shrew (*S. monticolus*)	NR	O	W. harvest mouse (*Reithrodontomys megalotis*)	P	P
Shorttail weasel (*Mustela erminea*)	NR	OH	Deer mouse (*Peromyscus maniculatus*)	OH	OH
Longtail weasel (*M. frenata*)	OH	OH	N. grasshopper mouse (*Onychomys leucogaster*)	OH	OH
Badger (*Taxidea taxus*)	P	P	Mountain vole (*Microtus montanus*)	O	O
Coyote (*Canis latrans*)	OH	OH	Sagebrush vole (*Lagurus curtatus*)	OH	OH
Bobcat (*Felis rufus*)	OH	OH	Muskrat (*Ondatra zibethica*)	NR	O
Townsend ground squirrel (*Spermophilus townsendi*)	OH	NR	W. jumping mouse (*Zapus princeps*)	NR	OH
Belding ground squirrel (*S. beldingi*)	P	P	Porcupine (*Erethizon dorsatum*)	NR	OH
Least chipmunk (*Eutamias minimus*)	OH	OH	Whitetail jackrabbit (*Lepus townsendi*)	NR	OH
Valley pocket gopher (*Thomomys bottae*)	P	NR	Blacktail jackrabbit (*L. californicus*)	OH	OH
Mule deer (*Odocoileus hemionus*)	OH	OH	Mountain cottontail (*Sylvilagus nutalli*)	OH	OH

[a]Meadow is defined as lowland riparian and/or wetland vegetation adjacent to springs and streams.
[b]O = obligate; P = preferential use; OH = typically more abundant in other habitat(s); NR = not recorded in the meadow habitat.

Saval Ranch during the inventory phase. Merriam's shrew (*S. merriami*) was recorded only in shrub–covered, south–facing mountain slopes and shrub–invaded meadows along ephemeral low–elevation drainages (Ports and McAdoo in press). Much of the latter habitat is in private ownership on the Saval Ranch. During the research phase, pitfall traps were used, and two other shrew species (*S. monticolus* and *S. vagrans*) were found in this same habitat. These two species appeared to be dependent on the herbaceous meadow vegetation.

We recorded lowland meadow use by mountain cottontails (*Sylvilagus nutalli*) and black–tailed jackrabbits (*Lepus californicus*) at both ranches, and white–tailed jackrabbits (*L. townsendi*) at the Saval Ranch. Of the three, black–tailed jackrabbits were the most abundant on both study areas. Jackrabbits tend to feed in areas with high grass cover (Johnson and Anderson 1984), often moving to these areas at night from adjacent upland habitat (Fagerstone et al. 1980).

The relatively high populations of prey species in the lowland meadows made these meadows attractive hunting areas for predators. Coyotes (*Canis latrans*) were frequently sighted in these meadows, and we also observed evidence of meadow use by badgers (*Taxidea taxus*), bobcats (*Felis rufus*), and short–tailed weasels (*Mustela erminea*). Rabbits and rodents comprise the bulk of coyote diets in the West (Sperry 1941, Murie 1951, Gier 1968, Kauffeld 1977). Badgers also rely heavily on rodents for food (Messick and Hornocker 1981).

Use of lowland meadows by mule deer (*Odocoileus hemionus*) was recorded at both ranches. Although summer deer populations were greatest in adjacent mountain ranges at each ranch, fall and spring use on the way to and from winter ranges was heavy. Mule deer feed primarily on grasses in the spring and forbs in the summer (Kufeld et al. 1973). Hay meadows provide green succulent forage and may be important as spring range for mule deer (Kerr 1979). Leckenby et al. (1982) emphasized the value to mule deer of water and succulent forage at streamsides, spring areas and other moist sites in arid rangelands. During the summer season, deer were observed bedding among willows and other shrubs along low–elevation stream courses and in Great Basin wildrye and other tall vegetation in irrigated meadows.

Management Practices and Implications for Wildlife

Since the vast majority of lowland meadows in the Great Basin are in private ownership, decisions on management and alteration of lowland meadows are made primarily on an economic basis. Resultant effects on wildlife, therefore, are mostly coincidental.

Management practices that can adversely affect wildlife populations on these lands include improper livestock grazing, cutting native hay, phreatophyte control, stream channelization, and habitat conversion through wetland drainage or planting crops. The adverse impacts of such practices can be minimized in some cases by proper planning. For example, livestock grazing intensity, timing and duration can be controlled to minimize impacts and even benefit some wildlife species. Irrigation and development of stockponds or troughs can be largely beneficial to wildlife if done properly. Other practices, such as channelization and phreatophyte control, eliminate more of an already limited habitat and, therefore, are almost always detrimental to wildlife.

Conclusions

Although lowland meadows in the Great Basin comprise only a small portion of the total land area, they provide critical wildlife habitat for many species. As with riparian areas elsewhere in the country, lowland meadows maintain high species diversity of both plants and animals. Numerous other species use these areas for short periods during migration or during dry periods when lush vegetation and water are not available in other habitats. Meadows also produce high populations of prey species important to a variety of avian and mammalian predators.

Predominantly private ownership of these meadows presents a unique challenge to wildlife managers in a region where most of the surrounding land is publicly owned. As Hubbard (1977) suggested for riparian ecosystems in the Southwest, there is a critical need for better education of both public and private land managers about the importance of lowland meadow ecosystems in the Great Basin. Johnson et al. (1980)

pointed out that wetland and riverine habitats often cross managerial and political boundaries. These areas owe much of their diversity to a large degree of edge, which is particularly vulnerable to mismanagement.

Jahn (1980:535) stated that wildlife managers should be challenged to produce "habitat management approaches for 1) wildlife species richness and 2) featured species applied broadly to assure sustained wildlife populations." Efforts to accomplish this in the Great Basin must be essentially holistic in nature if the lowland meadow habitat is included. Bury et al. (1980) emphasized the need for a holistic approach to the study and management of complex natural systems in general. As applied to this region, with its land–ownership patterns and historical livestock use, a holistic approach would specifically include consideration of a given rancher's *entire* land–use plan. More specifically, both the direct and indirect effects of public land grazing guidelines, as they might influence a rancher's use of his private land, must be considered. For example, ranchers faced with depressed market prices and increased production costs may respond to cutbacks in federal grazing permits or increased federal grazing fees by more–intensive use of their private lands. Such intensive management (e. g., phreatophyte control, habitat conversion, etc.) could mean long–term negative impacts on species richness and featured species.

The solutions to such complex land–management problems are not easily obtained and will require much cooperative effort from both the public and private sectors. In Nevada, the Department of Wildlife has worked cooperatively with landowners to preserve sandhill crane breeding habitat in recent years. This is only one example of how focusing on a featured species can result in maintenance of habitats that have value to a variety of wildlife species.

We agree with Carother's (1977:4) philosophy that ". . . we should not look back on land management practices of the past with too much remorse and certainly with no blame"—they merely reflect man's successful settlement, allowing current lifestyles. Rather, past management practices should be a "foundation for learning and understanding how to cautiously move forward in our interactions with the environment."

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Contaminant Situations: Correction/Prevention, Needs/Actions

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Opening Remarks

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It is with great pleasure that I introduce the special session of the 51st North American Wildlife and Natural Resources Conference that is concerned with "Contaminant Situations." This audience will be interested in the fact that a conference held almost 38 years ago to the day dealt with similar issues. The *Transactions* of the 1948 (13th) North American Wildlife Conference included a series of special papers that addressed the then-new issue of DDT in the environment and the consequences of exposure to this organic contaminant for living resources, especially aquatic life.

The papers presented at the 1948 Conference noted that there had been demonstrated effects of DDT. The various authors reported that there could be seen effects on growth and reproduction of fresh-water fish and that terrestrial wildlife had also been affected. There is little doubt that these and similar proceedings played a role in the development of the book *Silent Spring* (1962) authored by then-unknown federal biologist, Rachel Carson.

Certain of the 1948 papers suggested that DDT would not become the problem that it was then being predicted to be by other scientists. As we know, DDT did emerge as a major contaminant in the environment—one that would have very significant impacts on bird life and freshwater fisheries.

In the same *Transactions,* William Voigt presented a paper entitled, "Does Pollution Go on Forever?" This paper reviewed the major pollution issues of the day, and noted that legislation was being considered and passed that was thought then to be an effective deterrent to the development of future pollution problems. It is obvious *today* that legislation passed in the years immediately following World War II was not adequate to prevent continued pollution and physical deterioration of wildlife habitat and freshwater and coastal ecosystems.

Subsequently, extensive federal and state legislation has been passed that created agencies such as the U.S. Environmental Protection Agency. These agencies have grown from organizations consisting of hundreds of scientists and managers to bureaucracies that now employ tens of thousands of environmental scientists, technicians and managers. Despite the development of such environmentally oriented organizations, and despite major elements of the Departments of Interior and Commerce greatly increasing their environmental programs concerned with wildlife and fisheries, it can be documented today that there continues to be an increase in pollution and pollution effects. In fact, there have been increases in the rates at which habitats are being lost to development and to physical and chemical degradation.

This special session on Contaminant Situations grew out of one of the special sessions that was held during the 1985 (50th) North American Wildlife and Natural Resources Conference in Washington, D.C. The organizers of the present session believed that it would be appropriate to review what is presently known about specific contaminants and how contaminants might be affecting wildlife in several geographic areas. Some individuals believed that it would be prudent to concentrate on the effects of a particular contaminant within a geographic area, for instance, how selenium has affected water-fowl and fish in California's Kesterson National Wildlife Refuge. Others felt, however, that some attention should be given to other geographic areas. Thus, the final program developed with a broad national focus, but with a concentration of papers having to do with the Kesterson situation.

From today's papers, this audience should be able to see that there are problems in the Northeast, the northcentral states, in the area surrounding Puget Sound and, especially, in the central valleys of California. What should emerge from these papers is an understanding that the environmental and habitat issues of the late twentieth century are numerous and include problems that revolve around both point and nonpoint source situations. In some areas, for instance the coastal waters of the New York Bight, it has been shown that pollution effects appear in many cases to be related to direct inputs of contaminants. But in other regions, pollution effects are obvously the result of overall deterioration in water quality of entire drainage basins and connecting estuaries and wetlands.

Once we have heard the details and thrust of today's papers, it is perhaps most important to begin to think about the rate at which contaminants are having their impacts, about the total resources in jeopardy and, finally, about how we can best manage our society so as to prevent the continued loss of habitat, wildlife resources, and the numerous pleasures such as hunting, fishing and esthetics associated with our wildlife.

The persons who introduced the sessions of the 1948 conference were optimistic that steps being taken at the midpoint of this century would reverse the early trends seen as a result of aquatic and terrestrial pollution. At about the end of the third quarter of this century, many environmentalists felt that by observing Earth Day, in April 1972, the nation would focus its attention on environmental, habitat and wildlife issues. In many respects, unfortunately, the national attention span was brief. Pollution seems to be more widespread than ever. It has now reached the sources of drinking water for millions of humans. Moreover, the rate of habitat lost to development and physical degradation has actually increased on a per–annum basis.

On a more-optimistic note, today's session will serve to refocus increased attention on such environmental priorities. It would be most disturbing to think that 38 years from now these same issues would still be debated at the 89th North American Wildlife and Natural Resources Conference.

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Kesterson Reservoir and Kesterson National Wildlife Refuge: History, Current Problems and Management Alternatives

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In June 1960, Congress authorized construction of the San Luis Unit within California's Central Valley Project as a joint federal/state–funded irrigation project under Public Law 86–488. The Central Valley Project provides water to farmland within numerous water districts along the western side of the Central Valley. Much of the farmland within this area is underlain by impermeable clay layers. These natural barriers often cause the formation of shallow water tables that inhibit the complete leaching of naturally occurring salts beyond the root zone of crops. Installation of subsurface drainage systems has been accomplished to remove the salt–laden water. One provision of P.L. 86–488 empowered the Secretary of the U.S. Department of the Interior to construct a drain that would transport subsurface drainwater from the Westlands Water District to a discharge point in the western San Joaquin–Sacramento Delta at Suisun Bay (Figure 1).

In 1962, the California Department of Water Resources requested that the U.S. Bureau of Reclamation (USBR) construct an agricultural waste water drain. The USBR began the planning and preparation for that construction. In April 1964, however, the Department of Water Resources reversed itself and gave assurances that the drain for the Central Valley could be funded and, therefore, would be built by the State. Based on lack of State funding, the Department of Water Resources reversed itself yet again in May 1967, and requested that the USBR proceed with the Drain's construction.

In December 1967, the Kesterson Reservoir was included in the USBR's agricultural drainage program. A contract for construction of the first stage of the drain was awarded in March 1968. Shortly thereafter, the USBR purchased 5,900 acres (2,388 ha) of native grasslands and wetlands in Merced County, near Gustine, California. This property was to be used as the site of the Reservoir, the purposes of which would be to store and control the initial drain flows, pending results of a study on the effects of the eventual discharge into the San Joaquin–Sacramento Delta. Pending completion of a final supplemental environmental impact statement for the San Luis Unit, the Reservoir was to consist of approximately 4,700 acres (1,900 ha), and the San Luis Drain extended to its planned discharge point (Figure 2).

Following the USBR's acquisition of the 5,900 acres (2,388 ha) the U.S. Fish and Wildlife Service (USFWS) asked the Secretary of the Interior, under provisions of Section 3 of the Fish and Wildlife Coordination Act, to designate the area as a unit of the National Wildlife Refuge System. The Secretary approved in 1969 a general plan between the USFWS and the USBR to make these federal lands available to the USFWS for the conservation and management of wildlife resources, subject to the primary purpose of the Kesterson Reservoir for the regulation of drainage water. In July 1970, a cooperative agreement was signed and executed by the USFWS and the

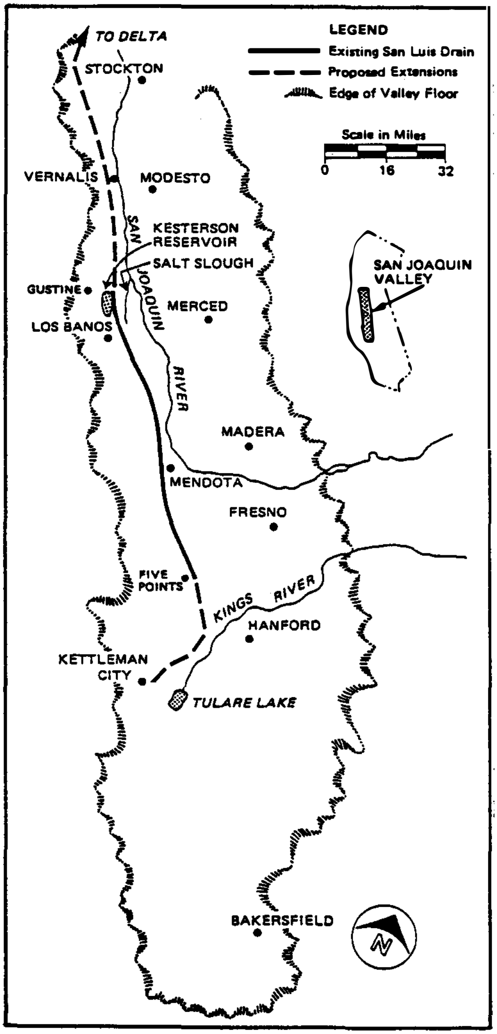

Figure 1. San Luis Unit, Central Valley Project, California.

USBR, formally establishing the Kesterson National Wildlife Refuge (Figure 2).

By 1972, 82 miles (132 km) of the concrete–lined San Luis Drain and 12 evaporation ponds totalling 1,280 acres (518 ha) within the Refuge were constructed. Between 1972 and 1978, the water discharged into the Reservoir consisted mainly of surface water from local sources. Its quality was similar to that of applied irrigation water. A diversity of aquatic plants began to appear and flourish in the ponds, including cattail (*Typha latifolia*), Baltic ruch, (*Juncus balticus*), alkali bulrush (*Scirpus robustus*), wild millet (*Echinochloa crusgalli*), horned pondweed (*Zannichellia palustris*) and swamp timothy (*Heleochloa schoenoides*).

A variety of aquatic wildlife species began to utilize the Reservoir for nesting

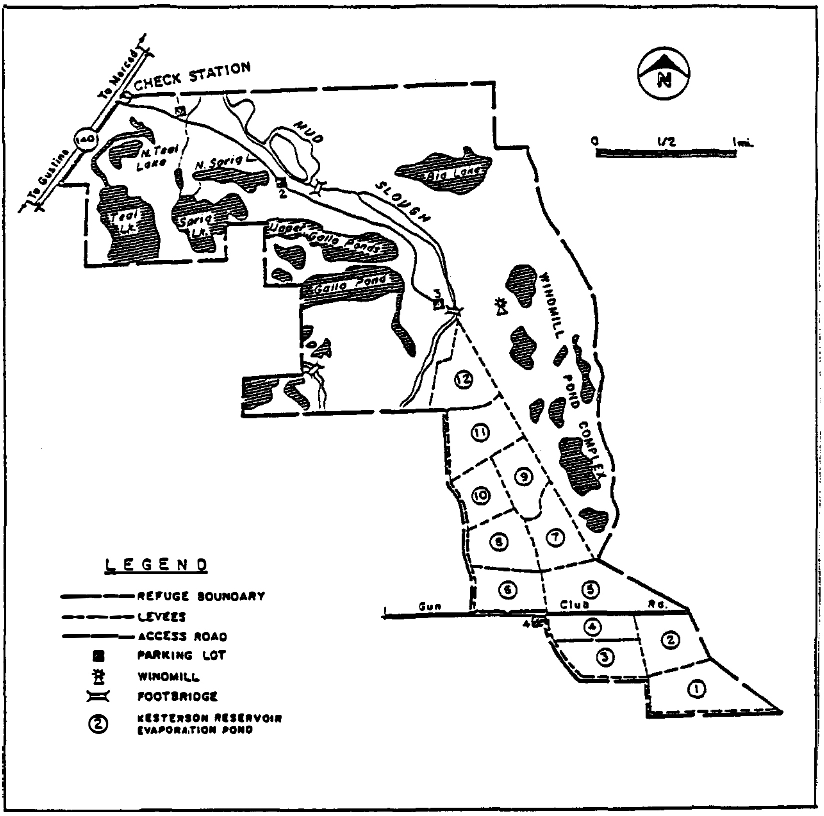

Figure 2. Kesterson National Wildlife Refuge, including Kesterson Reservoir, Merced County, California.

habitat, including American coot (*Fulica americana*), pied–billed grebe (*Podilymbus podiceps*), black–necked stilt (*Himantopus mexicanus*), mallard (*Anas platyrhynchos*) and cinnamon teal (*A. cyanoptera*). Many wintering birds were also attracted to the Reservoir's abundant food base. Peak populations of 12,000 waterfowl of various species were observed within the 1,280 acre (518 ha) unit. Up to 150,000 waterfowl have been observed within the natural wetland habitat on the Refuge.

Recreational activities associated with the Refuge and the Reservoir have included wildlife observation, hiking, photography and waterfowl hunting. Average total annual public use has been estimated at 2,500 visits.

During 1978, a limited quantity of subsurface drainage began to flow into the Drain. This drainage increased dramatically in 1980 and, by 1981, the water within the Drain was exclusively subsurface flow. Approximately 7,000 acre–feet (2,833 ha–ft) of subsurface drainage water was transported annually to the Reservoir.

During May 1981, USBR personnel began water quality testing within the Drain. This testing was in conjunction with the formal notification of minimum information required for a National Pollutant Discharge Elimination System permit. Initial test results for selenium appeared to be elevated, but were not specifically meaningful at that time.

In 1982, the USFWS agreed to provide a research proposal to the USBR for bioassays in determining toxicity from drainage constituents. During an April 1982 tour of the Reservoir, USFWS research and refuge personnel observed an apparent deterioration of the Reservoir's aquatic ecosystem. Following subsequent discussions with USBR personnel, it was judged that the Reservoir could be well–suited for a study on the biomagnification of toxicants in the food chain.

Preliminary samples of mosquitofish (*Gambusia sp.*) were collected in May 1982. Tests showed that selenium levels in mosquitofish from the Kesterson Reservoir were nearly 100 times greater than those from a nearby control area.

A subsequent review of published scientific research revealed that high concentrations of selenium cause mortalities and deformities in chicken and turkey embryos. Although no abnormalities had been observed in waterfowl at the Reservoir, USFWS research personnel were concerned that bird embryos could be affected. Field observations made by the USFWS in May and June of 1983 showed very high incidences of mortality and deformity among newborn coots, grebes, stilts and ducks at the Reservoir.

During 1982, the USBR established a monitoring program to determine groundwater levels. Groundwater and surface water quality was also monitored at selected sites within the Reservoir and surrounding areas. The objective of the monitoring program at that time was to evaluate the effects from storage of subsurface agricultural drainage in the Reservoir on surrounding landscape, including surface and subsurface water supplies. The program was also designed to define the extent of selenium and other trace element contamination in surface and groundwater at the Reservoir and measure the movement of these constituents both vertically and laterally from the Reservoir.

Because of potential impacts from public visitors to ongoing wildlife research programs within the Reservoir, the USFWS closed it to general public access in 1983. A public waterfowl hunting program, operated cooperatively between the USFWS and the California Department of Fish and Game, was continued at the Refuge, including the Reservoir, during the 1983–84 waterfowl hunting season. This hunting program was highly regulated, including the issuance of permits to limit numbers of hunters utilizing these areas on any specific day. No other public use was allowed within the Reservoir.

The discovery of wildlife deformities within the Reservoir received local, national and international media coverage. Official news conferences, tours, lectures and workshops on the situation have continued to present.

During November 1983 and January 1984, claims from a private individual were submitted to the Department of the Interior for alleged flooding damages associated with the construction and operation of the Drain and the Reservoir. In April 1984, the same individual filed suit against the United States to compel the Secretary of the Interior to close the Reservoir and clean up the alleged damage.

During December 1983, the California Department of Fish and Game collected coots from the Kesterson National Wildlife Refuge for testing. The results of these tests disclosed selenium contaminant levels of public health concern. The California Department of Health Services issued a notice of limitation on the consumption of coots from the Refuge, including the Reservoir. During 1984, research studies at the

Kesterson Reservoir further documented the presence of selenium in aquatic birds. The research findings included: embryo deformities and mortality; trend of body weight loss in adult birds; death of adult birds; trend of increasing selenium concentrations in bird samples; elevated levels of selenium in food chain organisms; and nesting failures. As a result of these findings, and in addition to positive identification of selenium toxicosis as the cause of death of American coots in the Reservoir, USFWS and USBR personnel initated plans for a waterfowl protection program at the Reservoir. The program consisted of three parts: (1) making the Reservoir unattractive to waterfowl; (2) hazing to frighten birds away; and improvement of nearby habitat to attract waterfowl.

The hazing program was implemented in September 1984. Scarecrows, propane exploders and such fireworks as whistle bombs and shellcrackers were utilized by USFWS personnel to frighten waterfowl and discourage their use of the Reservoir. Systematic bird census data was gathered to monitor the program's success. To offset the loss of habitat to birds as a result of hazing, the USBR provided a water supply of approximately 15,000 acre–feet (6,070 ha–ft) to improve nearby habitat. These waters were applied to selected private and public wetlands between October 1984 and June 1985. The result was enhancement of waterfowl habitat during the critical wintering and nesting periods.

The Kesterson Reservoir was closed to public waterfowl hunting during the 1984–85 waterfowl hunting season, but the rest of Kesterson National Wildlife Refuge was open to hunting and other public–use activities.

Effective February 5 1985, the California State Water Resources Control Board adopted Cleanup and Abatement Order No. WQ 85–1, requiring the USBR to eliminate nuisance conditions within three years. The order required the USBR to: minimize seepage at the Kesterson Reservoir; alleviate the threat of future surface discharges from the Reservoir due to inadequate capacity; mitigate nuisance conditions caused by the operation of the Reservoir; submit a revised Report of Waste Discharge or a closure and postclosure maintenance plan to the regional and state boards; submit details of a monitoring program; and submit bimonthly status reports.

The Solicitor of the Department of the Interior advised the Secretary on March 14, 1985, that, because the hazing program at the Reservoir was not entirely effective, employees performing their official duties in connection with the operation of the Reservoir could not be assured that their actions would not be found to violate the Migratory Bird Treaty Act if waterfowl died from ingesting selenium. Based on that advice, the Interior Department decided to begin immediately the process of plugging the San Luis Drain and closing the Reservoir. To implement this decision, the Department entered into an agreement with the Wetlands Water District on April 3, 1985, to curtail drain-water discharges to the San Luis Drain. The agreement specified that the amount of drainage would be reduced in phases and discontinued entirely by June 1986.

On July 5, 1985, the Department of the Interior submitted a framework plan to the California State Water Resources Control Board for closure and cleanup of the Kesterson Reservoir. The plan provided for a three–phase approach:

- *Phase I* of the plan included immediate activities to reduce the nuisance, such as vegetation removal and increased waterbird hazing, and provide supplemental water to wetlands and initiate a monitoring program.

- *Phase II* consisted of incremental reduction of drainwater inflow to the San Luis Drain. An EIR/EIS was to be prepared by the Wetlands Water District, to address long–term drainwater disposal.
- *Phase III* is the cleanup of the Kesterson Reservoir and the San Luis Drain. A detailed clean–up plan and an environmental impact statement will be prepared for submission to the California State Water Resources Control Board. The scope of the environmental impact statement, as determined by USBR and USFWS, includes the impact of land use and clean–up alternatives for the Reservoir and the entire length of the Drain. It also includes the impacts of providing mitigation for the loss of historical baseline wetland habitat values at the Reservoir. The final environmental impact statement will be completed by September 1986.

The unprecedented occurrence of selenium–related wildlife deformities at the Kesterson Reservoir has forced wetland managers throughout California's Central Valley to examine the quality of traditional water supplies. Drainwater has supplied over 60 percent of the annual water needs on 37,000 acres (14,975 ha) of privately owned wetland within the Grassland Water District of Merced County. A biological monitoring program has been implemented to determine possible impacts of drainwater on the area. This project, initiated in June 1985, will determine the levels of selenium and other heavy metals in major biotic and abiotic components of a wetland system that winters hundreds of thousands of migratory bird species. When completed, the project will provide information for future management decisions ranging from possible clean–up activities to a request for alternate, clean water supplies for these valuable wetlands.

Relationships Between Selenium Concentrations and Avian Reproduction

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Introduction

Aquatic birds nesting at Kesterson Reservoir in Merced County, California, experienced poor reproductive success in 1983 (Ohlendorf et al. 1986). A high frequency of both embryo mortality and developmental abnormalities occurred in most species. Forty-one percent of 347 nests followed through late incubation or hatching had at least one dead embryo; 20 percent had at least one embryo or chick with obvious abnormalities. Deformities were often multiple and included missing or abnormal eyes, beaks, wings, legs and feet. These defects were similar to those in embryos of chickens and mallards (*Anas platyrhynchos*) fed diets containing 7–25 ppm of selenium (Poley et al. 1937, Ort and Latshaw 1978, Heinz et al. in prep.). Reproductive problems similar to those observed in 1983 were also found at Kesterson during subsequent studies in both 1984 and 1985 (Ohlendorf et al. unpubl. data).

There have been increasing concerns raised about the potential effects of selenium on nesting birds throughout the western United States and in other areas where selenium levels may be elevated. However, levels of selenium required to produce embryotoxicity in various species have not previously been determined.

The objectives of this paper are to: (1) compare selenium concentrations in eggs of aquatic birds at Kesterson Reservoir with those from two nearby areas; and (2) determine the relationship between selenium concentration and reproduction in selected species.

Study Areas and Methods

Study Areas

Our primary study area was Kesterson Reservoir, located on the Kesterson National Wildlife Refuge, about 5 miles (8 km) east of Gustine, California. The reservoir consists of 12 shallow ponds, averaging less than 4 feet (1.2 m) deep, with a total surface area of about 1,200 acres (500 ha). Kesterson was originally intended to serve as one of several regulating reservoirs for the San Luis Drain, but when completion of the drain was delayed, Kesterson remained as a series of evaporation ponds. Kesterson's water originates from subsurface agricultural drains in Fresno County and is transported to the ponds via the San Luis Drain.

The control area for our study was the Volta Wildlife Area, located about 6 miles (10 km) southwest of Kesterson. This state–managed area covers about 2,800 acres (1,130 ha) and consists of 36 ponds managed primarily for wintering waterfowl. Volta receives water that is not contaminated by agricultural drainwater.

The third study area was the southern portion of the Grassland Water District in Merced County. This area between Los Banos and Dos Palos consists primarily of duck–hunting clubs. Our Grassland sites were located about 15–20 miles (24–32 km) southeast of Kesterson. Water for marsh management in this area is a mixture of subsurface agricultural drainwater and other water.

In 1983, water entering Kesterson Reservoir contained about 300 ppb selenium (Presser and Barnes 1984, Ohlendorf et al. 1986). Mean selenium concentrations in plants, invertebrates and fish from the ponds were 22–175 ppm (dry weight). These levels in biota were 12–130 times those found at Volta, which received water containing normal levels of selenium—about 1 ppb or less (Saiki 1986). Concentrations of heavy metals were generally similar in bird livers and in food organisms at Kesterson and Volta (Ohlendorf et al. 1986). Boron, however, occurred at higher concentrations in plants, invertebrates and fish at Kesterson than at Volta.

The water used for marsh management in the Grasslands during 1984 had an average selenium concentration of about 50 ppb (Presser and Barnes 1985), and selenium levels in the biota were generally intermediate between Kesterson and Volta (Ohlendorf et al. in prep.).

Field Methods

We searched for active nests of aquatic birds weekly during April–June 1983 and 1984 at Kesterson and Volta, and during April–June 1984 in the Grasslands. We checked the incubation status of marked nests each week to monitor hatching success. Although our searches were not conducted in a strictly random fashion, we assumed that the nests we found represented a "random" sample of those occurring on the study areas. The following species were selected for study because they had differing food habits and were abundant during the nesting season at one or more of the study areas: American coot (*Fulica americana*); mallard, cinnamon teal (*Anas cyanoptera*); gadwall (*A. strepera*); black–necked stilt (*Himantopus mexicanus*); American avocet (*Recurvirostra americana*); pied–billed grebe (*Podilymbus podiceps*); and eared grebe (*Podiceps nigricollis*).

A subgroup of the marked nests was randomly selected, and one egg was collected at random from each for chemical analysis. Eggs that failed to hatch or that were collected for other special reasons (e.g., abnormal chicks observed in the nest), were considered "non–random" but were analyzed for selenium. Embryos in all collected eggs were examined for viability and external deformities. Although embryo death usually could be detected at any incubation stage, deformities could be detected only in embryos that had at least reached moderate development (i.e., about one–half term).

Analytical Methods

We homogenized each egg in a Virtis blender and placed a one– to two–gram subsample in a drying oven overnight at 176 degrees Fahrenheit (80 degrees Celsius) for moisture determination. We placed another one–gram portion of the homogenate in an Erlenmeyer flask and added 20 ml of concentrated nitric acid for the selenium analysis. The acid–sample mixture was left at room temperature overnight, then placed on a hot plate at a low temperature setting for two hours. The temperature was then raised to boil slowly away all but 1–2 ml of digestate which was transferred to a 50–ml polypropylene tube and diluted to 25 ml with distilled, deionized water.

We made selenium determinations by graphite furnace atomic absorption spectrophotometry on a Perkin Elmer Zeeman 5000, equipped with an HGA 500 furnace, AS–40 autosampler, and data system 10. We also used the Stabilized Temperature Platform Furnace technique (Slavin et al. 1983) and Zeeman effect background correction. A selenium electrodeless discharge lamp was used at 196.0 nm with a spectral slit width of 2.0 nm. We used a matrix modifier containing 1.25 g/L of copper and 0.5 g/L of iron, and a furnace program similar to that described by Welz et al. (1983).

Recoveries from spiked chicken livers and eggs as well as National Bureau of Standards reference materials averaged 101 percent. The lower limit of reportable selenium was 0.05 ppm wet weight. Selenium concentrations were then converted to dry weight to maintain consistency with the samples of food chain organisms and livers collected and analyzed in conjunction with our other studies (e.g., Ohlendorf et al. 1986). Moisture content is shown for each group of egg samples in Table 1, so readers can make approximate conversions to wet–weight selenium concentrations.

Statistical Methods

Selenium concentrations were transformed to common logarithms for all statistical tests. When selenium was detected in at least half of the samples in a particular group, a value of 0.10 ppm was assigned to "not–detected" values for logarithmic transformations. Unless stated otherwise, the probability level used to determine statistical significance for all tests was $P < 0.05$.

We used analysis of variance to compare mean selenium concentrations in randomly collected eggs among species, locations and years (shown in tables 1 and 2). Duncan's multiple–range test was then used to separate means. Randomly collected eggs also were used to relate selenium concentrations to reproductive effects, unless the nest was later lost to predation or desertion. Results from non–randomly collected eggs were used only to relate selenium concentrations to the incidence of dead or deformed embryos and are not shown in tables.

We analyzed coot, stilt and eared grebe data to assess the effects of selenium on reproduction; data for other species were too limited for these analyses. We used logistic regression (Cox 1970) to relate selenium concentration in the sample egg to: (1) embryo death or deformity (considered jointly as "embryotoxicity") in the sample

Table 1. Seleniuim concentrations (ppm dry weight) in randomly collected eggs of aquatic birds from Kesterson Reservoir (KR) and Volta Wildlife Area (VWA) in 1983–84, and from the Grasslands Water District (GWD) of western Merced County, California in 1984.

Species and location	1983				1984			
	N	Mean[a]	Range	Moisture[b]	N	Mean[a]	Range	Moisture[b]
Coot								
KR	15	30.9	17–74	73				
VWA					5	Nd[c]	Nd	75
Stilt								
KR	11	28.2A[d]	14–58	70	37	24.8A	5.2–64.0	71
GWD					6	4.68B	3.8–5.7	73
VWA[e]	3	2.67B	1.3–7.3	70	10	0.386C	Nd–1.9	72
Avocet								
KR[f]	9	6.00A	2.3–22.0	68	26	16.4A	3.4–61	73
GWD					2	5.79A	5.0–6.7	74
VWA[e]	2	1.24B	1.1–1.4	69	5	0.320B	Nd–2.4	72
Eared grebe								
KR	18	69.7	44–130	76				
Pied–billed grebe								
GWD					1	5.6		78
VWA	1	1.9		76	2	0.259	Nd–0.67	76
Gadwall								
KR	6	18.8A	9.6–32.0	67	6	21.4A	18–26	70
GWD					4	4.83B	2.9–6.8	68
VWA	2	0.839B	0.64–1.1	65	1	Nd		68
Mallard								
KR	5	15.2	9.3–31.0	65	5	10.4A	3.6–19.0	71
GWD					7	3.64B	2.1–6.0	69
VWA	1	1.2		66	2	0.152C	Nd–0.23	69
Cinnamon teal								
KR	2	6.85	6.6–7.1	66	5	13.5A	7.7–37.0	69
GWD					4	6.52B	6.2–6.7	69
VWA					1	Nd		70

[a]Geometric mean calculated when two or more samples were analyzed and when >50 percent of samples had detectable (>0.20 ppm dry weight) levels of selenium. A value of 0.10 ppm was assigned to Nd values to enable computation of some geometric means.
[b]Average moisture content (percentage) in samples.
[c]Nd = Not detectable (limit = 0.20 ppm dry weight).
[d]Means followed by same capital letter are not significantly different ($P > 0.05$) between/among sites (within species and year).
[e]Selenium concentration was lower ($P < 0.001$) at VWA in 1984 than in 1983.
[f]Selenium concentration was greater ($P < 0.001$) at KR in 1984 than in 1983.

egg; (2) the incidence of embryotoxicity in any egg of the clutch; and 3) the hatching success of the nest.

We classified a clutch as showing embryotoxic effects if at least one of the examined embryos or chicks was dead or deformed. We determined the minimum frequency of mortality or deformity by examining some eggs from many of the nests. However, for other nests, no eggs were examined, or the eggs were collected too early during incubation to determine whether they showed embryotoxic effects. We included only nests monitored through late incubation to calculate the percentage of nests with dead or deformed embryos.

The clutch was considered "normal" if all examined eggs were classified as alive and normal or if all eggs were presumed to have hatched. We presumed that eggs hatched successfully if the nest was found empty near the expected hatching date, and we saw no evidence of nest predation. We also presumed that live, normal, late–stage embryos in collected eggs would have hatched successfully if left to term. A clutch was classified as "unknown" if we found no dead or deformed embryo but could not determine the status of at least one egg examined from the clutch.

We assumed that intraclutch variability of selenium values was low and that selenium concentration in any egg was a valid estimate for the clutch. Available data are insufficient to determine whether our assumptions are valid; further field or laboratory studies are needed to measure intraclutch variability.

The response variable for the logistic regressions was binary. We assigned a value of 1 if the embryo in the sample egg or in any other egg of the clutch was dead or deformed and 0 if alive and normal. We defined hatching success as the number of normal chicks that hatched or were presumed to have hatched from the eggs remaining in the nest (including those that could have hatched from any collected eggs), divided by the number of eggs in the clutch. For analysis of hatching success, we assigned nests a value of 0 if 0–50 percent of the eggs hatched and 1 if 51–100 percent hatched. We used standard maximum likelihood procedures to estimate and test appropriate parameters for all logistic regressions.

Results

Selenium Concentrations in Eggs

Mean selenium concentrations at Kesterson Reservoir were significantly higher than at Volta for all species we could test statistically (Table 1). However, one stilt egg from Volta in 1983 contained 7.3 ppm selenium, which was within the range of concentrations found at Kesterson in 1984. Only one other egg at Volta (an avocet in 1984) contained more than 2 ppm selenium. Selenium levels in eggs from the Grasslands were intermediate between Kesterson and Volta; differences were statistically significant for certain species in the three areas.

There were no interspecific differences in selenium concentrations at Volta or the Grasslands, but there were significant differences at Kesterson in 1983 and 1984 (Table 2). Eared grebe and coot eggs contained the highest mean selenium concentrations in 1983, but neither species nested at Kesterson in 1984. Of the species that did nest, the only significant change between years occurred in avocets. Because their mean selenium concentration nearly tripled in 1984, avocets (which were lowest in 1983) were not significantly different from stilts in 1984.

Reproductive Impacts

We found no deformed embryos and only two dead ones (a stilt and an avocet) at Volta during 1983–84. In both years, however, aquatic birds nesting at Kesterson produced eggs with high frequencies of embryotoxicity (i.e., dead or deformed embryos or chicks) (Table 3). Coots and grebes had similar frequencies of embryotox-

Table 2. Comparison of selenium concentrations (ppm dry weight) in randomly collected eggs of aquatic birds at Kesterson Reservoir, 1983–84.

Species	1983 N	1983 Mean	1984 N	1984 Mean
Eared grebe	18	69.7A[a]	0	
Coot	15	30.9B	0	
Stilt	11	28.2B	37	24.8A
Gadwall	6	18.8BC	6	21.4A
Mallard	5	15.2C	5	10.4B
Cinnamon teal	2	6.85D	5	13.5AB
Avocet	9	6.00D	26	16.4AB

[a]Geometric means within year followed by the same capital letter are not significantly different ($P < 0.05$).

Table 3. Frequency of embryotoxicity (dead or deformed embryos or chicks) and maximum hatching success for aquatic birds at Kesterson Reservoir, 1983–84.

Species (year)	Nests[a] Monitored	Nests[a] Found	Number (percentage) of nests with embryotoxicity[b] Dead	Deformed	Total	Hatching success[c] Number	Hatching success[c] Percentage
Coot (1983)	59	92	35 (59.3)	25 (42.4)	38 (64.4)	53	89.8
Eared grebe (1983)	141	163	84 (59.6)	22 (15.6)	89 (63.1)	116	82.3
Stilt (1983)	101	125	17 (16.8)	18 (17.8)	24 (23.8)	95	94.1
Stilt (1984)	63	189	7 (11.1)	12 (19.0)	14 (22.2)	48	76.2
Duck (1983)[d]	30	42	5 (16.7)	3 (10.0)	7 (23.3)	27	90.0
Duck (1984)[d]	13	36	6 (46.2)	0 (0)	6 (46.2)	6	46.2

[a]*Nests monitored* to hatching or from which a late-stage embryo was collected; *nests found* during study, including those lost to predation, flooding, desertion, etc.
[b]Dead = nests with one or more dead embryos; deformed = nests with one or more deformed embryos or chicks; total = sum of all nests with at least one dead or deformed embryo or chick. All percentages calculated by dividing by number of monitored nests.
[c]Number of nests in which at least one normal chick was observed or presumed to have hatched (see *Methods*). Percentage hatching success is based on number of monitored nests.
[d]Species as listed in tables 1 and 2.

icity in 1983; nearly two-thirds of their nests had at least one dead or deformed embryo or chick. More than 40 percent of the coot nests had at least one deformed embryo or chick.

At Kesterson, adult coots appeared to be about as numerous in 1984 as in 1983. However, where we found 92 nests in 1983, we found none in 1984. Instead, we found many dead and moribund adult coots in the ponds that year. This mortality and failure to nest have been attributed largely to the debilitating effects of selenium toxicosis (Kilness et al. in prep). Eared grebes also did not nest at Kesterson in 1984. However, we saw no more than 10 adult grebes there early in the spring and none during the nesting season (April–July) that year.

Stilts nested at Kesterson in substantial numbers during both years, and each year dead or deformed embryos were found in nearly one–fourth of the nests (Table 3). We also monitored avocet nests both years (17 in 1983; 51 in 1984), but found no evidence of embryotoxicity either year. However, we observed embryotoxicity in avocets as well as stilts, ducks and killdeer (*Charadrius vociferus*) during follow–up studies in 1985.

In 1983, the frequencies of dead and deformed embryos in ducks and stilts were similar (Table 3). Although duck deformities were not observed in 1984, embryo mortality nearly tripled in ducks. These changes may have been due to the small number of duck nests we were able to follow to the late stages of incubation. In 1984, more than one–half of the duck and stilt nests were lost to predation.

Circumstantial evidence suggested that hatchling survival at Kesterson Reservoir in 1983 was poor for grebes and coots (Ohlendorf et al. 1986). Also, intensive observations of stilts and avocets in 1984 indicated that no chicks survived beyond about two weeks of age (M.L. Williams personal communication).

Selenium Impacts in Sample Eggs

The predicted incidence of embryotoxicity in coot (Figure 1) and stilt (Figure 2) eggs increased significantly as selenium concentration in the analyzed egg increased. Coot embryos had an estimted 50–percent probability of embryo death or deformity when selenium concentrations in the eggs were about 18 ppm (dry weight). However,

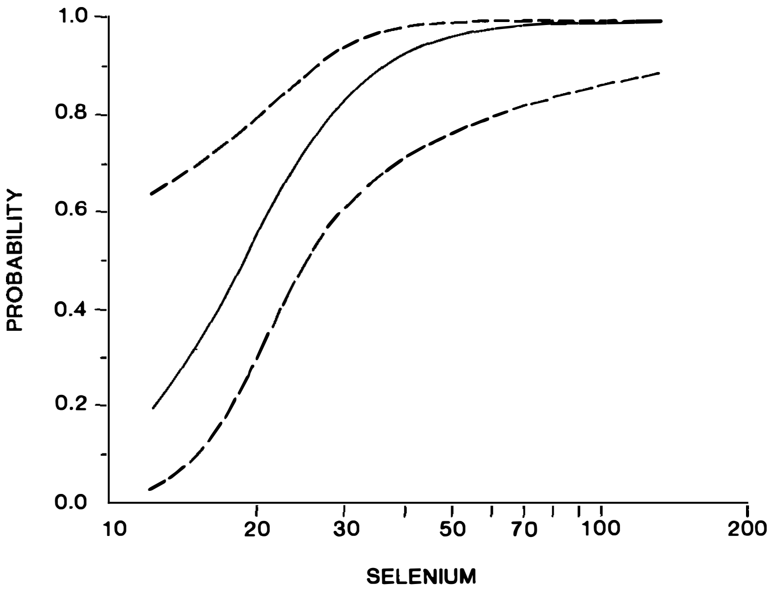

Figure 1. Relationship between the predicted incidence of embryotoxicity in sample coot eggs and the selenium concentration (ppm dry weight) in those eggs, 1983. Dashed lines show estimated 95–percent confidence interval.

even at the lowest selenium concentration recorded for coots at Kesterson (12 ppm in a non–random egg), the probability of embryotoxicity was about 20 percent. For stilts, the 50–percent level was about 24 ppm, and the 20 percent–level was about 5 ppm. Eight stilt eggs collected from Volta were included in the analysis, producing much better coverage of the lower selenium levels for this species than that for coots or eared grebes. One of these stilt eggs had a dead embryo that was probably not caused by selenium (0.45 ppm) in the egg.

Unlike in coot and stilt eggs, there was no significant relationship between embryotoxicity and selenium concentration in grebe eggs. It appears that even the lowest selenium concentrations (44 ppm) exceeded the embryotoxic level. The probability of embryotoxicity in grebes remained constant (84 percent) with respect to selenium level.

Selenium Impacts in Sampled Clutches

We could not determine whether embryotoxicity in coot clutches was related to selenium concentration in eggs, because each clutch had at least one dead or deformed embryo. Likewise, all but one of the eared grebe clutches had at least one dead or deformed embryo, and the relationship between selenium concentration and incidence of embryotoxicity was not statistically significant.

In stilts, the probability of embryotoxicity in the clutch was significantly ($P < 0.01$) related to selenium concentration in the sample egg (Figure 3). The probability of death or deformity in the clutch was estimated to be 50 percent when selenium concentration in the sample egg was 20 ppm; at about 5 ppm the probability was 20 percent.

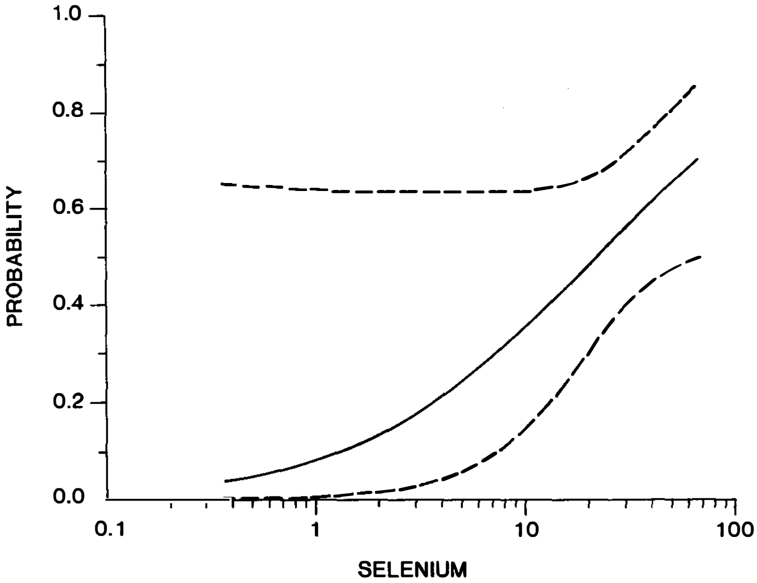

Figure 2. Relationship between the predicted incidence of embryotoxicity in sample stilt eggs and the selenium concentration (ppm dry weight) in those eggs, 1983–84. Dashed lines show estimated 95–percent confidence interval.

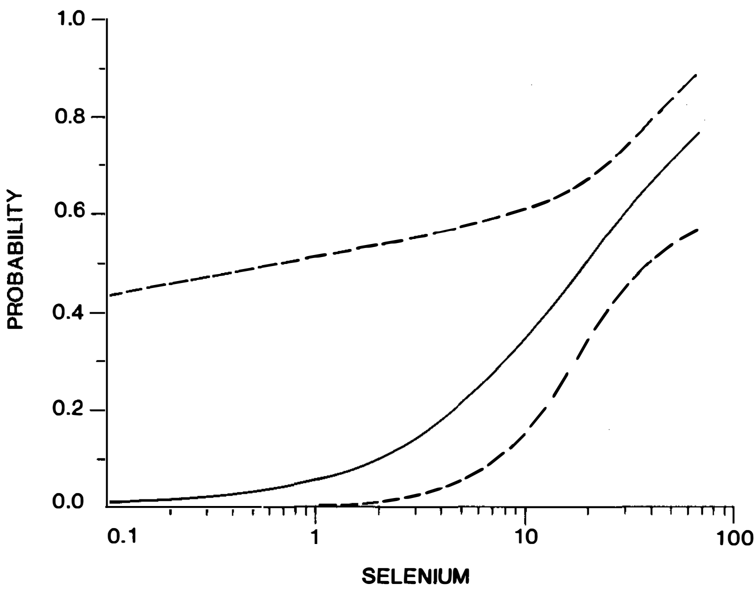

Figure 3. Relationship between the predicted incidence of embryotoxicity in at least one embryo of the clutch and selenium concentration (ppm dry weight) in the sample egg for stilts, 1983–84. Dashed lines show estimated 95–percent confidence interval.

Selenium Impacts on Hatching Success

Even at the highest concentrations of selenium, some eggs hatched in most coot, stilt and grebe nests at Kesterson Reservoir (Table 3). However, the percentage of eggs hatching within these nests was low in all three species (Ohlendorf et al. unpubl. data). Hatching success in coots and grebes tended to decrease as selenium concentration increased, but this relationship was not statistically significant. All monitored coot and grebe nests at Kesterson apparently contained eggs with embryotoxic concentrations of selenium.

The coot and grebe nests considered in this logistic analysis (as well as in the sampled clutches above) were a subset of all the nests monitored through late incubation (Table 3). Eggs were not collected from some nests monitored through late incubation, and many nests were included in the logistic regression because they had dead or deformed embryos or chicks (i.e., non–random eggs collected because they failed to hatch, etc.—see *Methods*). Hence, the frequency of observed embryotoxicity and estimated hatching success in this subset are not directly comparable with the entire populations of coots or grebes at Kesterson.

Hatching success of stilt nests decreased significantly as selenium concentrations in eggs increased (Figure 4). However, overall hatching success was much higher than for either coots or grebes, both of which had higher mean selenium levels and higher frequencies of embryotoxicity than did stilts. Even at the highest selenium level used in this regression (61 ppm), the probability that more than half of the eggs would hatch successfully was 44 percent.

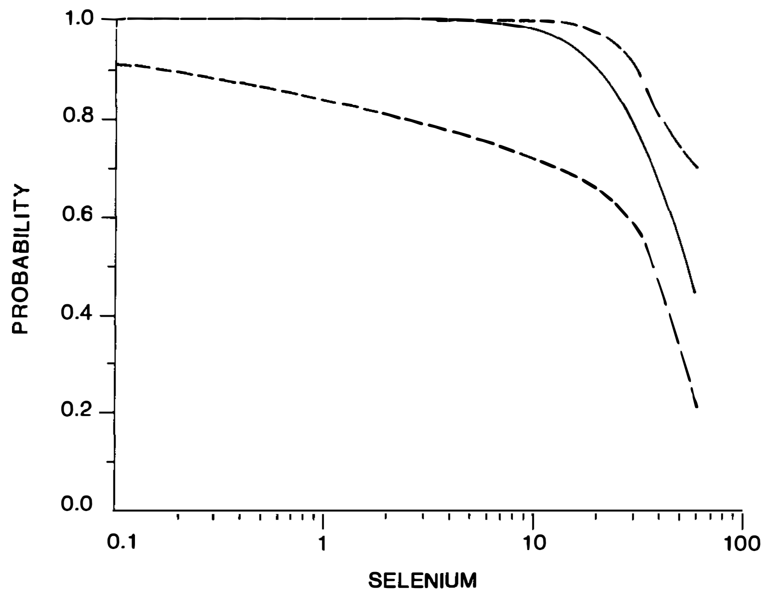

Figure 4. Relationship between predicted hatching success for stilt nests and selenium concentration (ppm dry weight) in a sample egg from the nest, 1983–84. A nest that hatched more than 50 percent of the available eggs was defined as successful. Dashed lines show estimated 95–percent confidence interval.

Discussion

Eggs have been used to measure exposure of birds to certain environmental contaminants, such as organochlorines and mercury (Ohlendorf et al. 1978). Based on our data and the results of previous studies with chickens (e.g., Ort and Latshaw 1978, Latshaw and Biggert 1981, Moksnes 1983), we conclude that eggs can also be used to indicate selenium exposure. Our egg samples reflected differences among the three sampling areas that were confirmed by similar results for samples of fish and adult birds from these same areas (Saiki 1986, Ohlendorf et al. in prep.). They also showed differences among species nesting at Kesterson Reservoir, which probably resulted from differences in food habits, local feeding sites and migratory patterns (Ohlendorf et al. 1986).

We do not know the "normal" selenium concentrations in eggs for the species we studied. In other freshwater and estuarine bird species, approximate mean dry–weight concentrations in eggs (converted from wet weight) have ranged from 0.8 to 3.0 ppm (Eisler 1985). Some of the birds breeding at our control site (Volta) apparently arrive there from contaminated areas shortly before the nesting season. One effect of this movement is that these birds—especially those that nest soon after arriving—lay eggs with elevated selenium levels. The highest selenium concentration found in a stilt egg from Volta (7.3 ppm) was three times the next–highest level in eggs from that site; some other eggs from Volta may also reflect the influence of the birds feeding elsewhere before the breeding season.

Selenium concentrations in bird livers also show this effect. From the early (April–May) to the late (June–July) segments of the nesting season, mean selenium concentrations in livers of stilts decreased by about one–half (10.7 to 5.41 ppm dry weight; mean moisture content equals 70 percent) at Volta, while they doubled (41.8 to 94.4 ppm) at Kesterson (Ohlendorf et al. in prep.). This indicates that selenium increased in birds feeding at Kesterson, whereas birds at Volta tended to lose selenium.

Inadequate dietary levels of selenium may reduce egg production and hatchability (Latshaw et al. 1977). However, excessive dietary levels are also harmful, and avian embryos are especially sensitive to selenium toxicity (National Academy of Sciences 1976). Our data show a significant positive correlation between the incidence of embryotoxicity and selenium concentration in the egg. The frequency of embryonic mortality and deformity at Kesterson is discussed in more detail elsewhere (Ohlendorf et al. 1986). However, it is important to note here that although previous studies conducted elsewhere have reported less than 2–percent embryonic mortality and no deformities in coot eggs (Miller and Collins 1954), 14.6 percent of the coot eggs examined at Kesterson contained dead embryos, while 8.8 percent had deformed embryos.

When mallards were fed diets containing 10 ppm selenium as selenomethionine, some embryos had deformities similar to those we observed at Kesterson, and survival of ducklings was reduced (Heinz et al. in prep.). Hatching success also appeared reduced, but the difference from controls was not statistically significant. The eggs from treated ducks averaged about 14 ppm selenium dry weight (converted from reported wet–weight value of 4.6 ppm), and eggs from ducks on the untreated (control) diet averaged about 0.15 ppm selenium dry weight.

Other chemicals also may produce embryonic mortality and deformity (Romanoff 1972), but heavy metal concentrations were generally similar in bird livers and in food organisms at Kesterson and Volta, and organochlorine concentrations in mosquitofish (*Gambusia affinis*) were low at Kesterson (Ohlendorf et al. 1986). However, the occurrence of boron at high concentrations in plants, insects and fish at Kesterson is of concern. Although little is known about the effects of boron ingestion on the reproduction of birds, boron compounds (e.g., boric acid and borax) produce mortality and teratogenic development when they are injected into the egg (Landauer 1952, Birge and Black 1977). For this reason, further study is warranted to determine whether ingested boron may be transmitted to the egg and adversely affect hatchability or development of embryos.

In our analyses, we used the *minimum* frequency of dead or abnormal embryos in eggs or clutches examined and the *maximum* values for hatching success. Thus, we used a conservative approach to identifying significant relationships. Hence, when we are able to analyze additional data (e.g., other species from 1983–85 or for stilts in 1985), we may be able to define better the threshold selenium levels. We evaluted several other statistical procedures and found that logistic regression was the most suitable method for analysis of our data. A logistic approach also could be used to test for relationships between selenium and reproductive effects in controlled laboratory studies, to confirm the relationships we have found in our field studies.

Although reproductive studies are necessary to evaluate fully the effects of selenium on nesting birds, these studies are time–consuming and otherwise often difficult to conduct. By comparison, it is easier to collect sample eggs for analysis. The relationships described here should help biologists to estimate the likelihood of selenium–induced reproductive effects occurring in nesting birds in areas they sample. This would then indicate where more–detailed reproductive studies are warranted.

Acknowledgments

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Impacts of Selenium on Early Life Stages and Smoltification of Fall Chinook Salmon

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Introduction

Contamination of irrigation return flows by trace elements and pesticides leached from farmland can adversely affect aquatic resources in receiving waters, and has been suggested as one of the causes in the decline of striped bass (*Morone saxatilis*) in California (Stevens et al. 1985). Recently, public interest has been raised in California concerning selenium contamination in the San Luis Drain and its terminus—Kesterson Reservoir. The selenium originates in irrigation return flows from several thousand acres of farmland in the San Joaquin Valley. In 1982, the U.S. Fish and Wildlife Service discovered high concentrations of selenium in fish (Saiki 1985) and, in 1983, incidences of deformities and mortality among birds at Kesterson Reservoir (Ohlendorf et al. 1985). A debate has begun on various alternatives to minimize the toxicity of the water in the San Luis Drain and in agricultural waste water in general. Two alternatives that have been proposed could adversely affect salmonids: discharge into the San Joaquin River; and discharge into the Sacramento–San Joaquin estuary.

Toxicological impacts on salmonids would occur primarily in the early life stages, when fry migrate down the San Joaquin River from spawning grounds in the tributaries. Smolts migrate down both the San Joaquin and Sacramento rivers and live in nursery areas of the Delta and Suisun Bay until they undergo parr–smolt transformation and migrate to the sea. Young salmonids could be exposed to waterborne and dietary sources of selenium and other trace elements from the San Luis Drain if drain water were discharged into these waters.

The present research was undertaken to attempt to obtain the information needed to enable decision makers to evaluate soundly the effect of discharging selenium and other contaminants in the San Luis Drain into receiving waters inhabited by fall chinook salmon (*Oncorhynchus tshawytscha*).

Methods

Dietary Exposure to Selenium

In a study conducted at the Marrowstone Field Station of the Seattle National Fishery Research Center (Washington), five groups of fall chinook salmon parr were fed different amounts of an Oregon moist pellet (OMP) diet containing organoselenium, for a six–week period beginning April 25, 1985, to determine the effects of dietary uptake of selenium on survival, growth, predator avoidance, parr–smolt transformation and whole–body residues. Fish were held during the study in circular tanks four feet (1.2 m) in diameter at a loading capacity of 4 pounds fish/gpm (700 fish/tank) and with water quality characteristics of hardness 74 ppm, alkalinity 74 ppm, pH 8.1, and 50 degrees Fahrenheit (10°C). The diet was prepared by the isocaloric incorporation of selenium–contaminated mosquitofish (*Gambusia affinis*) collected from the San Luis Drain and the Kesterson National Wildlife Refuge into the OMP diet; the mosquitofish composed 16 percent of the diet. Three experimental groups received a partial ration of the selenium–containing diet, by feeding once, twice or four times per day. These feeding rates resulted in selenium concentrations in the diet of 6.5, 13 and 26 ppm (μg/g diet), which corresponded to selenium intakes of 0.23, 0.46 or 0.92 ppm (μg/g body weight) per day. Selenium was quantified by atomic absorption. The remainder of the daily ration consisted of a standard OMP diet containing no added mosquitofish. Two controls were incorporated in the experimental design—a positive control (0.7 ppm selenium) consisting of an OMP diet incorporating uncontaminated mosquitofish purchased from a commercial fish farm, and a negative control (0.5 ppm selenium) consisting of the standard OMP diet with no added mosquitofish. All five groups were fed at the rate of 3 percent of body weight per day, and thus received the same total amount of diet.

Survival, growth, predator–avoidance behavior and characteristics of parr–smolt transformation and subsequent seawater growth and survival were evaluated at various intervals during the study. Growth—as percentage weight gained and specific growth rate—was determined after 30 days exposure for 20 fish held in floating cages within each experimental tank. Predator–avoidance behavior of the group fed 26 ppm selenium for 43–50 days was compared to that of the negative control group, using a modification from the method of Bams (1967). Ten freeze–branded fish from each group were simultaneously offered together to three two–pound (0.9 kg) sea–run cutthroat trout (*Salmo clarki*) in dilute seawater (15 pp thou) in a four-foot (1.2 m) diameter, 170–gallon (644 L) circular, fiberglass tank. Predators were allowed to remove approximately half of the prey. Survivors were captured and identified by brand. The experiment was repeated six times.

Development of smoltification was monitored at weekly intervals by performing 24–hour seawater challenge tests on 10 fish samples from each group starting three weeks after diet administration was begun. Challenge tests were conducted using full–strength seawater; variables measured were survival and plasma sodium concentrations (measured with a flame photometer). Na^+–K^+–ATPase activity (Zaugg 1982) was determined at weekly intervals in gill tissue of 10 fish from each exposure group beginning after the first week of diet administration.

Migratory behavior was assessed after 34 days of diet administration. Two hundred fish from each experimental group were differentially freeze–branded and transported to Quilcene (Washington) National Fish Hatchery for a volitional outmigration test

(Lam 1985). A standard hatchery raceway was modified by installing notched dividers at 20–foot (6.1 m) intervals to create four pools, each eight inches (20.3 cm) shallower than the one upstream from it. Water cascaded from pool to pool through a four–inch (10.2 cm) notch in each divider. After five days of acclimation, fish were given a 30–day volitional migration period. Fish that successfully traveled to the downstream pool across the three dividers were identified by their brands and scored as migrants.

Seawater growth and survival over a three–month period were evaluated after 33 days of diet administration. One hundred fish from each experimental group were measured for weight and total length, transferred to a separate tank, and acclimated to full–strength seawater by mixing freshwater with seawater to increase salinity to 10 pp thou for 48 hours, 20 pp thou for 48 hours, and then to full strength, 28 pp thou. Growth and survival were monitored monthly.

Histological examinations were conducted on five fish from each experimental group after 30 days of diet administration to determine whether pathological changes had occurred in gill, pseudobranch, kidney, gonads, liver, digestive tract, spleen, heart, skin and muscle. Tissues from each fish were processed, stained with hemotoxylin and eosin, and May–Grunwald Giemsa, and histologically examined.

Whole–body concentrations of selenium, molybdenum and boron were determined in 10 fish from each dietary group after 33 days on diet. Molybdenum and boron were quantified because they were assumed to be present in mosquitofish collected from the San Luis Drain, which has elevated concentrations of both elements.

Waterborne Exposure to Selenium

In two chronic-toxicity studies, fall chinook salmon were exposed to waterborne selenium for 90 days, to determine the effects on survival, growth and osmoregulatory ability. Molybdenum and boron were also present in the waterborne selenium studies in the environmental ratios and concentrations that they were found with selenium in the San Luis Drain. The studies were conducted at the Yankton (South Dakota) Field Research Station of the Columbia (Missouri) National Fisheries Research Laboratory. One chronic–toxicity study was conducted in well water (hardness 612 ppm, alkalinity 214 ppm, pH 7.8, and 53.6 degrees Fahrenheit [12°C]) with eyed–eggs exposed for two weeks before the expected hatching date and continuing for 90 days posthatch. In the second chronic toxicity study, 0.01-ounce (0.3 g) fry were exposed for 90 days in water blended to simulate San Luis Drain water if the concentrations were diluted 10–fold by the San Joaquin River at a point immediately downstream from the Merced River (hardness 371 ppm, alkalinity 210 ppm, sulfate 200 ppm, chloride 228 ppm, pH 7.9, and 53.6 degrees Fahrenheit [12°C]). The studies were conducted in intermittent flow diluters (Mount and Brungs 1967); each diluter delivered five concentrations with a dilution factor of 0.50 between concentrations and a control to two replicates. Fish were exposed to a mixture of selenium, molybdenum and boron in the environmental ratios and concentrations that would be present if the San Luis Drain were diluted 10–fold in the receiving water. Nominal exposure concentrations were 0.25X, 0.5X, 1X, 2X and 4X where 1X was the environmental concentration and composed of 35 ppb selenium (μg/L; 6:1 ratio of Na_2SeO_4:Na_2SeO_3), 49 ppb Mo (μg/L; $Na_2MoO_4 \cdot 2H_2O$), and 1400 ppb B (μg/L; H_3BO_3). Each aquarium was loaded with 100 fall chinook salmon two days before the mixture of trace elements was introduced.

Mortality was recorded daily, and growth was evaluated at 30–day intervals during the studies. Growth was monitored by measuring total length and weight of 10–fish subgroups held in two growth chambers in each replicate.

In the blended–water study, challenge tests in 28–pp thou seawater were conducted for a 10–day period on 15–fish subsamples after 90 days of exposure.

Results and Discussion

Dietary Exposure to Selenium

Growth was significantly reduced ($P < 0.05$) after 30 days of exposure in fish fed the positive control diet (containing uncontaminated mosquitofish) compared with the negative control (Table 1). However, compared to the positive control, there was no effect on growth in the three groups exposed to selenium in the diet (Table 1). Although growth, as either percentage weight gain or specific growth rate, was lowest in fish fed the highest level of the selenium–contaminated (26 ppm) diet, the decrease was not significant ($P > 0.05$). Part of the trend toward decreased growth may be due in part to reduced feeding, which was observed in the 26 ppm selenium diet group during the latter part of the study. Hilton et al. (1980) reported that 13 ppm selenium in the diet as sodium selenite reduced growth rate, reduced feed efficiency and increased mortality in rainbow trout (*Salmo gairdneri*) after 20 weeks.

These researchers observed initial feeding excitement in fish fed 13 ppm selenium in the diet, but the fish did not feed. Avoidance of food containing selenium is a common response of animals fed high selenium diets (Underwood 1971). Avoidance of feeding would restrict the daily selenium dose, which, in turn, may have reduced mortality. Goettl and Davies (1978) reported that 10 ppm selenium in the diet as sodium selenite reduced survival of rainbow trout after 10 weeks. In our study, the absence of significant adverse effects on growth and survival in fish fed diets containing selenium may have been due to the short exposure period of the study (30 days), compared with the longer exposure periods of 20 and 10 weeks in the studies by Hilton et al. (1980) and Goettl and Davies (1978), respectively.

No adverse effect on predator–avoidance behavior was observed in the fish fed 26 ppm selenium compared to fish fed the negative control diet.

Table 1. Mean growth[a] for chinook salmon exposed to a diet containing selenium, for 30 days beginning April 25, 1985. Survival was 100 percent in all groups.

Test group (ppm Se)	Exposure period		Percentage weight gain	Specific weight rate ($g/g_0 \cdot 10^3$)
	Outset	30 days		
0 (controls)[b]				
Negative	4.4 (1.0)	6.9[c](1.7)	57	19
Positive	4.0 (0.9)	5.7 (1.4)	42	14
6.5	4.2 (0.9)	6.1 (1.5)	45	14
13	4.2 (0.9)	5.6 (1.1)	33	11
26	4.3 (1.0)	5.5 (1.5)	28	9

[a]Weight in grams (standard deviation).
[b]Negative control—diet incorporating no mosquitofish; positive control—diet incorporating uncontaminated mosquitofish.
[c]Significant difference from the positive control ($P < 0.05$).

Several biologically important trends in parr–smolt transformation were adversely affected by dietary uptake of selenium. After three, four and five weeks of exposure to selenium in the diet and a 24–hour seawater challenge, mortality was highest in fish fed 26 ppm selenium (Table 2). Although both test and control groups demonstrated osmoregulatory competence by regulating plasma sodium concentration to about 170 mmo/L or less after six weeks of dietary exposure (June 4), the development of seawater tolerance was delayed, and reversion to the parr stage began quickly in the group fed 26 ppm selenium. ATPase activity was lowest in the group fed 26 ppm selenium, but was not significantly different from that of either control (Table 3). Fish in the positive control group also did not show the normal rise in ATPase shown by the negative control. This absence of a rise in ATPase levels in the positive control group coupled with the trend for reduced growth suggests a possible nutritional deficiency of the mosquitofish incorporated in the diet. Nutritional differences among the three diets (positive control, negative control and selenium diets) could have been in micronutrients. However, analysis of diet composition showed nearly identical amounts of protein, fat, carbohydrate, fiber, moisture and ash content in the three diets.

After 34 days of exposure, migratory behavior was substantially reduced in fish

Table 2. Percentage mortality and (in brackets) plasma sodium (Na^+) concentration of survivors after 24 hour seawater challenge tests with fall chinook salmon exposed to selenium in the diet. Fish were fed experimental diets beginning April 25, 1985; those groups with sufficient numbers were maintained on experimental diets until all fish were sampled (June 25).

	Percentage mortality by challenge date (week)						
	May			June			
Test group (ppm Se)	15th (Week 3)	22nd (Week 4)	28th (Week 5)	4th (Week 6)	11th (Week 7)	18th (Week 8)	25th (Week 9)
0 (controls)							
Negative	10 [193]	0 [184]	0 [174]	0 [166]	0 [172]	0 [185]	a
Positive	0 [201]	20 [181]	0 [181]	0 [173]	0 [175]	0 [194]	10 [209]
6.5	0 [201]	0 [174]	0 [164]	0 [176]	0 [170]	0 [183]	0 [213]
13	0 [198]	0 [178]	0 [177]	0 [179]	0 [181]	0 [176]	0 [197]
26	22 [205]	50 [182]	30 [200]	0 [176]	0 [183]	a	a

[a]Insufficient numbers remained in groups to conduct challenge tests.

Table 3. Mean gill Na^+–K^+–ATPase activity (μm Pi/mg protein/hour) for fall chinook salmon exposed to selenium in the diet. Fish were fed experimental diets for six weeks beginning April 25, 1985.

Test group (ppm Se)	Exposure period (weeks)					
	1	2	3	4	5	6
0 (contols)						
Negative	17.0	17.6	19.3	24.9	33.2	34.6
Positive	16.8	17.3	18.9	23.0	20.7	23.2
6.5	15.5	17.1	21.0	24.2	32.5	28.1
13	14.9	17.2	21.4	22.4	20.1	26.6
26	14.3	16.8	15.6	19.5	21.1	19.4

fed 26 ppm selenium (Figure 1). Both control groups had similar final migration rates (60 percent in the positive controls and 57 percent in the negative controls), but the final migration rate was only 43 percent for fish fed 26 ppm selenium. No adverse effects on growth or survival in seawater were observed in the three–month period that followed 33 days on the experimental diet.

In general, fish from both the negative and positive controls grew more rapidly in freshwater, showed greater osmoregulatory competence and tended to migrate more readily than did fish receiving 13 or 26 ppm selenium in the diet. Fish fed 6.5 ppm selenium were similar in growth and osmoregulation to those in control groups, but they did not migrate as readily. The negative control group showed the strongest and most consistent rise in gill Na^+–K^+–ATPase activity during the parr–smolt transformation.

Our experiment with selenium is the first dietary study to demonstrate adverse impacts on parr–smolt transformation. Several other investigators have reported that exposure to waterborne trace elements can alter parr–smolt transformation and reduce chances of successful migration to the ocean and adaptation to seawater. Lorz and McPherson (1976), for example, reported partial or complete inactivation of gill ATPase activity, reduced seawater survival and reduced downstream migration during the parr–smolt transformation of coho salmon (*Oncorhynchus kisutch*) exposed to copper concentrations ranging from 5 to 30 ppb for 6 days in freshwater. Davis and Shand (1978) reported reduced regulation of plasma sodium concentrations and

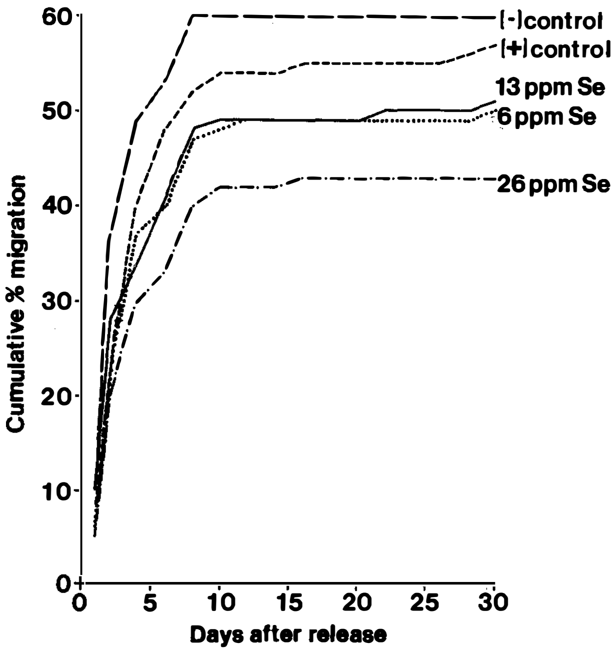

Figure 1. Cumulative percentage downstream migration, over 30 days, of fall chinook salmon fed different amounts of selenium-contaminated *Gambusia* in fresh-water for 34 days before they were released in a simulated stream, June, 1985.

reduced survival following seawater challenge tests in smolts of sockeye salmon (*Oncorhynchus nerka*) exposed to 30 ppb of copper for 6 days in freshwater. Lorz et al. (1978) showed reduced seawater survival in coho salmon smolts exposed in freshwater to cadmium, copper or mercury, but not to nickel, chromium or zinc. And Nichols et al. (1984) demonstrated reduced migration and transient changes in gill ATPase and plasma thyroxine in coho salmon exposed to 300 ppb of arsenic for 6 months. All of these studies of waterborne trace elements, like our diet study with selenium, showed adverse effects on parr–smolt transformation at exposure concentrations lower than those causing acute and chronic effects on growth and survival in freshwater. Similarly, our dietary study with selenium–contaminated mosquitofish showed adverse effects on parr–smolt transformation of fall chinook salmon at concentrations—i.e., 6.5 ppm selenium—not affecting growth and survival.

Various degrees of histopathological changes were observed in the gills in all experimental groups, including the positive and negative control groups after 30 days of exposure. Lamellar epithelial hyperplasia, hypertrophy and epithelial separation from pilaster cells were frequently seen. Normal epithelial cells of the lamellae are squamous, and both the cells and their nuclei are flat (Figure 2A). An irregular, ragged–looking lamellar epithelium, caused by ovoid nuclei, was consistently seen in various degrees in most of the positive control fish and in the groups fed selenium (figures 2B and 2C). However, a minor form of ragged–looking epithelium occurred in only one fish from the negative control—an observation suggesting that mosquitofish may not be an acceptable feed for chinook salmon. Degenerative changes in the pseudobranchial epithelium were also noted in most fish with ragged–looking lamellar epithelium (figures 2D and 3A).

Subtle histopathological changes were found in the kidney glomeruli and the livers of fish fed 13 and 26 ppm selenium for 30 days. In the kidney, degenerative changes occurred in the endothelial cells of the glomerular capillary loop (figures 3B and 3C). This pathological change was seen in all five fish fed 26 ppm selenium, in 3 of the 5 fish fed 13 ppm selenium and in 1 of 5 fish fed 6.5 ppm selenium. A subtle form of possible megalocytosis, usually characterized by an increase in the diameter of hepatocyte and their nuclei (McCain et al. 1982), was found in the livers of 2 of 5 fish fed 26 ppm selenium and 1 of 5 fish fed 13 ppm selenium (Figure 3D). No cytopathic changes were detected in livers of fish fed 6.5 ppm selenium.

Tissue changes in our fish were not similar to those observed by Sorensen et al. (1982, 1983) in green sunfish (*Lepomis cyanellus*) from a lake contaminated with selenium in eastern Texas. Sorensen et al. observed proliferative glomerulonephritis, vacuolation of parenchymal hepatocytes, and increase of Kupffer cells. Nephrocalcinosis was reported by Hicks et al. (1984) in rainbow trout exposed to dietary selenium. The greater length of their experiment—16 weeks, as compared to the 30 days of our study—may have caused this difference. In contrast to our results, Hilton et al. (1980) found no histopathological lesions or abnormalities in liver, kidney, muscle or spleen of rainbow trout fed up to 13 ppm selenium for 16 weeks (gills were not examined).

Whole–body concentrations of selenium were dose–dependent, but concentrations of molybdenum and boron were generally below detection limits (Table 4). Concentration factors (tissue concentration/exposure concentration) in our study were 0.2 to 0.3, or slightly lower than those reported by Hilton et al. (1980), who demonstrated concentration factors of 0.4 to 0.5 in rainbow trout fed 1 to 13 ppm selenium for 16

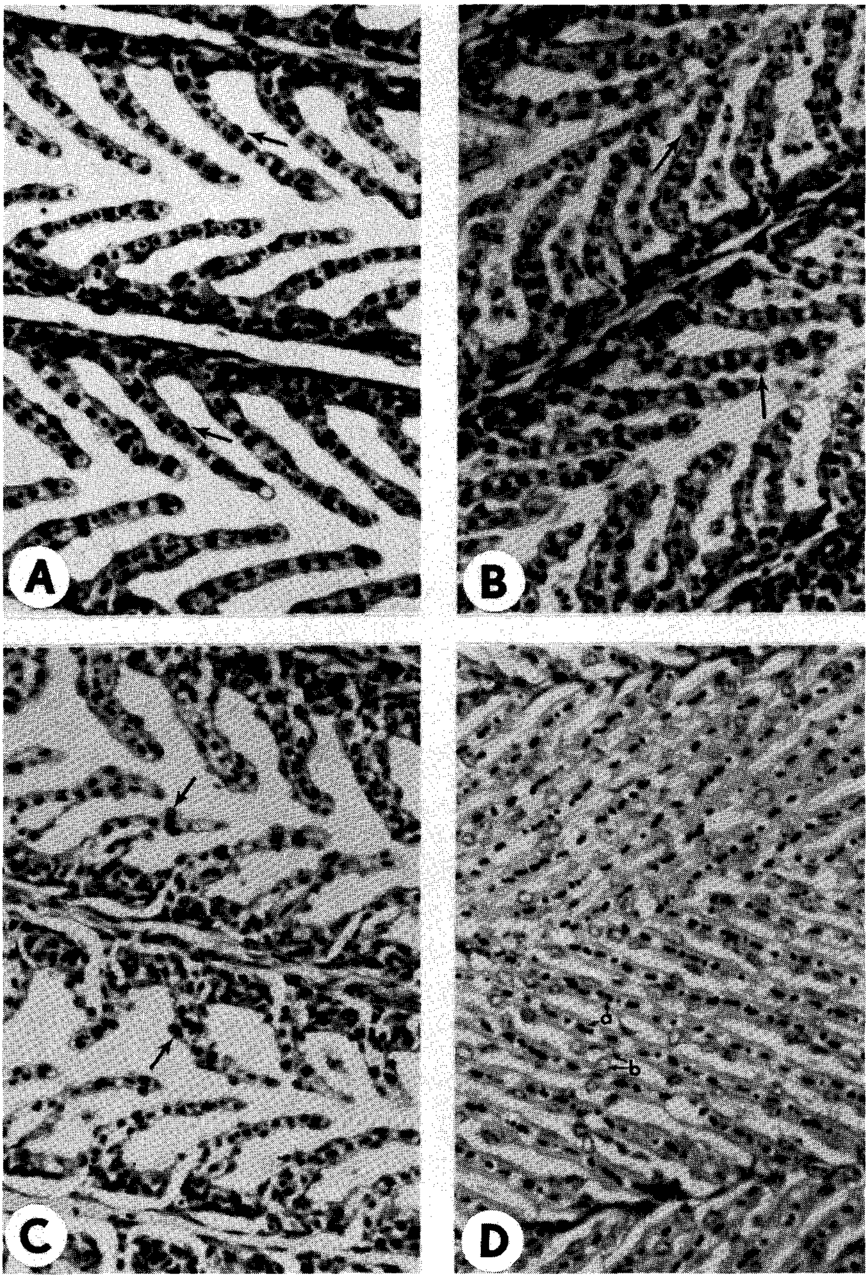

Figure 2. Tissues of juvenile fall chinook salmon exposed to different concentrations of selenium in the diet for 30 days: A. gill (×250) of negative control fish (fed no mosquitofish) showing normal flat lamellar epithelium (arrow); B. gill (×300) of positive control fish (fed diet incorporating uncontaminated mosquitofish), showing ragged–looking lamellar epithelium with ovid nuclei (arrows); C. gill (×300) of fish fed 26 ppm selenium, showing ragged–looking lamellar epithelium with ovoid nuclei (arrows) as in panel B.; D. gill (×250) of negative control fish showing regular arrangement of the pilaster (a) and epithelial (b) cells.

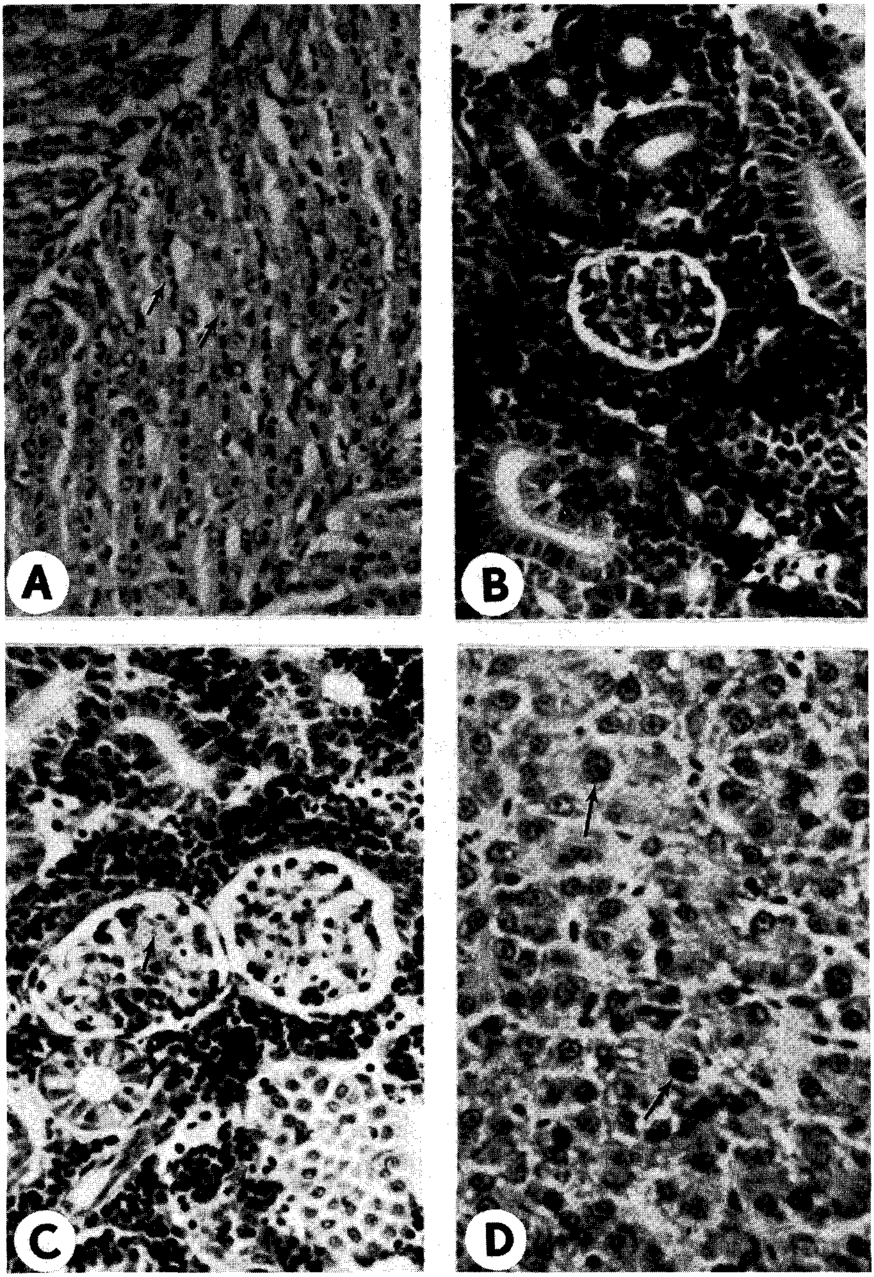

Figure 3. Tissues of juvenile fall chinook salmon exposed to different concentrations of selenium in the diet for thirty days: A. gill (×250) of fish fed 26 ppm selenium, showing irregular arrangement of the pilaster and epithelial cells and the disruption of the regular morphological appearance by the degenerative epithelial cells (arrows); B. kidney (×200) of negative control fish showing normal glomerulus in the center (arrow); C. kidney (×360) of fish fed 26 ppm selenium showing subtle degenerative cellular changes in the glomerulus (arrow); D. liver (×640) of fish fed 26 ppm selenium showing subtle form of megalocytosis with the large hepatocytes (arrows).

Table 4. Whole–body concentrations (ppm) of selenium, molybdenum and boron in fall chinook salmon exposed to a diet containing selenium for 33 days.

Test group (ppm Se)	Element			
	Selenium	Molybdenum	Boron	R[a]
0 (controls)				
Negative	0.3	<0.2	2.0	4.12
Positive	0.2	<0.2	1.0	4.50
6.5	2.1	<0.2	<1.0	4.56
13	2.9	<0.2	2.0	4.63
26	4.9	<0.2	<1.0	4.63

[a]Wet/dry factor: (ppm wet weight) × (R) = ppm dry weight.

weeks. In both studies, concentration factors decreased as dietary exposure increased. This could be explained by the previously noted reduced feeding at high selenium concentration or the relatively short duration of our study.

Waterborne Exposure to Selenium

Exposure of eyed eggs of fall chinook salmon for two weeks before hatch and for 90 days posthatch to selenium in water had no effect on hatchability, median time to hatch, or survival of sac–fry to the swim–up stage. Similar results have been reported for the toxicity of waterborne selenium on embryonic and newly hatched zebrafish (*Brachydanio rerio*) (Niimi and LaHam 1975), eggs of common carp (*Cyprinus carpio*) (Huckabee and Griffith 1974), and eggs and sac–fry of rainbow trout (Goettl and Davies 1976). However, Hodson et al. (1980) reported a significant reduction in hatch of rainbow trout eggs exposed as newly fertilized eggs to 26 ppb selenium or greater as sodium selenite, although the reduction was only 3.5 percent below that of the control. Halter et al. (1980) also reported that the hatchability of eggs of fathead minnows (*Pimephales promelas*) was not affected by exposure to selenium, but that median incubation time was reduced by exposure to concentrations of 15 ppm selenium or greater, and median survival time was reduced in all concentrations tested (1–40 ppm selenium). The lowest exposure concentration tested by Halter et al. (1980) was seven times greater than our highest exposure concentration.

Survival and growth of fry in well water were significantly reduced in concentrations of 2X (70 ppb selenium) or greater after 60 days exposure (Tables 5 and 6). Fry survival in blended water was significantly reduced in concentrations of 0.5X (17 ppb selenium) or greater after 30 days of exposure and in concentrations of 2X (70 ppb selenium) or greater after 60 days of exposure (Table 7). Growth of fry in blended water was significantly reduced in the 4X (140 ppb selenium) concentration after 60 days of exposure (Table 8). Goettl and Davies (1976) reported a no–effect concentration for selenium toxicity to rainbow trout exposed for two months of 40–80 ppb in soft water (hardness 28 ppm). Hodson et al. (1980) reported no effects on survival or growth in their 44–week study with rainbow trout exposed to selenium concentrations ranging from 5–53 ppb in slightly hard water (hardness 135 ppm). Our results agree with those of Goettl and Davies (1976) and Hodson et al. (1980) in showing that concentrations of selenium in the range of 50–70 ppb adversely affects growth and survival of early life stages of salmonids.

In the blended–water study, the 90–day exposure to selenium reduced survival of

Table 5. Percentage mortality of fall chinook salmon exposed to a diet mixture of selenium, molybdenum and boron in well water for 30, 60 and 90 days.

	Exposure period		
Test group[a]	30 days	60 days	90 days
0	3.0	4.7	7.9
0.25X	1.0	5.4	5.4
0.5X	1.0	1.0	1.0
1X	1.0	1.8	8.2
2X	2.0	22.9[b]	36.8[b]
4X	1.1	99.1[b]	100.0[b]

[a]X = mixture of 35 ppb selenium, 49 ppb molybdenum and 1,400 ppb boron.
[b]Significant difference from the control ($P \leq 0.05$).

Table 6. Mean growth of fall chinook salmon exposed to a diet mixture of selenium, molybdenum and boron in well water for 60 and 90 days.

	Exposure period			
	60 days		90 days	
Test group	Length[a]	Weight[b]	Length[a]	Weight[b]
0	51.7 (3.7)	1.17 (0.27)	61.9 (5.5)	2.14 (0.61)
0.25X	52.1 (3.3)	1.20 (0.24)	61.3 (4.1)	2.04 (0.45)
0.5X	52.0 (3.6)	1.19 (0.28)	61.1 (5.6)	2.04 (0.60)
1X	52.1 (3.6)	1.20 (0.28)	60.7 (6.3)	2.02 (0.66)
2X	48.6[c](4.5)	1.00[c](0.28)	57.0[c](7.0)	1.75[c](0.64)
4X	47.8[c](4.0)	0.94[c](0.24)	58.6[c](4.4)	1.79[c](0.44)

[a]In millimeters (standard deviation).
[b]In grams (standard deviation).
[c]Significant difference from the control ($P \leq 0.05$).

Table 7. Percentage mortality of fall chinook salmon exposed to a diet mixture of selenium, molybdenum and boron in blended water for 30, 60 and 90 days.

	Exposure period		
Test group	30 days	60 days	90 days
0	2.5	7.2	12.0
0.25X	3.7	6.0	10.7
0.5X	13.7[a]	18.0	22.2
1X	13.7[a]	15.7	15.7
2X	12.5[a]	21.1[b]	29.9[b]
4X	11.2[a]	34.6[b]	38.9[a]

[a]Significant difference from the control ($P \leq 0.05$).
[b]Significant difference from the control ($P \leq 0.10$).

Table 8. Mean growth for fall chinook salmon exposed to a diet mixture of selenium, molybdenum and boron in blended water for 60 and 90 days.

Test group	Exposure period			
	60 days		90 days	
	Length[a]	Weight[b]	Length[a]	Weight[b]
0	59.1 (4.7)	1.83 (0.48)	69.9 (5.8)	3.20 (0.86)
0.25X	57.7 (6.1)	1.71 (0.60)	69.3 (7.4)	3.13 (1.20)
0.5X	58.7 (6.5)	1.77 (0.59)	70.2 (8.2)	3.28 (1.19)
1X	59.6 (4.9)	1.87 (0.51)	71.0 (9.3)	3.47 (1.51)
2X	58.9 (7.6)	1.85 (0.82)	70.3 (12.0)	3.39 (2.20)
4X	54.8[c](6.0)	1.44[c](0.53)	62.8[c] (8.5)	2.39[c](1.06)

[a]In millimeters (standard deviation).
[b]In grams (standard deviation).
[c]Significant difference from control ($P \leq 0.05$).

fish in a 10–day seawater challenge test. In the challenge test, mortality was 35 percent and 33 percent among fish exposed to 70 and 140 ppb selenium, respectively, compared with 6 percent in control fish. A reduction in survival of this magnitude could sharply reduce the number of fish returning to spawn in future years.

Comparison of Laboratory Results with Environmental Conditions

The sampling and analysis of environmental conditions in the San Luis Drain/ Kesterson Reservoir area, related to selenium concentrations in surface waters and plant and animal tissues, are currently continuing, with few published reports available. Preliminary findings suggest extensive selenium contamination of the surrounding wetlands, canals and ditches. Selenium concentrations up to 330 ppb in water and 94–370 ppm (dry weight) in mosquitofish have been found in Kesterson Reservoir and the San Luis Drain (Saiki 1985). Selenium concentrations in food chain organisms collected from Kesterson ponds are also elevated, ranging from 12 to 330 ppm (dry weight) in filamentous algae and from 58 to 120 ppm (dry weight) in net plankton (Saiki 1985). Fish readily take up organic selenium from zooplankton fed selenium–containing phytoplankton or zooplankton exposed to inorganic selenium in water (Sandholm et al. 1973).

Drainage from land adjacent to the San Luis Drain also has high selenium concentrations that are discharged into the San Joaquin River indirectly by way of wetlands in the Grasslands Water District, south of Kesterson Reservoir (U.S. Bureau of Reclamation 1984). Mud Slough, which serves as the primary drainage system for the Grassland Water District, receives selenium–contaminated discharge from the Helm and Main canals by way of the Santa Fe and San Luis canals, and from smaller ditches and drains. Concentrations of selenium in Helm and Main canals ranged up to 75 ppb, and up to 26 ppb in Mud Slough. Fish collected from Mud Slough and Helm Canal often exceeded 2 ppm selenium in tissue as wet weight, and exceeded 5 ppm selenium in tissue in some samples (Saiki 1985).

In general, concentrations of selenium in freshwater fish collected from throughout the United States in 1979–80 as part of the National Contaminant Biomonitoring Program averaged 0.48 ppm wet weight, with 85 percent of all samples containing 0.87 ppm or less (Baumann and May 1984). Moreover, Baumann and May (1984) reported that fish residues greater than 2 ppm wet weight represent elevated concentrations that could cause toxic effects such as reproductive problems. The high concentrations of selenium in water and fish in the San Luis Drain, Kesterson Reservoir and the Grasslands Water District exceed those shown to affect adversely parr–smolt transformation of fall chinook salmon in our dietary study with selenium and those causing reduced survival and growth in our study of exposure to waterborne selenium.

The San Joaquin River has not been adversely affected by discharges from nonpoint sources of selenium contamination because water residues are less than 2 ppb selenium and fish samples contain about 0.8 ppm selenium in tissue as wet weight (Saiki 1985). However, increased drainage or continued long–term subsurface seepage of selenium–contaminted drain waters could elevate water and tissue concentrations of selenium in aquatic organisms of the San Joaquin River and the Delta to the point where there would be adverse impacts on salmonids using these waters. Based on the results of the present study, if selenium concentrations exceed 50 ppb in water or 13 ppm in food sources in the San Joaquin River or the Delta, fall chinook salmon would be adversely affected.

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Potential Impacts of Agricultural Chemicals on Waterfowl and Other Wildlife Inhabiting Prairie Wetlands: An Evaluation of Research Needs and Approaches

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Introduction

The prairie–pothole region of North America (Figure 1) extends from southcentral Canada into the northcentral United States—an area of 300,000 square miles (777,000 km^2), with about 36 percent in the United States. This region encompasses the principal breeding grounds of several species of North American waterfowl and provides essential habitat for many other wildlife species (Stewart and Kantrud 1973, 1974, Kantrud and Stewart 1984). Although the region comprises only 10 percent of the continent's waterflow breeding area, it accounts for 50 percent or more of the annual waterfowl production in North America (Smith et al. 1964). Unfortunately, loss of prairie wetlands to drainage for agriculture has been severe, and only about 35 percent of the original wetland area remains (National Research Council 1982:239). In North and South Dakota, for example, prairie–pothole wetlands originally covered 7 million acres (2.8 million ha); today, only slightly more than 3 million acres (1.2 million ha) remains (Tiner 1984).

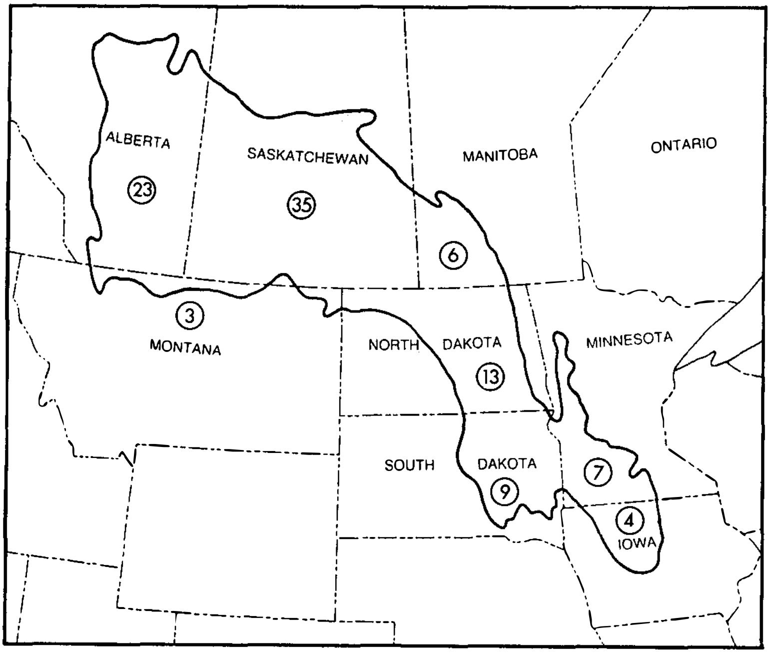

Figure 1. The prairie–pothole region of North America (after Kantrud and Stewart 1977). Encircled numbers denote the percentage of the total area within each state or province.

In an effort to preserve some of these wetlands, the U.S. Fish and Wildlife Service (USFWS) has acquired wetlands outright through purchases or affected their preservation with easements. Although these wetlands are protected from drainage, they may still be impacted by adjacent land use. Many of the remaining wetlands are bordered by agriculture and subject to inputs of agricultural chemicals. For example, in 1985, 94 percent of the Waterfowl Production Areas (WPAs) within the Arrowwood Wetland Management District in North Dakota had cropland adjacent to at least one of their boundaries and 37 percent were completely surrounded by cropland (Table 1). Comparable data for 1964 were 91 and 9 percent, respectively. Therefore, knowledge of how agricultural practices affect the quality of these wetlands is essential if their value to wildlife is to be preserved.

Except for wetland drainage, little is known about the impacts of agricultural practices on these wetlands. For example, we are aware of only two published studies (Hanson 1952, Krapu et al. 1973) that have investigated the effects of agricultural chemicals on prairie–wetland wildlife *in situ,* and only one dealt with chemicals or chemical formulations in wide use today. In the present paper, we first describe historical changes in habitat conditions, agricultural practices and wildlife populations within the region, as well as the potential for wildlife inhabiting prairie–pothole wetlands to be exposed to agricultural chemicals. We then discuss the possible direct and indirect effects these chemicals could have on wetland wildlife. The risk to wetland wildlife from the most widely used chemicals in the region is assessed by evaluating the relative toxicity of these chemicals, the persistence of these chemicals

Table 1. Land use adjacent to Waterfowl Production Areas (WPAs) within the Arrowwood Wetland Management District, North Dakota, 1985.

		Percentage of WPAs with					
	Number of	Cropland		Hay		Pasture–range	
County	WPAs	Adjacent	Surrounding	Adjacent	Surrounding	Adjacent	Surrounding
Stutsman	81	96	42	36	1	46	2
Wells	27	93	33	19	0	63	7
Foster	10	100	20	70	0	30	0
Eddy	17	82	29	35	12	53	6
Total	135	94	37	35	2	49	4

within wetland systems, and the potential vulnerability to these chemicals of the species of wildlife that depend on prairie–pothole wetlands for survival and reproduction. We conclude with an evaluation of research needs and approaches for obtaining needed data. Although wildlife that inhabit lands surrounding these wetlands may also be impacted by the use of agricultural chemicals, this topic is beyond the scope of the present paper. A more–detailed analysis of the potential impacts of agricultural chemicals on wildlife inhabiting prairie wetlands and their watersheds from the Canadian perspective is available in Sheehan et al. (1986).

Agricultural Chemical/Wildlife Interface: Past and Present

Changes in agricultural practices over the last 50 years have greatly increased the potential for wildlife that inhabit prairie–pothole wetlands to be exposed to agricultural chemicals. Within the Canadian prairies (Alberta, Manitoba, Saskatchewan), cultivated lands (lands in crop or summer fallow) increased 34 percent between 1951 and 1981, and the amount of pasture has increased 129 percent (Sheehan et al. 1986). The increase in agricultural activity on the Canadian prairies appears to have resulted primarily from the conversion of woodlands, particularly within Saskatchewan (Sheehan et al. 1986).

Within some parts of the region in the United States, the total amount of cultivated land has remained relatively constant, but in both countries, the number of farms has decreased while average farm size has increased (Taylor et al. 1981, North Dakota Crop and Livestock Reporting Service [NDCLRS] 1985, Sheehan et al. 1986) (Figure 2). In North Dakota, for example, the number of farms decreased from 84,606 in 1930 to 36,000 in 1984, and the average farm size increased from 496 acres (201 ha) to 1,129 acres (457 ha) (Taylor et al. 1981, NDCLRS 1985). Concomitant with relatively large farm size has been an increase in mechanization and a greater reliance on monocultures: the former leads to greater physical disturbance of the habitat, whereas the latter results in an increase in the use of pesticides.

Wheat continues to be the predominant crop within the prairie–pothole region (Taylor et al. 1981, NDCLRS 1985, Sheehan et al. 1986). The acreage planted to wheat has nearly doubled in North Dakota since 1960 (Figure 2), and wheat is expected to remain the predominant crop—50 percent of all cropland (Weaver et al. 1982)—within the Canadian prairie provinces through 1990. Two significant changes in the crops planted within the region since the early 1960s have been the

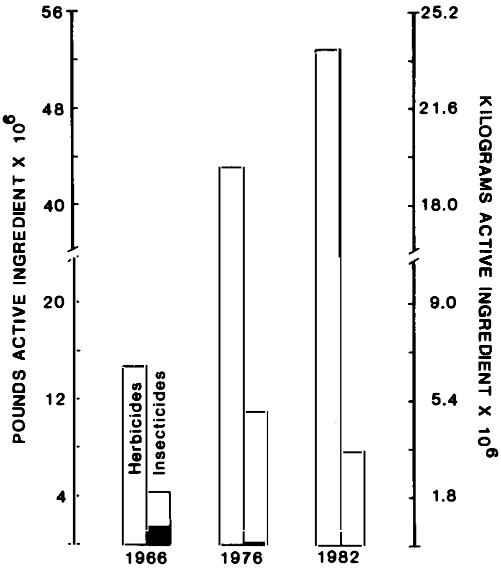

Figure 2. Crop acreage in North Dakota, 1930–80 (data from Taylor et al. 1981, North Dakota Crop and Livestock Reporting Service 1985). W = wheat, O = oats, B = barley, H = hay, S = sunflower, M = miscellaneous (includes beans, corn, flax, mustard, potatoes, soybeans and sugar beets).

introductions of sunflowers primarily in the U.S. and rapeseed (canola) in Canada. Sunflowers constituted about 10 percent of the total cultivated acreage within the prairie–pothole region of North Dakota in 1984 and ranked third behind wheat and barley in acreage planted (Figure 2). The acreage planted to canola on the Canadian prairies in 1981 accounted for nearly 6 percent of all crops, ranking it fourth behind wheat, barley, and forage crops, primarily alfalfa (Sheehan et al. 1986).

The types and quantities of pesticides used within the prairie–pothole region have changed dramatically since the 1960s. Data for the Northern Plains within the United States (Figure 3) indicate that the use (pounds of active ingredient applied) of herbicides increased 356 percent between 1966 and 1982; insecticide use increased 170 percent. Organochlorine compounds comprised 34 percent of the insecticide use on the Northern Plains in 1966, but less than 1 percent in 1982. The majority of insecticides currently used within the prairie–pothole region are organophosphates (OPs) and carbamates (CBs). Of the 27 insecticides applied to crops in North Dakota in 1984, 17 (63 percent) were OPs, 4 (15 percent) were CBs, 4 (15 percent) were organochlorines (OCs), and 2 (7 percent) were synthetic pyrethroids (SPs) (NDCLRS 1985). Data available for the Canadian prairies are similar to those for North Dakota. In 1984, 20 insecticides were available for field crops in Canada and, of these, 12 (60 percent) were OPs, 2 (10 percent) were CBs, 3 (15 percent) were OCs, and 3 (15 percent) were SPs (Sheehan et al. 1986).

Pesticide use on the predominant crops (percentage of acreage treated) grown in North Dakota in 1978 and 1984 is given in Figure 4. For most crops, 80–90 percent of the acreage planted was treated with herbicides, whereas with the exception of

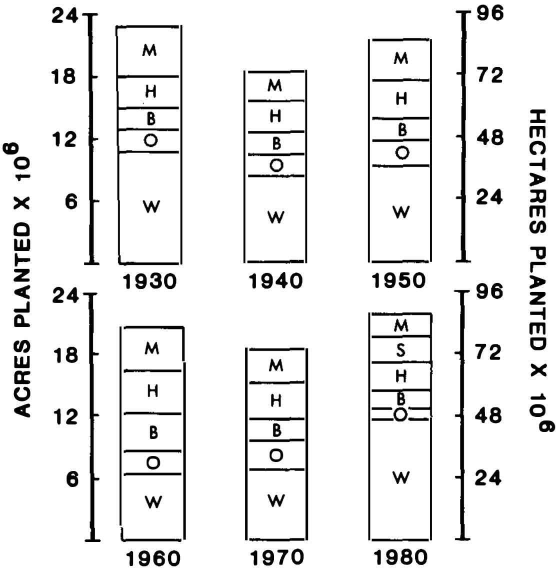

Figure 3. Pesticide use on the Northern Great Plains in 1966, 1976 and 1982 (Eichers et al. 1970, 1978, U.S. Department of Agriculture unpublished data). Solid bars denote the amount of organochlorine insecticides used.

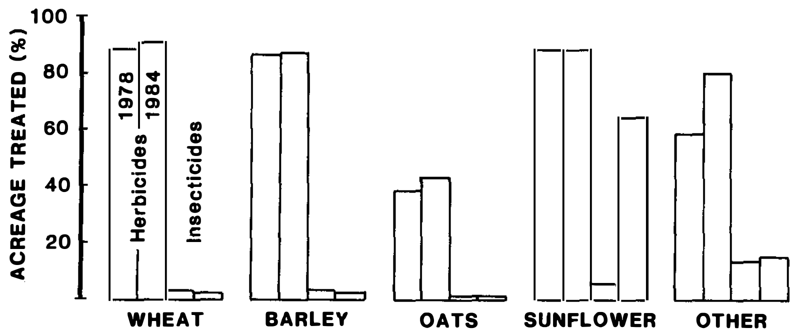

Figure 4. Crop acreage treated with pesticides in North Dakota in 1978 and 1984 (data from Nalewaja et al. 1980, North Dakota Crop and Livestock Reporting Service 1985). "Other" includes beans, corn, flax, mustard, potatoes, soybeans and sugar beets, but does not include hay, pasture and rangelands, all of which had less than 2 percent of their acreages treated with herbicides or insecticides in 1978 and 1984.

sunflowers and vegetables, insecticides were applied to less than 4 percent of the acreage planted. Insecticide use on sunflowers increased from less than 6 percent of the planted acreage in 1978 to nearly 65 percent in 1984. Pesticide use on hay, pasture, and rangeland was low in comparison to other agricultural land uses.

Within the Canadian prairies, use of herbicides and insecticides appears to be similar to that in North Dakota. Between 30 and 80 percent of the acreage planted in wheat, oats, barley, flax, or rape is treated with herbicides (Peden et al. 1982 *in* Sheehan et al. 1986). Sheehan et al. (1986) estimated that within the Canadian prairies 1.3 to 3.8 million acres (0.5–1.5 million ha) are treated annually with insecticides. Another 5 million acres (2 million ha) may be treated during years of major grasshopper (Acrididae) outbreaks, and an additional 1 million acres (0.4 million ha) may be treated to control periodic armyworm (*Mamestra configurata*), cutworm (*Agrotis* and *Euxoa* sp.) or diamond–back moth (*Plutella xylostella*) infestations. Assuming that most of this insecticide use takes place on agricultural lands (cultivated land + pasture: 95 million acres [38 million ha] in 1981), insect control usually takes place on 3–4 percent of the agricultural lands in Canada, increasing to 8–9 percent during major grasshopper outbreaks, and up to 10–11 percent if grasshopper outbreaks coincide with those of other pests. In 1985, the Canadian prairies were plagued by one of the most serious grasshopper outbreaks in recent history, as well as a widespread diamond–back moth infestation. Sheehan et al. (1986) estimated that 16–17 million acres (6.5–7.0 million ha) within the Canadian prairies were sprayed with insecticides in 1985—about 17–19 percent of all agricultural lands, or about 26–28 percent of all lands planted to field crops in 1981. In addition, the adoption of conservation tillage practices by farmers within the region will probably result in an increase in the use of herbicides, and possibly an increase in the use of insecticides to control insects within crop residues (Allmaras and Dowdy 1985). On the Northern Plains within the United States, 29 percent of the farmers who planted for harvest in 1983 used some form of conservation tillage (Magleby et al. 1985).

Other pesticides used extensively on cereal and oil–seed crops are fungicides. Presently, these chemicals are used almost entirely as seed treatments and, therefore, would not be expected to enter prairie wetlands readily. However, several postemergence fungicides for use on cereals are currently being considered for registration in Canada (Sheehan et al. 1986).

Data also indicate that the use of fertilizers has increased dramatically. In 1975, 489,943 tons (445,346 metric tons) were applied in North Dakota; comparable values for 1984 were 616,409 tons (560,372 metric tons) (NDCLRS 1985). Rennie et al. (1980) estimated that the consumption of nitrogen fertilizers alone will increase by 300 percent in western Canada during the 1980s.

A large proportion of the land within the prairie–pothole region of both the United States and Canada is cultivated. More than 75 percent of the cropland in North Dakota is within the prairie–pothole region. Sheehan et al. (1986) estimated that 63 percent of the land classified in Waterfowl Classes 1 through 5 (Canada Land Inventory, CLI), which include 93 percent of the ducks nesting on the Canadian prairies, overlaps the best agricultural lands (CLI Agricultural Classes 1–3). If Agricultural Class 4 lands were cultivated, the impact would be greatest on the best waterfowl habitat (Waterfowl Class 1 lands) and would increase the overlap between agricultural and waterfowl use on the Canadian prairies by 21 percent.

Several other factors related to the proximity of agricultural lands to prairie–pothole wetlands may increase the exposure of wetland wildlife to agricultural chemicals. The cultivation of wetland borders may result in greater amounts of chemicals entering wetlands through runoff. Brace and Caswell (1985) documented the impacts of agriculture on wetland margins (defined as 33 feet [10m] from the high water level) within the Canadian prairies in 1980 and 1984. About 50 percent of the wetlands surveyed in southern Saskatchewan and southwestern Manitoba had severely reduced margins, as did 90 percent of the wetlands surveyed in southern Alberta. During drought conditions, wetland basins frequently are cultivated and treated directly with pesticides and fertilizers. Methods of chemical application may also affect the potential exposure of wetland wildlife. Herbicides and fertilizers are usually applied by ground equipment, whereas most insecticides are more commonly applied by aircraft. In 1978, 21 percent of all insecticides used in North Dakota were applied by aircraft, as were 12 percent of all herbicide applications. Comparable data for 1984 were 59 and 9 percent, respectively (McMullen et al. 1985) (Table 2). In addition, use of prairie wetlands by wildlife is greatest during the growing season. For example, the breeding season of most birds, including waterfowl, within the prairie–pothole region occurs when most herbicides and insecticides are applied (Figure 5) (Sheehan et al. 1986).

The intensification of agricultural activity on lands adjacent to wetlands has been implicated in the declines of some wildlife species within the prairie–pothole region, but the relationships have not been clearly defined. Most notable has been the decline in waterfowl populations. The fall flight of ducks in 1985, based on breeding surveys, was projected to be 22 percent below that for 1984—the lowest ever projected (USFWS and Canadian Wildlife Service [CWS] 1985). Reasons for the low projections include fewer breeding ducks and reduced production in the Dakotas, a second

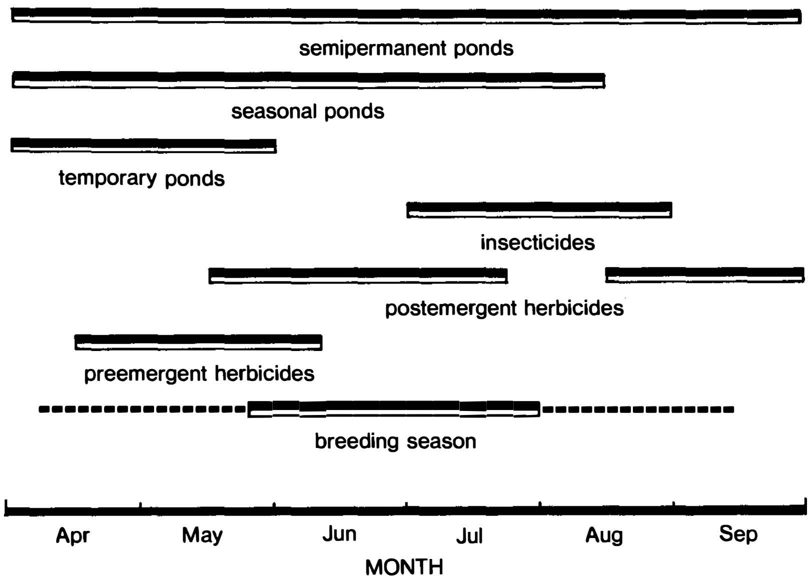

Figure 5. Phenology of pesticide use in the prairie–pothole region of North Dakota in relation to typical seasonal permanence of wetlands and the avian breeding season (data compiled from Stewart 1975, Kantrud and Stewart 1977, North Dakota Cooperative Extension Service and North Dakota Agricultural Experiment Station 1984, C. D. Fanning personal communication, G. A. Swanson personal observations). Solid bar for breeding season denotes period most birds are reproductively active.

Table 2. Use, method of application and toxicity class for pesticides most frequently applied within the prairie–pothole region of North Dakota.

Pesticide[a]	Area treated[b] Acres (× 10^3)	Area treated[b] (Hectares)	Percentage of area treated by air[b]	Toxicity class[f]: Aquatic invertebrates[c] (LC_{50})	Birds: Acute oral[d] (LD_{50})	Birds: Dietary[e] (LD_{50})	Birds: Reported[g] dieoffs	Mammals[h]: Acute oral (LD_{50})
Insecticides								
Acephate (Orthene®)	30.8	(12.5)	46	L	M	L		M
Aldicarb (Temik®)	9.7	(3.9)	8		VH	M	1	VH
Carbaryl (Sevin®)	78.4	(31.7)	29	M	L	L		M
Carbofuran (Furadan®)	419.7	(170.0)	43		VH	H	2*	VH
Chlorpyrifos (Dursban®)	43.1	(17.4)	8	VH	H	M	2*	H
Fenvalerate (Pydrin®)	1,414.1	(572.7)	64	VH	L	L		M
Lindane	27.7	(11.2)	0	M	L	L		H
Malathion	101.9	(41.3)	86	VH	L	L		M
Methyl parathion	14.5	(5.9)	91	H	VH	M	2*	VH
Moncrotophos (Azodrin®)	9.5	(3.8)	21	M	VH	VH	2	VH
Parthion	504.8	(204.4)	92	H	VH	H	3*	VH
Permethrin	24.6	(10.0)	10	H	L			M
Phorate (Thimet®)	55.9	(22.6)	2	H	VH	M	2	VH
Phosphamidon	31.0	(12.5)	4	M	VH	M	2	VH
Terbufos (Counter®)	74.6	(30.2)	1					VH
Toxaphene	10.4	(4.2)	43	M	H	M	4	H
Others (11)	39.0	(15.8)						
Total Insecticides	2,880.2	(1,166.4)	59					
Herbicides								
Acifluorfen (Blazer 25)	102.6	(41.5)	16		L	L		L
Alchlor (Lasso®)	188.1	(76.2)	8		L			L
Atrazine	211.3	(85.6)	13		L	L		L
Barban (Carbyne®)	182.7	(74.0)	20		L			M
Bentazon (Basagran®)	368.1	(149.1)	18	M	H			L
Bromoxynil (Buctril®)	222.2	(89.9)	11					H

Bromoxynil & MCPA	710.8	(278.9)	17				
Chlorsulfuron (Glean®)	281.3	(113.9)	21				
Cyanazine (Bladex®)	214.1	(86.7)	13	L	L		M
Diallate (Avadex®)	136.8	(55.4)	5				M
Dicamba (Banvel®)	1,469.4	(595.1)	6	L	M		L
Diclofop–Methyl (Hoelon®)	655.7	(256.6)	15	L	L		M
Difenzoquat (Avenge®)	245.1	(99.3)	13				M
Endothall	9,246.0	(3,744.6)	5	M	H		H
EPTC (Eptam®)	175.1	(70.9)	4	L			L
EPTC & Safener	232.5	(94.2)	5				
Ethalfluralin (Sonalan®)	153.6	(62.2)	3				L–M
Glyphosate (Roundup®)	880.3	(356.5)	6	L	L	L	L
MCPA	2,061.4	(834.9)	13				M
Metribuzin (Sencor®)	158.7	(64.3)	4		H		L
Pendimethalin (Prowl®)	233.3	(94.5)	5				L
Picloram (Tordon®)	258.5	(104.7)	11	M	L	L	L
Trillate (Avadex®BW)	1,675.3	(678.5)	3	M	L		M
Trifluralin (Treflan®)	4,540.6	(1,838.9)	4	L	L		M
2, 4–D (Total)	8.574.5	(3,472.7)	11	L	L	L	M
Others (27)	414.4	(167.7)					

[a]Common names correspond to those given in *The Merck Index* (1976).
[b]Data from McMullen et al. (1985); only insecticides used on about 10,000 acres (4,050 ha) or more, and herbicides on more than 100,000 acres (40,500 ha) are listed.
[c]Data for *Gammarus* sp. except for bromoxynils, diclofop–methyl, and triallate where data for *Daphnia* sp. are given. Data from Johnson and Finley (1980), except permethrin (Muirhead–Thompson 1971), fenvalerate (Anderson 1982), and bromoxynil, diclofop–methyl, and triallate (Weed Science Society of America 1983).
[d]Data for 3– to 5–month–old mallards (Elliott and Janes 1978, Weed Science Society of America 1983, Hudson et al. 1984); except for diclofop–methyl, fenvalerate, glyphosate, and triallate—northern bobwhite (Bradbury and Coats 1982, Weed Science Society of America 1983); and dicamba—ring–necked pheasant (*Phasianus colchius*) (Weed Science Society of America 1983).
[e]Data for 5– to 14–day–old mallards or 14–day–old Coturnix from Hill et al. (1975) and Hill and Camardese (1986).
[f]Toxicity classes: invertebrates 96 h LC_{50} (24 h LC_{50-95} for permethrin and fenvalerate), Low (L) = >1.0, Moderate (M) = 0.01–1.0, (H) = 0.001–0.01 and Very High (VH) = >0.001 ppm; birds and mammals LD_{50} (mg/kg) and LC_{50} (ppm), L = >1000, M = 201–1000, H = 41–200 and VH = 0–40.
[g]Reports of inintentional poisonings as numbered: 1–Pest Infestation Control Laboratory (1978); 2–Grue et al. (1983); 3–E. F. Hill (personal communication); 4–McEwen et al. (1972); *indicates waterfowl involved.
[h]Data from Gaines (1969), Christensen and Luginbyhl (1974), Berg (1982), and Lewis and Tatken (1982).

year of record low numbers of ducks in Montana, and significant declines in breeding ducks on the Canadian prairies (USFWS/CWS 1985). Several possible explanations for the declines in North American waterfowl populations have been advanced: increased hunting pressure (primarily in the United States); periodic drought on the southern prairies; and loss of both quantity and quality of habitat resulting from agricultural practices, including pesticide use (Sheehan et al. 1986). Increased predation related to reductions in the quantity of habitat also appears to be a significant factor limiting waterfowl production (Sidle 1985, Sugden and Beyersbergen 1986).

In addition, populations of red–winged blackbirds (*Agelaius phoeniceus*) in the Dakotas declined 42 percent between 1965 and 1981 (Besser et al. 1984). The authors attributed the declines to periodic decreases in precipitation and increased tillage of small wetlands. However, drainage of wetlands and the burning of cattail (*Typha* spp.) may also have been factors responsible for the observed declines.

Routes of Exposure

Agricultural chemicals applied to cropland may enter prairie–pothole wetlands directly by overspray, aerial drift, or cultivation and treatment of dry wetland basins, or indirectly through volatilization and postapplication runoff. The likelihood of direct contamination of prairie wetlands (except through cultivation of wetland basins) is largely dependent on the method of application, whereas the likelihood of indirect contamination is more dependent on meteorological events and properties of the chemical used and its formulation. We believe the most significant routes of pesticide entry are direct overspray, aerial drift, particularly from aerial applications of insecticides, and the treatment of cultivated wetland basins. Most prairie–pothole wetlands are less than 1 acre (0.4 ha) in size (Smith and Stoudt 1968, Millar 1969), and may number as many as 100 per square mile (39/km^2) (Smith et al. 1964). Thus, the relatively short distance between wetlands and their small size make avoidance of direct overspray by aerial applicators impossible. Spray deposit from aerial applications, however, rarely reaches 100 percent; an average deposit of 50 percent of applied quantities from a single swath may be realistic (Ware et al. 1970). Spray deposits of 80 percent of applied quantities may be expected from multiswath coverage common in insect control (Sheehan et al. 1986); deposits of up to 200 percent of the application rate were observed following aerial application of the OP, fenthion, to wet meadow habitat in Wyoming (L. R. DeWeese, L. C. McEwen, R. D. Deblinger and L. A. Settimi unpublished manuscript).

Contamination of wetlands from aerial drift of herbicides and insecticides is likely to occur, particularly when wetland margins are treated. For example, Maybank et al. (1976, 1978a, 1978b) reported that ground application of 2,4–D formulations resulted in 3–5 percent drift of initial droplets, whereas aerial spraying of 2,4–D contributed to losses of 15–35 percent of applied amounts. In other studies, 19–57 percent of aerially applied 2,4–D was deposited on target with the remainder accounted for by drift or atmospheric volatilization (Renne and Wolf 1979). For 16 separate aerial applications of the insecticide methoxychlor, Ware et al. (1970) reported that 14–95 percent was deposited on the target area, with an average of 54 percent drifting off-target. The amount of on–target deposit varied from 28 to 79 percent for aerial applications of deltamethrin (Hill and Kinniburgh 1984). Ultra–low–volume (ULV) applications by ground equipment and aircraft result in extensive downwind loss of pesticides. For example, drift losses from an aerial ULV application of fenvalerate approached 65 percent, in comparison to 37 percent for an aerial application at a higher volume (Ware et al. 1984). The factors that influence the deposition and drift of pesticide formulations have been reviewed by Gohlich (1983).

Depending on seasonal precipitation, large numbers of temporary, seasonal and semipermanent wetlands may be cultivated and their basins treated with agricultural chemicals. In years with normal precipitation, one–third of all prairie–pothole wetlands may become dry, whereas in a dry year, as many as two–thirds may lose their water (Smith et al. 1964). For example, in 1985, only 37 percent of the wetlands surveyed by the USFWS in North Dakota in May contained water in July (USFWS/CWS 1985).

Volatile or surface–mobile chemicals may enter prairie–pothole wetlands indirectly after application through volatilization and subsequent drift, or runoff. Volatilization losses of up to 40 percent of applied quantities have been reported for some esters of 2,4–D (Grover et al. 1972, 1985, Maybank et al. 1978b, Gile 1983). Vapor losses of 25 percent of applied quantities were observed for trifluralin (White et al. 1977), and up to 75 percent for EPTC (Cliath et al. 1980). In contrast, wetland contamination resulting from the movement of pesticides into the watertable or surface runoff is believed to be minimal for most hydrophobic pesticides because of adsorption to soil particles. However, runoff is probably the most significant route of entry for some herbicides, because aerial applications represent only a small percentage of the total applied. In his summary of seasonal losses of pesticides in surface runoff from agricultural fields, Wauchope (1978) concluded that for the majority of commercial pesticides, runoff losses would be 0.5 percent or less of the amount applied, unless severe rainfall events occurred within one to two weeks after application. The latter situation could result in runoff losses of about 20 percent for the more–mobile chemicals (Wauchope 1978). Sheehan et al. (1986) estimated that within the Canadian prairies, runoff could contribute up to 50 percent of the total pesticide input within a wetland following a "catastrophic" runoff event. Of factors that govern the amount of chemicals in runoff from agricultural fields (reviewed by Willis and McDowell 1982), the intensity, duration and timing of rainfall, the properties of the chemical and its formulation, and characteristics of the soil drainage system are believed to be most important. Although adoption of conservation tillage practices may mean greater use of herbicides, studies in cornfields indicate that runoff losses of herbicides from no–till agriculture may be less than that from conventionally plowed fields. This is because the remaining crop residue increases herbicide infiltration and slows surface movement (Triplett et al. 1978).

Ingestion of contaminated food and water, preening, dermal absorption and inhalation are the routes by which wildlife within prairie wetlands may be exposed to agricultural chemicals. Chemical exposure may vary among wildlife species and be associated with differences in their behavioral traits. In terrestrial habitats, ingestion is believed to be the primary route of exposure of wildlife to pesticides (for review, *see* Grue et al. 1983). However within wetlands, dermal absorption may be significant, particularly for those wildlife species that spend the majority of their time in water. For example, Wilson's phalaropes (*Phalaropes tricolor*) appear to be more vulnerable to applications of the OP fenthion than are other wetland birds, possibly because their foraging behavior increases their exposure to the pesticide (DeWeese et al. 1983). Dermal contact with pesticides has been documented in wildlife follow-

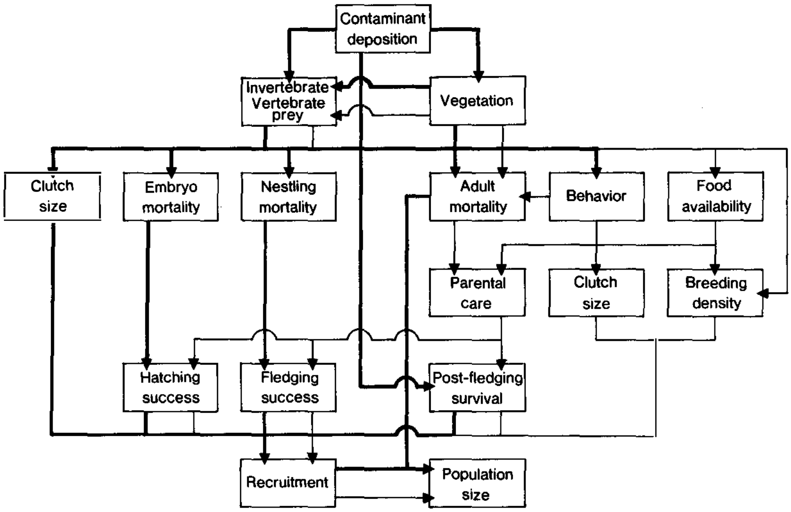

Figure 6. Potential effects of agricultural chemicals on birds inhabiting prairie–pothole wetlands. Bold lines indicate direct toxic effects; narrow lines indicate indirect effects. Semicircles within lines indicate that lines cross but do not intersect. This schematic is also representative of potential effects on other wildlife species; the reproductive terminology for birds need only be replaced by comparable terms for amphibians, reptiles or mammals.

ing pesticide applications, and laboratory studies have shown that dermal exposure can result in pesticide poisoning (for review, *see* Grue et al. 1983). However, dermal exposures are usually less toxic than equivalent oral dosages. For example, the average percutaneous median lethal dose (LD_{50}) for 17 OPs to mallards (*Anas platyrhynchos*) was nearly 12 times the average oral LD_{50} for the same chemicals (Hudson et al. 1979). Comparable data for exposure of wildlife to pesticides via inhalation are lacking.

Potential Impacts on Wetland Wildlife

Agricultural chemicals that enter prairie–pothole wetlands may impact wetland wildlife directly through lethal and sublethal effects, or indirectly by altering vegetative cover or food abundance (Figure 6).

Direct Effects

The potential impacts of pesticide–induced mortality of adult and juvenile wildlife on reproductive success and recruitment are obvious; other direct toxic effects may be subtle. For example, direct pesticide exposure can be lethal or teratogenic to avian embryos (Hoffman and Albers 1984). Sublethal pesticide exposure may also affect reproduction and survival of wetland wildlife. Birds and mammals exposed to OP insecticides frequently become anorexic and lose body weight (Grue et al. 1983). Pesticide–induced reductions in food consumption may affect reproduction by inhibiting egg production (Stromborg 1981), reducing litter size (Spyker and Avery 1977) or retarding growth of young (Grue and Shipley 1984). Loss of body weight following pesticide exposure may also result in a greater susceptibility of affected animals to environmental stressors. This may be particularly important to small birds and mammals with high metabolic rates (Grue et al. 1983). The implications of below–normal weights in juvenile wildlife, resulting from pesticide exposure, are not known, but for birds not exposed to contaminants, low fledging weights have been associated with a decrease in postfledging survival (e.g., *see* Nur 1984). Pesticide exposure may also alter the production and structure of the song of breeding birds (Forsyth 1980, Grue and Shipley 1981), which may affect territoriality and courtship. Behavioral anomalies that may affect pairing have been observed in coturnix (*Coturnix coturnix*) following sublethal exposure to carbaryl (DeRosa et al. 1976). Pesticide–induced reductions in visual acuity, vigilance and food–seeking behavior may affect the ability of adults to care for or protect their young. For example, adult laughing gulls (*Larus atricilla*) orally dosed with parathion spent less time incubating their eggs than did controls (White et al. 1984). Similarly, adult female European starlings (*Sturnus vulgaris*) orally dosed with dicrotophos made fewer trips to feed their young and remained away from their nests for longer periods of time than did controls (Grue et al. 1982). Sublethal exposure of birds and mammals to pesticides has also been shown to alter hormone levels (Rattner et al. 1984), lower body temperatures (Chattopadhyay et al. 1982, Rattner and Franson 1984), reduce resistance to disease and impair learning (for review, *see* Grue et al. 1983). Finally, pesticide–induced alterations in behavior may increase the potential for predation of sublethally exposed animals. That predatory birds appear to be attracted to pesticide–treated areas (Zinkl et al. 1981, L. R. DeWeese, L. C. McEwen, R. D. Deblinger, and L. A. Settimi unpublished manuscript) supports this conclusion. In addition, McEwen and Brown (1966) suggested that the loss of radio–tagged sharp–tailed grouse (*Tympanuchus phasianellus*) to predators was increased following a sublethal dose of malathion. Similarly, predation of captive northern bobwhite (*Colinus virginianus*) following exposure to methyl parathion was greater than that for controls (Galindo et al. 1985).

Results of these studies suggest that exposure to many of the pesticides currently used within the prairie–pothole region has the potential to reduce reproduction or survival of wetland wildlife. However, little is known about the toxic effects of particular chemicals on wildlife inhabiting these wetlands. Hanson (1952) investigated the effects of aerial applications of 2,4–D (amine in water, 0.5 pounds per acre [0.4 kg/ha]; ester in No. 2 fuel oil, 1 pound per acre [1.1 kg/ha]) on a wetland in North Dakota, but no effects on wildlife were detected. Other studies on the direct toxic effects of pesticides on wetland wildlife have been conducted outside the prairie–pothole region. In the Skagit Valley of Washington State, an aerial application of 1.6 pounds per acre (1.8 kg/ha) of methyl parathion (emulsifiable concentrate) to fields adjacent to wetlands severely reduced the survival of mallard and blue–winged teal (*Anas discors*) ducklings. Sixteen percent of the ducklings present within the treated watershed ($n = 24$) were alive 22 days postspray, whereas 58 percent of the ducklings ($n = 37$) on the control study area survived (L. W. Brewer, C. J. Driver, R. J. Kendall, C. Zeinier, and T. E. Lacher, Jr. unpublished data). In contrast, parathion applied by air at the rate of 1 pound per acre (1.1 kg/ha) to a pond in California had no obvious adverse effects on pinioned adult mallards (Mulla et al. 1966). Also, young

American black ducks (*Anas rubripes*) and mallards on ponds in Maine aerially sprayed with 0.7 pound per acre (0.8 kg/ha) or carbaryl did not appear to suffer any direct toxic effects (Hunter et al. 1984).

Indirect Effects

The reproductive strategies of wildlife utilizing prairie–pothole wetlands have evolved to synchronize reproduction with food abundance. For most avian species, the reproductive season corresponds with peaks in aquatic invertebrate populations (Swanson et al. 1974, Sheehan et al. 1986), which also occur at the same time insect populations on surrounding agricultural lands are treated with insecticides (Figure 5) (Sheehan et al. 1986). Therefore, insecticide applications could interfere with reproduction by depressing invertebrate abundance. However, the effects of insecticide–induced reductions in invertebrate abundance on the behavior, survival and reproductive success of wetland wildlife are poorly known. Growth rates of ducklings of mallards and American black ducks were reduced in response to a decrease in the availability of invertebrates following an aerial application of carbaryl (Hunter et al. 1984). Ducklings on the sprayed ponds spent more time searching for food and less time resting than ducklings on unsprayed ponds. Similarly, an aerial application of carbaryl (1 pound per acre: 1.1 kg/ha) on watersheds surrounding prairie–pothole wetlands in North Dakota decreased the invertebrate abundance within the wetlands by 15 percent, and censuses of waterfowl suggested that fewer duck broods utilized the treated wetlands compared to unsprayed controls (McEwen et al. 1964). Many of the insecticides commonly used within the prairie–pothole region are more toxic than carbaryl to aquatic invertebrates (Table 2).

Studies within upland habitats have suggested that birds and small mammals emigrate from insecticide–treated areas because of reductions in insect abundance (for review, *see* Grue et al. 1983). The effects of such movement on breeding birds may be severe. Abandonment of nests may mean reduced reproductive success, as second–nesting attempts of many species of birds are often less successful (Lack 1970:32). For wildlife species that remain in treated areas, reductions in insect abundance may result in reduced survival of young. Survival of grey partridge (*Perdix perdix*) chicks in agricultural areas has been directly related to herbicide– and insecticide–induced reductions in insect abundance (Potts 1977). In contrast, reproductive success in red–winged blackbirds was not affected by a 50–percent reduction in the principal food of nestlings following an application of fenthion (Powell 1984). However, Powell noted that the abundance of insects may have been above–average during his study, and insecticide–induced reductions in prey could have a pronounced effect when food resources are naturally low.

Herbicides that enter wetland systems may have direct toxic effects on aquatic plants and invertebrates and, therefore, may indirectly affect reproduction and survival of wetland wildlife by altering food and cover. We are aware of only one study that has investigated the effects of herbicides on wetland wildlife. Hanson (1952) found that aerial applications of 2,4–D (amine and ester) resulted in the death of 50–100 percent of nine species of dicotyledons within a wetland and its borders. Monocotyledons were also affected by both forms of the chemical; the ester formulation was the more toxic. Only a few invertebrates were killed by the ester formulation, presumably because it was mixed with oil. In a recent study of the effects of the herbicide atrazine on aquatic insect communities within experimental ponds (Dewey

1986), the abundance of nonpredatory insects was greatly reduced following addition of the chemical, whereas predatory insects were unaffected. The author suggested that the observed effects were primarily indirect, resulting from a reduction in the food and habitat of nonpredators.

Eutrophication of prairie wetlands as a result of nutrients from inputs of agricultural fertilizers may have significant indirect effects on wetland wildlife by altering water quality and the distribution and abundance of aquatic plants and invertebrates.

Risk Assessment

A number of factors must be considered when evaluating the risk agricultural chemicals pose to wildlife inhabiting prairie–pothole wetlands. Factors governing the exposure of wetland wildlife to these chemicals include: the rate, frequency, timing and method of application; the amount of area treated; weather conditions during and following application; the persistence of the chemical within the wetland ecosystem; and the behavioral traits of wildlife potentially exposed. The magnitude and duration of direct toxic and indirect effects depend on the factors governing exposure, the relative toxicity of the chemicals to wildlife, aquatic plants and invertebrates, and the resiliency of affected populations.

Chemical Toxicity

The potential for agricultural chemicals to enter prairie wetlands and affect the reproduction and survival of wetland wildlife appears to be great, particularly for the most toxic and widely used insecticides. Of the 16 most widely used insecticides in North Dakota in 1984, 9 (56 percent) have been implicated in wildlife mortality elsewhere. The seven insecticides with the most crop/pest recommendations in Canada—malathion, deltamethrin, dimethoate, azinphos–methyl, methidathion, carbofuran, and methomyl (Sheehan et al. 1986)—and six of the most widely used insecticides in North Dakota in 1984 (Table 2) are either highly toxic to aquatic invertebrates or to birds. In addition, a large number of these chemicals are applied by air. For example, 59 percent of the agricultural land treated with insecticides in North Dakota in 1984 was sprayed by aircraft (Table 2). Insecticides widely used in North Dakota, other than those listed above for Canada, which are also highly toxic to aquatic invertebrates or to birds, include fenvalerate, parathion, phorate, and terbufos (Table 2).

Insecticides are generally much more toxic to vertebrate wildlife than are herbicides (Hudson et al. 1984, Hill and Camardese 1986). Although, comparable data for fertilizers are lacking, there have been unconfirmed reports of wildlife mortality associated with the use of granular fertilizers in North Dakota (C. D. Fanning personal communication). Exposure to herbicides may indirectly affect wetland wildlife. Median lethal concentrations (LC_{50}s) for the herbicides used on the Canadian prairies that are most toxic to aquatic invertebrates (2,4–D esters, triallate, trifluralin, atrazine and simazine) and others commonly used in North Dakota (endothall and picloram) are one to two orders of magnitude less toxic to aquatic invertebrates than the most–toxic insecticides (Sheehan et al. 1986) (Table 2). In addition, most herbicide applications are conducted from the ground and some are incorporated into the soil.

Although many of the insecticides (OP, CB and SP) and herbicides used within the prairie–pothole region are toxic to aquatic invertebrates and may indirectly affect wetland wildlife, only the organophosphate and carbamate insecticides are presently considered a direct toxic hazard to wetland wildlife (Table 2) (Elliott 1977, Morrison and Meslow 1983). An exception to this would be the potential direct toxic effects of herbicides on avian embryos (Hoffman and Albers 1984). For birds and mammals exposed to these insecticides, the time between initial pesticide exposure and the onset of toxic effects, and the duration of these effects, vary among chemicals (Grue et al. 1983, Hill and Camardese 1984, Hudson et al. 1984). If an animal survives the initial exposure, it may become symptom–free within a few hours or days even though exposure continues. In other cases, effects may be apparent as long as the animal is exposed, followed by rapid recovery after exposure ceases. Or effects may persist for weeks or months, even though levels of the target enzymes within the exposed animal have returned to normal.

Chemical Persistence

Data on the persistence of agricultural chemicals within actual prairie–pothole wetlands and their watersheds are lacking. Laboratory and field studies within other aquatic or terrestrial ecosystems have demonstrated that the environmental persistence of pesticides is affected by many chemical, physical and biological variables that are too complex to detail here (for review, *see* Nimmo 1985). Temperature, pH, hardness, alkalinity, redox potential, organic carbon content, the presence of microbial populations, and intensity and duration of sunlight are some of the primary factors governing the persistence of pesticides in water and sediments of prairie wetlands.

Organophosphate, carbamate and synthetic pyrethroid insecticides are degraded relatively rapidly in the environment. Parathion, carbofuran and fenvalerate—the three most widely used insecticides in North Dakota in 1984—represent these three insecticide groups, respectively. Reported half–lives for parathion in water vary from 27 (pH 7.4, 100 degrees Fahrenheit [37.5°C]) to 170 days (pH 6.1, 68 degrees Fahrenheit [20°C]) and in moist soil (pH 6.2, 68 degrees Fahrenheit [20°C]) up to 180 days; most other OPs are less persistent (Freed et al. 1979). The degradation of carbofuran in water is strongly influenced by pH, with estimated half–lives in sterile water of 13.3 years at pH 5.0–6.0 and 7 days at pH 8.0 (Chapman and Cole 1982). Carbofuran also decomposes rapidly in soils at pH greater than 7.0 with half lives of about 35 days, 6 days and 6 hours at pH 7.0, 8.0 and 9.0, respectively (Finlayson et al. 1979). Carbofuran residues within a pond ecosystem were not detected 25 days after the water (pH 6.6–9.7) was treated with 0.05 ppb of the insecticide (Klaassen and Kadoum 1979). Levels of fenvalerate in water were still toxic to aquatic invertebrates two to three weeks after treatment (Mulla et al. 1978). The half life of fenvalerate in two types of soil at 77 degrees Fahrenheit (25°C) varied between 15 days and 3 months (Ohkawa et al. 1978).

Herbicides also degrade rapidly in the environment but generally persist for longer periods of time than do organophosphate, carbamate and synthetic pyrethroid insecticides. A review of the data available for selected herbicides within Canadian agricultural soils (Smith 1982 *in* Sheehan et al. 1986) indicates that the half–lives for most compounds are less than 22 weeks. Depending on the time of application, some herbicides (e.g., triallate and trifluralin) may remain in soils one year after treatment at levels of 25 percent or more of the applied rate. Fall applications followed by the cold winter weather in the prairie–pothole region may enhance carryover. Even 2,4–D, which normally degrades rapidly, may persist in soil to the next growing season when applied in the fall (Smith 1982 *in* Sheehan et al. 1986).

The environmental persistence of pesticides must be coupled with knowledge on the actual bio–availability and toxicity of their residues in wetland ecosystems in order to assess the risk to nontarget wetland wildlife. Recent laboratory studies (Huckins et al. 1986, Johnson 1986) utilizing habitat–specific microcosms (simulating a northern prairie wetland ecosystem) indicated that the half–lives of field formulations of atrazine, trifluralin, triallate and fonofos in microcosm water and wetland sediment were less than half of the average values reported for topsoils in the field. These findings support the contention that potential direct toxic effects on wetland biota are probably short–lived. The observed rapid adsorption of most of the pesticides to benthic sediment having high organic carbon content was a major factor reducing the adverse effects on aquatic invertebrates. For example, the acute toxicity of methyl parathion and carbofuran to water column–dwelling *Daphnia magna* was 143 and 2 times greater, respectively, than that for daphnids within microcosms simulating a northern prairie wetland (J. N. Huckins unpublished data). In contrast, complete mortality of sediment–dwelling midge (*Chironomous riparius*) was observed in this study even though daphnids are usually an order of magnitude more sensitive to pesticides than are midges.

Finally, concurrent contamination of wetlands by more than one agricultural chemical may alter the persistence of the compounds and their toxicity to wetland wildlife. For example, the presence of parathion may increase the persistence of herbicides in soils (Sethunathan et al. 1977). Conversely, herbicides, particularly atrazine, increase the toxicity of parathion to insects (Sethunathan et al. 1977). Similarly, exposure to one pesticide may increase or decrease the sensitivity of wildlife to subsequent pesticide exposure (Grue et al. 1983).

Wildlife at Risk

Birds appear to be the wildlife group most at risk from applications of agricultural chemicals (e.g., *see* Grue et al. 1983, Walker 1983). The large number of avian dieoffs following applications of pesticides in comparison to those involving mammals (Grue et al. 1983) probably reflects the conspicuousness of birds and their sensitivity to these chemicals. Several factors, including anatomical, physiological and biochemical differences (for review, *see* Walker 1983), may account for the greater sensitivity of birds to pesticides compared to mammals. Perhaps most importantly, compared with mammals, birds exhibit low activity levels of "A" esterases and hepatic microsomal monooxygenases. Both enzymes are essential for the biochemical degradation and excretion of pesticides.

Bird species that require prairie–pothole wetlands for survival and reproduction are likely to be those most at risk from the direct and indirect effects of agricultural chemicals (Table 3). Of these species, those that depend entirely on wetlands for food and cover, such as adult waterfowl and their young (Swanson and Duebbert 1986), may be the most vulnerable. Indeed, waterfowl have been the avian group most often represented in poisonings of wildlife by OPs in North America, in part because their food habits and flocking behavior tend to concentrate them in agricultural fields (Grue et al. 1983). Of the nine insecticides widely used in North Dakota in 1984 and implicated in wildlife mortality elsewhere, four have been associated with the deaths of waterfowl (Table 2).

Data for two- to four-month-old mallard ducklings (Tucker and Haegele 1971) suggest that waterfowl may not be more sensitive to acute insecticide exposure than are other species of birds in prairie wetlands. The acute oral toxicity of nine OPs to young mallards was comparable to that for house sparrows (*Passer domesticus*). Median lethal doses (LD_{50}s) of five of the OPs were lower for mallards than for the sparrows, but the average ratios of the LD_{50}s (sparrows/mallards) was only 1.4 (range = 0.2–3.6). In addition, there does not appear to be a clear relationship between age and sensitivity to insecticides in mallards (Hudson et al. 1972), although young altricial birds appear to be more sensitive to OPs than are adults (Grue and Shipley 1984).

However, we believe the food habits of juvenile and adult waterfowl and their foraging behaviors may increase their exposure to agricultural chemicals above that of other species of birds and make them more vulnerable to pesticide-induced reductions in aquatic invertebrates and plants. During their first days of life, ducklings are particularly dependent on emerging insects (Chura 1961, Sugden 1973). Pesticide-induced reductions in this food resource could reduce duckling growth and survival (e.g., *see* Hunter et al. 1984), especially during periods of inclement weather (Sheehan et al. 1986). During egg laying, female waterfowl are also dependent on aquatic invertebrates as a source of protein and calcium (Krapu 1979, Swanson et al. 1979). Nest losses force many hens to renest one or more times during the breeding season, drawing heavily on body reserves already depleted in previous nesting attempts. In addition, overland movement of hens and their broods in search of adequate food (Talent et al. 1982) may increase losses to predation.

Red-winged and yellow-headed (*Xanthocephalus xanthocephalus*) blackbirds, and savannah sparrows (*Passerculus sandwichensis*) are the most abundant species of birds within wetlands of the prairie-pothole region of North Dakota. These birds, as well as the marsh wren (*Cistothorus palustris*) and common yellowthroat (*Geothlypis trichas*), must ingest large quantities of food per unit body weight, because of their small size and high metaboloic rates. Therefore, they may be more vulnerable than larger birds to insecticides. Use of adjacent agricultural fields by the blackbirds and savannah sparrows for some of their food may further increase their exposure to pesticides. Even young of these altricial species may also be exposed to agricultural chemicals indirectly by ingesting contaminated invertebrates fed to them by their parents (e.g., *see* White et al. 1979).

Shorebirds and other wading birds (Table 3) may be attracted to dead or dying invertebrates that accumulate near the shoreline. Consumption of contaminated invertebrates under these conditions can cause mortality (J. O. Keith unpublished data).

Wildlife inhabiting seasonal, semipermanent and undifferentiated tillage wetland types (Table 3) may be the species with the greatest potential for exposure to agricultural chemicals. These wetlands are usually relatively small in size and commonly interspersed within agricultural fields, which increases the probability of pesticide inputs from direct overspray and aerial drift.

Table 3. Density categories of predominant breeding bird species by wetland type within the prairie–pothole region of eastcentral North Dakota.[a]

Species[b] and group	Wetland type: Ephem-eral	Tempo-rary	Seasonal	Semi-permanent	Permanent	Alkali	Fen	Undifferentiated tillage
(Percentage of total area)	<1	<1	23	28	27	19	2	<1
Anatids								
Dabbling ducks								
Green–winged teal		IV	II	IV	IV	IV		MIII
Mallard		MII	III	III	IV	IV	III	III
Northern pintail	III	MII	II	III	IV	IV	III	II
Blue–winged teal	MI	I	I	II	III	IV	III	III
Northern shoveler		MIII	III	III	IV	IV	III	III
Gadwall		MII	III	III	IV	III	III	III
American wigeon		MIV	IV	IV	IV	IV	IV	IV
Breeding pairs/km²	187	364	317	189	36	38	125	193
Diving Ducks								
Canvasback			IV	MIV	IV	IV	IV	IV
Redhead			IV	MIII	IV	IV	IV	IV
Ring-necked duck			IV	MIV	IV	IV		IV
Ruddy duck			IV	MIII	IV		III	IV
Breeding pairs/km²			17	73	17	2	27	7
Non-anatids								
Pied–billed grebe			III	IV	IV		MIII	
Horned grebe			MIV	IV	IV			
Eared grebe			MIV	IV	IV			
Western grebe				IV	MIV			
American bittern		IV	IV	IV	IV		MIV	
Black–crowned night-heron			IV	IV	IV		MIII	
Northern harrier			IV	IV			MIV	
Virginia rail			IV	IV			MIV	
Sora		III	III	III		IV	MIII	
American coot		III	II	MI	IV		II	
Piping plover				IV		MIV		
Killdeer		MIII	IV	IV	IV	IV		
American avocet			IV	IV		III		MIII
Willet		III	MIII	IV	IV	IV	IV	
Marbled godwit		MIII	IV	IV	IV	IV	IV	
Wilson's phalarope		III	III	III	IV	IV	IV	MII
Black tern		IV	III	MIII	IV		III	
Marsh wren			IV	III			MII	
Common yellowthroat			IV	IV			MII	
Savannah sparrow	I	MI	III	III		IV	IV	
Red–winged blackbird	I	MI	I	I	III	III	I	
Yellow–headed blackbird		III	III	I			MI	
Breeding pairs/km²	200	633	432	724	39	52	674	89

[a]Data for anatids from Kantrud and Stewart (1977) and from Stewart and Kantrud (1974) for nonanitids; density categories are based on breeding pairs/km² of wetland type: I = >90, II = 50 to 89, III = 10 to 49, and IV = <10 breeding pairs/km²; M = wetland class where each species reached maximum density.
[b]Common names correspond to scientific names in AOU (1983).

Research Needs and Methods

Our analysis as well as that of Sheehan et al. (1986) for the Canadian prairies, indicate that the data presently available are inadequate to assess the impacts of agricultural chemicals on wildlife inhabiting prairie wetlands and their watersheds, and that a diverse and coordinated research effort is needed. That agricultural chemicals may be contributing to the degradation of wetland habitats and declines in waterfowl populations makes this effort even more important.

Specific needs include a thorough compilation of pesticide use data within the region. The use of agricultural fields by wetland wildlife and other species also needs to be quantified. Of particular concern is the use of sunflower fields, because of the greater use of insecticides compared to other crops. Periodic surveys of the distribution and abundance of wetland types and their wildlife populations, similar to those conducted in North Dakota in the 1960s (Stewart and Kantrud 1974, Kantrud and Stewart 1977), may help monitor changes related to agricultural practices and land use.

Additional laboratory data are needed on the toxicity of agricultural chemicals to different species of plants, invertebrates and wildlife in prairie–pothole wetlands. Pesticide formulations should be included because of reported differences in toxicity between the parent compounds and their formulations (e.g., Coats and O'Donnell–Jeffery 1979, Hill and Camardese 1984, 1986). Studies need to be conducted on the effects of multiple exposure to pesticides and the interaction of pesticide exposure and disease.

The use of manmade wetlands may help bridge the gap between laboratory toxicity tests and field studies. Naturally derived multispecies wetland communities have been used to assess the impacts of agricultural chemicals on aquatic invertebrates under laboratory conditions (Huckins et al. 1986, Johnson 1986). These models mimic many of the complex processes involved in pesticide runoff from fields and the subsequent deposition and impact of pesticide residues on wetland plants and invertebrates. The models consisted of a simulated runoff device for the delivery of sediment/water/chemical mixtures and multicomponent microcosms containing reconstituted water, wetland sediments, invertebrates and aquatic plants from a natural prairie–pothole wetland.

A similar approach was used by Stephenson and Kane (1984) to study the persistence and effects of parathion and the herbicide linuron on aquatic invertebrates. The authors built enclosures from cylinders of transparent polyethylene with the tops suspended above the water surface by a metal frame and the bottoms attached to a fiberglass base. The enclosures were lowered into a natural pond and the rim of the base pushed into the sediment to effect a water seal.

A more–realistic alternative is the use of manmade ponds. Small (0.04 acre: 0.02 ha) enclosed ponds have been used successfully to study the effects of acidification on the abundance of natural aquatic invertebrates and the growth and survival of young black ducks introduced to the ponds (G. M. Haramis unpublished data). Similar wetlands have been used by Swanson et al. (1986) to study various aspects of the ecology of breeding waterfowl including renesting and the relationship between food availability and the growth and survival of mallard ducklings (G. A. Swanson unpublished data). Another approach is the partitioning of entire wetlands (Sheehan et al. 1986) using techniques similar to those described by Stephenson and Kane (1984). Pesticide treatments could then be randomized among compartments within two or three partitioned wetlands to determine their ecological impacts.

Laboratory toxicity tests and studies on experimental wetlands provide data essential to the design of field studies (e.g., data on persistence and potential direct and indirect effects), but they are not a substitute for field tests. Environmental mediation of direct toxic effects and ecological influences (predation, competition, life history) on population and community response can only be fully tested under field conditions. In addition, only field studies account for the variability inherent in natural populations and, consequently, they more accurately assess the severity of pesticide–induced impacts. Experimental designs that incorporate procedures to separate biological variability from variability in responses to pesticide inputs are essential to successful field tests. Field studies assessing the impacts of selected agricultural chemicals on free–living adult and juvenile waterfowl and pen–reared wild–stock broods in prairie–pothole wetlands are currently being conducted in North Dakota by the USFWS (Patuxent Wildlife Research Center, Northern Prairie Wildlife Research Center, and Arrowwood National Wildlife Refuge). As part of this study, techniques for introducing orphaned broods of mallards and blue–winged teal were developed (C. E. Grue, G. A. Swanson, L. R. DeWeese unpublished data) to ensure that adequate numbers of ducklings are present for statistical comparisons among study wetlands. Techniques described by Pehrsson (1979) and Hunter et al. (1985) for imprinting ducklings on domestic mallard hens, or on the investigators themselves, offer the advantage of studying younger ducklings that are not yet able to thermoregulate, but which may be most vulnerable to pesticide–induced reductions in aquatic invertebrates.

A long–term research program to evaluate the impacts of agricultural chemicals on wetland wildlife under field conditions and the establishment of designated research areas within the prairie–pothole region would permit the timely testing of new chemicals and the evaluation of cumulative effects. Wetlands and watersheds for which the history of contaminant exposure is known and on which investigators have control of agricultural manipulations would be a necessity. For example, USFWS studies on the impacts of agricultural chemicals underway in North Dakota are being conducted on watersheds located entirely within WPAs, lands owned by the USFWS. The major goal of this type of research program should be the development and testing of predictive models capable of comparing the relative impacts of specific chemicals on prairie–wetland ecosystems. Presently, however, much of the data needed to develop satisfactory models has not been collected (for review, *see* Sheehan et al. 1986). Only when the impacts of agricultural chemicals on waterfowl inhabiting prairie–pothole wetlands and their watersheds have been quantified can the contribution of these impacts to observed declines in waterfowl populations be accurately assessed. Determination of the exposure of wildlife to agricultural chemicals, the amounts of these compounds within the various components of wetland ecosystems and the comparison of these data with those from laboratory and controlled field studies is the critical link in establishing cause–and–effect relationships in the field. The development of simple, rapid field techniques (bio–assays and bio–indicators) for quantifying exposure or the amount of chemical present would greatly facilitate this process.

Summary and Conclusions

The potential for agricultural chemicals to enter prairie–pothole wetlands and impact wildlife dependent on these wetlands for survival and reproduction appears to be great. However, the actual risk to wetland wildlife from the inputs of these chemicals cannot be adequately assessed at this time, because of insufficient data. Available data on the use of pesticides in the prairie–pothole region and the toxicity of these pesticides suggest that insecticides pose the greatest hazard to wetland wildlife, particularly birds. The majority of the most widely used insecticides within the region are very toxic to aquatic invertebrates and birds. Of particular concern are the impacts of agricultural chemicals on the quality of the remaining wetlands in the region and whether or not these impacts have contributed to observed declines in waterfowl populations. Although existing data suggest that adult and juvenile waterfowl may not be more sensitive to these chemicals than are other wetland wildlife, their food habits and feeding behaviors may make them more vulnerable to direct toxic effects or chemical–induced changes in the abundance of aquatic invertebrates. Laboratory and field studies in the United States and Canada are critically needed to assess these potential impacts.

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Insights from Contaminated Fish in New York

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Introduction

Current concerns about chemical contamination of fish include the effects of these contaminants on wildlife consumers and the potential for public health problems. Mercury was the first contaminant in fish to receive careful public health study, when residents of Minamata, Japan, were found to be suffering severe illness and death from mercury poisoning. These deaths and illnesses were traced to mercury contamination of the fishery by industrial discharges of mercury to Minamata Bay. With data from these studies and from a number of acute poisonings from grain contaminated with mercurial fungicides, the U.S. Food and Drug Administration (FDA) established an action level for mercury in fish or shellfish. The sale of swordfish was prohibited in the United States when it was found in the mid–1960s to exceed the action level.

The effective use of DDT during World War II for control of such insect–transmitted diseases as malaria and typhus soon lead to its widespread use in agriculture and for forest pest control. New York State joined the federal government to eradicate the gyspy moth from the Northeast, and thousands of acres of wild forest lands were aerially sprayed with DDT. By 1964, George Burdick and others had implicated DDT as the cause of poor reproductive success of lake trout in many New York lakes (Burdick et al. 1964). Soon thereafter, the decline of many birds of prey, particularly piscivores, was clearly linked to the widespread use of DDT. As a result, New York State banned DDT use in 1971, and a national ban was imposed in 1973.

In New York State, contamination of fish by mercury to levels in excess of the FDA action level was discovered in late 1969 and early 1970. Throughout 1970, fish from one water after another were discovered to exceed the action level. A series of public announcements closed fisheries in a number of waters in the State. In 1971, there was a statewide advisory to eat no more than one meal of fish per week from any water of the State.

By the early 1970s, limited data were collected on polychlorinated biphenyls (PCB) in New York fish. When the FDA established a temporary tolerance limit for PCB in 1974, intensive sampling for PCB began. By early 1976, sufficient information about PCB contamination was available to prohibit commercial fishing for striped bass in 150 miles (241 km) of the Hudson River estuary and to close an additional 40 miles (64 km) of the river to recreational fishing. Later that year, the discovery of mirex contamination in fish from Lake Ontario lead New York to ban the possession of seven species of Lake Ontario salmonids and to terminate the stocking of Pacific salmon, with the exception of limited coho salmon stocking for the purposes of continued contaminant monitoring.

Since 1976, the Department of Environmental Conservation in New York State has continued an aggressive program to monitor and evaluate bioaccumulable contaminants in fish throughout the State. Possession of salmonids from Lake Ontario is no longer prohibited, but restrictive advisories still persist. In addition, a number of additional policy decisions have been necessary, including an extension of the prohibition of commercial fishing for striped bass into marine waters of the State in 1985 and the very recent adoption of a policy on contaminants in fish.

This paper is intended to review some of the technical findings of the last 10 years and to comment on the changing public perceptions about contaminated fish.

Contaminated Waters Can Be Anywhere

Over the past 10 years, fish have been collected from several hundred waters in New York State. Lakes, ponds, rivers and streams have been sampled. Many waters are remote from any obvious potential source of contaminants (e.g., the Adirondacks), while others are bordered by extensive industrial development (e.g., Niagara River).

Seven contaminants have been found to exceed FDA tolerance or action levels in fish and three others are considered of concern by the New York State Department of Health (DOH) even though FDA standards have not been established for them. Elevated levels of contaminants are found in fish from 30 waters (Table 1).

These waters include rivers, streams, ponds and lakes, small and large, remote and industrial. In several cases, the source is known; others can be guessed but have not been proven. However, for the majority, sources are unknown.

PCB contamination is most frequently found to be in excess of the new FDA tolerance limit of 2 ppm. The discharge of PCB from approximately 1948 until 1977 by a capacitor and transformer manufacturing facility on the Hudson River is primarily responsible for fishery contamination in the Hudson, Harlem and East rivers and in marine waters. Although active discharge of PCB ceased nine years ago, continued fishery contamination results from leaching and resuspension of heavily contaminated river sediments primarily localized to 5 miles (8 km) of the river. The environmental consequences of this notorious case have been well–documented (Horn et al. 1979, 1983, Armstrong and Sloan 1981, Sloan and Armstrong 1981, Horn and Sloan 1984, Brown et al. 1985, 1986). In 1977, goldfish collected 25 miles (40 km) downstream from the discharge at Stillwater, New York, averaged 576 ppm PCB (Horn et al. 1979). Largemouth bass from the same location averaged 69 pmm. In 1982, goldfish averaged 12 ppm and largemouth bass 4 ppm. Since 1982, PCB levels in fish have remained essentially unchanged.

In a rural portion of the Valatie Kill/Nassau Lake/Kinderhook Lake watershed, erosion and leaching of PCB from a solid waste dump site contaminated fish to levels as high as 62 ppm (Sloan et al. 1981). Remedial work at the site was completed in 1985 and follow–up sampling will be scheduled for 1986 and later. This will be the first opportunity to evaluate the effectiveness of engineered control of PCB releases from a solid waste site in New York State.

Numerous other waters contain fish with excessive PCB levels, but the source(s) remain unknown. Most of these waters have no point source discharges of PCB, and in others, PCB levels in fish are too high to be explained by known or suspected point sources.

Mercury contamination is the second most commonly found excessive contaminant in fish in New York waters. Although the contamination of Onondaga Lake fish has a relatively obvious source in a chloralkali manufacturing facility and its associated waste–disposal beds (Sloan and Karcher 1983), four other waters in the State have fish approximating the same levels of contamination as fish found in Onondaga Lake. The watersheds of these lakes are virtually undeveloped and contain no industrial activities that could be a significant source of mercury. Atmospheric deposition of mercury, acid deposition and leaching of mercury from soils and bedrock geology, and environmental conditions conducive to accumulation by fish have all been postulated as contributing to excessive mercury contamination of fish in these lakes (Sloan and Schofield 1983). However, no careful studies have been carried out to document clearly that this is so.

Excessive chlordane contamination in fish may soon be found to be more common than mercury contamination. So far, the contamination appears to be limited to urban ponds, particularly in the New York City and Long Island area. Until 1985, when New York prohibited its use, chlordane was used to control termites. In the past, chlordane use was more widespread, including spraying turf and at least one case in the early 1950s to control insect forest damage by aerial spraying. At present, it is not possible to determine whether recent legal or illegal use of chlordane or the older uses have produced fishery contamination.

These examples and the others listed in Table 1 serve to demonstrate that a wide variety of activities and uses involving these chemicals can produce significant fishery contamination. Industrial discharges are important contributors, but by no means can they be implicated as being the major sources at this time. Only with more–thorough survey efforts nationally will it be possible to determine whether these patterns exist elsewhere in the country.

Variability in Fish Contamination

The general observation that the contamination of fish at any site is found to exhibit large variability is of some significance to public policy and the design of contaminant–monitoring programs. Much of the variability remains unexplained or is not consistently explainable from location to location with the same factors. Location of capture, species, size, age, lipid content and season have all been found to contribute variability. When these sources of variability can be virtually eliminated (e.g., analyzing young–of–the–year of one species) the coefficient of variation can approach 20 percent. However, if one analyzes sport fish of legal size, the coefficient of variation is usually between 30 and 100 percent for any species at a particular location. With such large variability, collection of large samples of fish is required to estimate properly the degree of contamination, thus influencing the design of monitoring programs.

Knowledge of this variability may also be important in making policy decisions. For example, seasonal variability in PCB contamination of coho salmon from Lake Ontario follows a consistent pattern (Figure 1). Fish caught in the spring are less contaminated than those caught in the fall. Only in 1979 when a small spring sample was taken have spring–caught fish exceeded 2 ppm on the average, although fish caught in the fall have been well in excess of the 2 ppm standard. With this pattern, it has been possible to advise anglers to fish in the spring if they wish to eat their catch and not to eat their fall catch.

When dealing with commercial fisheries, the variability of contamination becomes even more important (Sloan and Horn 1985). No agency would willingly take action

Table 1. Sources of contaminants of New York State waters in which fish exceed tolerance limits for various contaminants.

Contaminant	Source	Water(s)
PCB	Industrial discharge, sediments	Hudson River, Harlem River, East River, Marine waters
	Industrial waste	Nassau Lake/Valatie Kill, Kinderhook Lake
	Industrial waste, unknown	Hoosic River
	Waste salvage, unknown	Canadice Lake
	Unknown	Niagara River, Mohawk River, Lake Ontario, Sheldrake River, Lake Champlain, Buffalo River, Canandaigua Lake, Sawmill River
Mercury	Chloralkali plant, waste disposal	Onandaga Lake
	Unknown	Schroon Lake, Indian Lake, Stillwater Reservoir, Long Pond
DDT	Unknown	Canandaigua Lake, Keuka Lake, Fourth Lake
Chlordane	Pesticide use	Long Island waters (5), Sheldrake River
Mirex	Industrial discharge, industrial waste, sediments	Lake Ontario/St. Lawrence river
Dieldrin	Pesticide use	Sheldrake River
Heptachlor epoxide	Pesticide use	Sheldrake River
2, 3, 7, 8–TCDD	Industrial waste	Cayuga Creek, Lake Ontario/ Niagara River
Cadmium	Sediments	Hudson River
Lead	Industrial discharge	St. Lawrence River

to close a commercial fishery on the basis of inadequate information. When the level of contamination is only slightly in excess of the FDA tolerance level, sample size can become a very important factor. Additionally, one must adequately sample (geographical or seasonal) subsets of the fishery. For example, in 1985, continued evaluation of the striped bass fishery in New York's marine district required a carefully designed and controlled sampling effort totalling 450 fish. The last fish were collected just before Thanksgiving, and data must be interpreted in time to develop new fishing regulations by May 1.

Response to Source Abatement

As mentioned above, PCB contamination of fisheries in the Hudson River responded very rapidly to significant reductions of PCB discharge to the River. Figure 2 shows the dramatic reduction of PCB levels in striped bass caught from the Hudson River between 1978 and 1985. Fish caught in 1978 averaged 11 ppm. By 1980, the average PCB level was 4.0 ppm. As previously noted, other species in the river have responded similarly or even more dramatically.

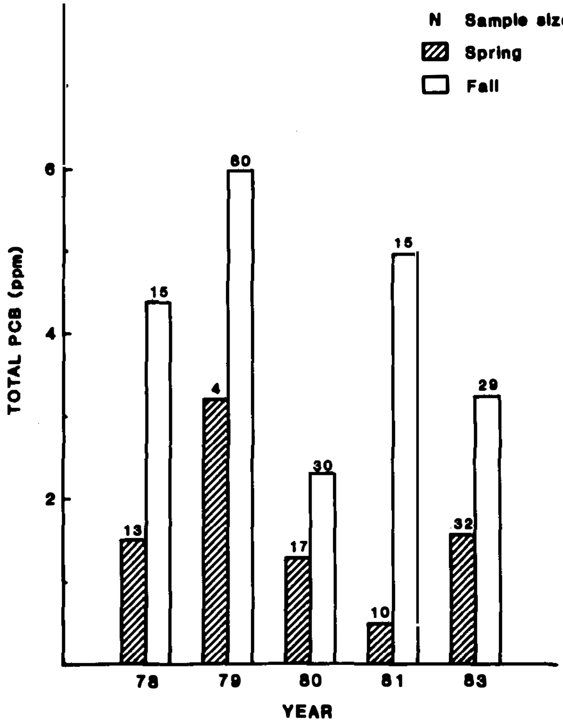

Figure 1. Total PCB, as ppm (μg/g) wet weight, in coho salmon (*Oncorhynchus kisutch*) collected from Lake Ontario in the spring and fall of the year.

Continued excessive PCB contamination persists because sediments in the river erode and leach PCB into the overlying water column, thus exposing fish. Control of the point source was effective, but the remaining non–point source is still a major problem. Dredging of "hot spots" (sediments exceeding 50 ppm PCB) could remove 40–60 percent of the PCB contained in the river sediments (Brown et al. 1986). Major political issues surround choice of a dredge–spoil site and continue to prevent further attempts to control this source of fishery contamination.

Abatement of mirex discharge to the Niagara River in 1975 produced a similar but less dramatic response in fish. Since 1978 mirex levels in salmonids from Lake Ontario and the Niagara and St. Lawrence rivers have been stable and remained above the FDA action level (0.1 ppm). Only in smallmouth bass did mirex levels decrease enough to change the restrictive consumption advisory on that species. Contamination of Lake Ontario sediments probably constitutes the greatest threat to fish, but inactive hazardous waste sites could be important. Unfortunately, we have very little understanding of the relative contribution of these two sources to the biota of the lake.

An industrial discharge originally contaminated fisheries with cadmium in the Hudson River and with mercury in Onondaga Lake. Here, too, the discharge reductions or abatement were not adequate to reduce contamination of fish below the FDA

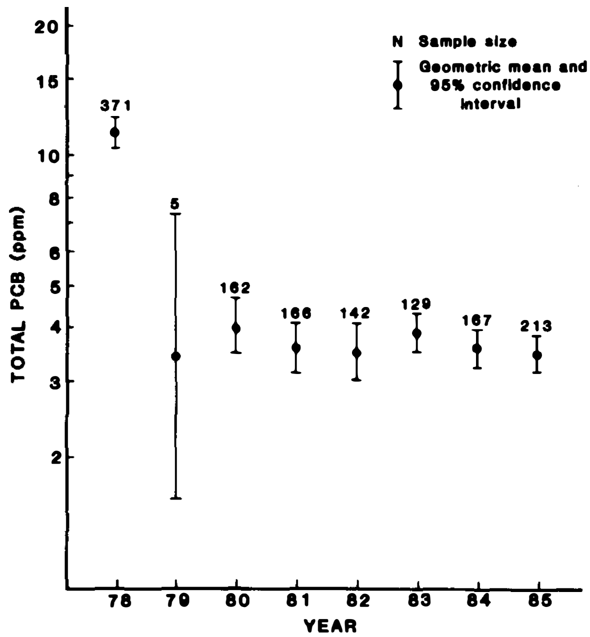

Figure 2. Total PCB, as ppm (μg/g) wet weight, in striped bass (*Morone saxatilis*) from the Hudson River estuary between Poughkeepsie and the George Washington Bridge.

limit. It remains to be seen whether additional remedial actions at either of these sites can result in uncontaminated fisheries.

An absolute prohibition against the use of DDT in New York 15 years ago has resulted in reduced DDT and DDE contamination of fish in most waters in the state. However, three large waters contain fish contaminated above the FDA level of 5 ppm (Table 1). This contamination is not a residual from DDT applications prior to 1971. Higher ratios of DDT/DDE have been found in these waters than in others with lower contamination. Illegal DDT use is suspected, but some Kelthane has been reported to contain DDT and has been used in the Canandaigua Lake and Keuka Lake watersheds.

Public Perceptions

Considerable public confusion surrounds the chemical contamination of fish. Most of the angling public and many other individuals want to know: "Are the fish safe to eat?" State, provincial and federal public health agencies have found that this simple question has no simple answer. These agencies, particularly at the state and provincial level, have provided responses that are difficult to understand and frequently differ from jurisdiction to jurisdiction even with regard to the same fish. U.S. federal agencies spend much of their energies avowing lack of jurisdiction. In 1981, when federal, state and provincial public health agencies were brought together to discuss what should be done regarding dioxin contamination of fish in the Great Lakes, the representatives parted company agreeing to disagree.

In New York, public discussion of a policy on contaminants in fish (Horn and Skinner 1985) uncovered a wide variety of opinions about what should be done when fishery contamination is discovered. Although virtually everyone agreed to the need for public warnings, the nature of the warnings and the form and effort devoted to the warnings were hotly debated. Some individuals and organizations believe that warnings are not adequate and that fishing should actually be prohibited to protect public health. Some disagreement was also expressed over the recommendation to only post signs where fishing is prohibited. Many thought that signs should be posted wherever the public was warned to not eat fish. Others thought that other restrictive advisories should also be posted. The State was also criticized for not providing more detail about the procedures, protocols and rationale for the health advisories. It was suggested that the advisories should be based on quantitative risk assessments for carcinogens at a 1:1,000,000 risk level rather than using FDA standards.

Unfortunately, these controversies have diverted attention away from what is being done or not being done to correct the problem at its source.

Conclusions

As noted above, fish collected from a wide variety of New York waters have been found to contain contaminants in excess of public health standards. Contaminants can be found in waters remote from industrialization or other development. More and more frequently it appears that non–point sources are responsible.

Before much can be done to rectify the contamination of fisheries, we will need more effort to identify sources. Past experiences in remediating point sources have been easy compared to what is needed where non–point source problems prevail. For a point source, information can usually be rapidly acquired about how much of a chemical contaminant is being used and discharged. Treatment of the effluent or modification of the industrial process has usually been feasible, affordable and effective. In some cases, the offending chemical can be eliminated entirely from the process.

Non–point sources of contaminants to water (e.g., overland runoff, solid waste sites, lake and river sediments, atmospheric deposition) are much more difficult to identify and quantify. Once quantified, the alternatives for abatement or treatment are rarely obvious. If technology is available, the expense is usually great. But more often, no proven technology is available.

More effort should be diverted to a thorough evaluation of the effectiveness of abatement technologies being applied to non–point source control. Such evaluation should include monitoring fish and/or other biotic elements to determine the ultimate effectiveness of these technologies. Such monitoring will usually require several years beyond the remedial action itself. In some cases (e.g., containment schemes such as capping solid waste sites), periodic monitoring should be carried out for several decades.

Successful improvement of fishery contamination will also require a better understanding of the bioaccumulation and environmental fate of contaminants. A quantitative understanding of the interactions between sediment, water, forage and fish could contribute to identifying innovative means to reduce fishery contamination.

But, what is more important, without that understanding the billions of dollars being devoted to source control, discharge abatement, Superfund "cleanup" and other programs to rectify the problem may continue to fall short of what is needed.

Finally, more biologists and more agencies should turn their attention to these problems. Even if fisheries themselves are not being adversely affected by these contaminants, other fish–consuming wildlife (e.g., birds of prey, mink) may well be. In addition, this contamination impairs, if not precludes, the recreational and commercial use of the resource. Resource managers should not expect engineers to solve the problem. Fishery contamination seriously challenges engineers, biologists, other environmental scientists and the public to working cooperatively to determine what can and should be done.

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Plans for Managing Natural Resources: Status, Quality and Field Accomplishments

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Opening Statement

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The theme of this conference is "Resource Management: First Line of National Defense." Taking this as a given, one could argue that land–use plans are—or should be—the chief weapon in the nation's defense arsenal. This would appear to be particularly true here in the West, where the federal government is the principal landowner, and the two largest federal agencies—the Forest Service and the Bureau of Land Management—are currently spending the majority of their time and money on land use and related resource–planning activities. The papers to be presented by this panel emphasize the planning activities of federal resource agencies, and the BLM and Forest Service in particular, in part because of the location of this meeting, but also because of the enormous implications these activities have for the fish and wildlife habitats and other publicly owned resources of the nation.

The BLM manages approximately 300 million acres of publicly owned land in the 11 western states and Alaska. This vast acreage constitutes more land—and more wildlife habitat—than any other federal or state agency manages. It is acreage that is subject to ever–increasing demands for conflicting uses at a time when more than 100 of the plants and animals that inhabit these lands have already been officially listed as endangered or threatened, largely as the result of exploitive activities permitted in the past. Another 800 species are believed to be in equal danger.

The Forest Service manages 191 million acres of forests and grasslands in 43 contiguous states, Alaska and Puerto Rico. Altogether these lands provide habitat for about 3,000 species of wildlife and fish. Some 65 plants and animal species have been designated endangered or threatened, while several hundred additional species are believed to qualify for listing.

Both the Forest Service and the BLM were given detailed planning mandates by Congress in the 1970s, and the planning activities I have referred to are being carried out in response to these mandates. Although the statutes that apply to each agency are different in a number of important respects, they contain a number of important similarities. For example, both agencies are supposed to be preparing comprehensive land–use plans that provide for multiple–use and sustained–yield management of the public's resources. Both agencies are supposed to prepare their plans with full public participation and full consideration of environmental impacts. They are supposed to prepare them in an interdisciplinary manner, using inventory data that have been collected. The land–use plans these agencies are preparing are supposed to determine and control the future course of resource management and land use for at least 10 to 15 years. The important differences between the agencies' respective planning mandates include the fact that the BLM was given no deadline for promulgation of the required plans. The Forest Service, in contrast, was given the target date of September 30, 1985, for completing all needed plans.

The Bureau received its planning mandate in 1976. It completed its first plan, known as a Resource Management Plan or RMP, in January, 1984—nearly eight years later. By January, 1986, the agency had completed a total of 18 plans out of the 154 plans that are to be prepared and, as of March 1986, it estimated that between 24 and 50 additional plans were underway.[1] Pending completion of RMPs, the agency's lands are being managed pursuant to plans known as Management Framework Plans or MFPs—noncomprehensive plans developed pursuant to an informal planning process that has been criticized by the General Accounting Office, the Office of Technology Assessment and the American Society of Planning Officials, among others.

Although the Forest Service did not meet its statutory target for completion of land–use plans, it is farther ahead than its sister agency, and not surprisingly so, since it has far more money and personpower to manage a much smaller land base. Of the 118 plans the Forest Service intends to prepare, some 25 have been completed and another 50 to 60 are underway.

It is through these land–use plans that the BLM and the Forest Service will be allocating the limited forage supplies of the public's lands between livestock on the one hand and wildlife, vegetative needs and everything else on the other. It is through these plans that decisions will be made regarding how—if at all—damage done in the past to critically important and vulnerable riparian areas, by such activities as mining and grazing, will be rehabilitated and future demage avoided. Preparation of these plans will lead to decisions about which wildlife habitat areas will be deemed suitable for coal mining and oil and gas development, and which will be protected from such developments. They will determine how much old–growth timber will be retained for wildlife; they will determine water quality standards and other needs, as well as how much land will be offered for sale and how many roads should be built. Many will contain recommendations regarding which *de facto* wilderness areas should be formally included in the National Wilderness Preservation System and, in the case of BLM, many will also recommend which lands should be sold or otherwise removed from public ownership.

Obviously, making these and other similar decisions is not an easy task for the conscientious land manager. And, as the result of my own experiences, I can attest to the fact that participating in the planning process is not an easy task for concerned

[1]Letter dated March 4, 1986, with enclosures, from Guy E. Baier, Acting Deputy Director, BLM, to Johanna H. Wald.

members of the public. Not surprisingly, given the nature of the decisions facing BLM and Forest Service decision makers, the plans that are being prepared by these agencies have received close scrutiny from many members of the public and have sparked a great deal of controversy. Environmentalists and conservationists in particular have charged that the plans of both agencies are far too slanted toward commodity production and place insufficient emphasis on resource conservation and protection. In many instances, their comments have been echoed by state fish and wildlife agencies, which have asserted that planning decisions will harm wildlife habitat as well as fail to improve already degraded resource conditions. Virtually every plan prepared by both agencies has been protested—BLM documents reveal that one plan received 29 protests,[2] and I have been told that one Forest Service plan received 30. One lawsuit involving a BLM plan is already underway, and it is likely that other lawsuits will be filed in the future against one or both agencies.

Clearly, this is an opportune and appropriate time to take a hard look at the planning activities of the Bureau, the Forest Service and other agencies, to see what we can learn from them. What are the problems plaguing their plans and procedures? What types of management practices are they calling for and what will be the impacts of implementing these practices? Are certain resources being short–changed by the plans being prepared and, if so, which ones? What are the causes of the problems that are occurring and what can be done to resolve them? Are the problems with planning or with the agencies doing the planning? How and what are other agencies doing?

Each of today's panelists possesses a wealth of experience in planning and a unique perspective. I am certain that they will provide us with useful and provocative insights into the problems and possibilities of land–use planning.

[2] Letter dated March 4, 1986, with enclosures, from Guy E. Baier, Acting Director, BLM, to Johanna H. Wald.

National Forest Planning: Problems and Solutions

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Introduction

The current program of national forest planning was initiated in 1976 with passage by Congress of the National Forest Management Act. Enacted as a means of resolving controversies over clearcutting, development of roadless areas, the effects of management on wildlife and water quality, and other issues, this law required the Forest Service to prepare comprehensive land– and resource–management plans for all of the 155 national forests. Because some national forests are combined into jointly administered units, only about 118 plans are being prepared.

Unfortunately, the planning process is doing little to resolve controversies. The Forest Service has made the process so complicated that few forest officials can understand it, much less members of the public. The agency has responded to controversies by centralizing the process, so that assumptions about recreation values and timber demand may be made thousands of miles away from a national forest's headquarters.

As a result, most members of the public consider the plans to be just another source of controversy, and little is done by either forest officials or special interest groups to reduce that controversy. Many of those officials and groups continue to regard controversy and polarization to be in their own best interests.

This paper will describe the planning process and detail some of its problems. It will conclude by suggesting ways in which wildlife biologists, interest groups, conservation agencies or any member of the public can work to improve a forest plan. It is based largely on in–depth reviews by Cascade Holistic Economic Consultants (CHEC) of over 35 forest plans in every region of the country.

The Planning Process

A forest plan is expected to make a wide variety of decisions about a national forest, including the level of annual timber harvest, the number of acres suitable for timber management, the number of acres that may be withdrawn from mineral entry, and the level of range management. In addition, subject to the whim of Congress, forest plans propose budgets for timber management, wildlife, recreation and other resources.

In theory, local forest planners work with the public to determine which issues need to be addressed by a plan, develop inventory data and assess land productivity, estimate the economic value of many forest resources and the relationships between resources, and build this information into a computer model called FORPLAN. Planners then prepare alternatives by asking FORPLAN how much timber, grazing and other resources can be produced given a goal of maximizing economic values and constraints designed to protect resources whose economic value is difficult to determine. The forest supervisor selects one of these alternatives as preferred.

In reality, many key decisions are made by higher levels of the Forest Service before local planners ever begin to work with the public. In particular, most of the economic decisions, including the values of all nontimber resources and the basic question of how economics is incorporated into planning, have been made by the Washington Office of the Forest Service. Estimates of timber values and yield tables for timber, wildlife and other resources are often made by the regional offices.

In addition, the Washington Office of the Forest Service has established targets for the levels of planned timber, range and other outputs that the regions must reach. The regions, in turn, pass these targets on to the local forest planners. Although these targets are supposed to be flexible, planners often feel compelled to meet and justify timber targets no matter what the cost to the economy, environment or their integrity.

Planning Decisions Made at the National Level

The Washington Office of the Forest Service has given far more direction to the forest planning process than to any previous Forest Service planning effort. This direction starts with forest planning regulations adopted in 1979 and modified by the Reagan Administration in 1982.

Under these rules, economic analyses are a major driving force in planning. The level of timber harvest and number of acres of land managed for timber are particularly determined by economics.

This does not mean that the Forest Service will not manage timber if it loses money. Instead, plans are to be "cost–efficient"—meaning that they will produce predetermined timber targets at the least cost. This direction ensures that most national forests will continue to lose money on timber sales and that serious conflicts between timber and other resources will remain unabated.

The predetermined timber targets are partially based on the Resources Planning Act of 1974, or RPA. This law directs the Forest Service to prepare a national program for its activities every five years. The RPA Program establishes targets for timber and other resources, which each region is expected to meet.

A major problem is that the timber and range targets tend to be "hard"—easily measured physical outputs of wood and AUMs—while recreation, fish and wildlife, and soils and water targets tend to be "soft"—either measurements of inputs such as acres of habitat improvement or difficult–to–measure outputs such as acre–feet of water that meets federal water quality standards—whatever those standards are. While there is heavy pressure on Forest Service employees to meet timber targets, no one is ever chastised because recreation use is low or wildlife populations are declining.

The RPA Program also estimates the economic value of recreation, including wildlife–oriented recreation, grazing and water. Although better estimates may be locally available, the RPA estimates are usually used by forest planners in FORPLAN.

Serious questions have been raised about the reliability of many of these values (O'Toole 1984). For example, the Reagan Administration ordered the Forest Service to reduce arbitrarily the 1985 RPA recreation and wildlife values by 37.5 percent. The Administration apparently felt that high recreation values would tend to bias planning away from commodity production. It turns out that this is probably not true.

The water values used in the 1985 RPA Program are even more specious. In many regions of the country, water is supposed to be worth $40–60 per acre–foot. Forest planners are dutifully incorporating these values into FORPLAN. Because planners also assume that timber cutting increases water yields, these high values lead the computer to propose more timber cutting.

It turns out that the high water values used by RPA are gross values of water delivered to irrigators. This is inconsistent with all the other values used in RPA, which are the net values of resources in the forest. If all the storage and delivery costs are subtracted from the water values, the remainder would often be negligible or even negative. For example, any additional water produced by the Tahoe or Shoshone national forests will simply run to the ocean unless expensive storage facilities are built with heavy federal subsidies. Yet planners assumed this water is worth $30–50 per acre–foot (CHEC 1985d, 1985e).

Grazing values in RPA are also very high. Although the Forest Service collects only $1.35 per AUM for grazing in the West, the RPA values are between $10 and $15. Planners say this is justified because the economic value of grazing is actually much greater than the rate derived from the Congressionally established fee formula.

Yet the 1985 Grazing Fee Review and Evaluation prepared by the Bureau of Land Management and Forest Service estimated grazing to be worth only about half the values used in RPA. On the Tahoe and Okanogan national forests, the value estimated by RPA far exceeds grazing costs—yet the value estimated by the Grazing Fee Review is less than management costs (O'Toole 1985). This value plays a crucial role in proposed grazing levels.

RPA does not set timber prices for planners, but it does estimate the rate at which timber prices will increase in the future. These rates or "price trends" tend to bias planning towards timber in two ways.

First, the rates are far higher than is realistic. While the trends often predict timber prices will double in 10–40 years, most economists agree it will take far longer for prices to even return to their prerecession levels. Since, as will be seen, most forests assume timber is worth the prices bid for it prior to the recession, these trends seriously overestimate future prices.

The second bias comes from the assumption, required by the Washington Office, that all costs and all resource values except timber will remain constant for the next 50 years. In fact, recreation values and many timber–related costs are rapidly increasing.

The assumption that only timber prices will increase leads to the absurd conclusion that near–deserts will eventually become valuable for timber. Under the planning process, such acres are immediately available for management. For example, without the price trend, virtually no land on the Gallatin National Forest in Montana would be considered economically suitable for timber. With the price trend, over 300,000 acres are being proposed for timber management, because they might, after 50 years, begin to be worth cutting (CHEC 1985a).

Although the Forest Service would plan to cut some acres on the Gallatin anyway, the price trends lead it to include far more acres in the timber base than are actually needed to meet its timber targets. Thus, thousands of acres of valuable roadless areas and habitat for grizzly bear and other wildlife will be open to road development timber cutting. This is a problem on most forests in Regions 1, 3, 8, and perhaps 5 and 6, because of the way price trends are used in those regions.

Planning Decisions Made at the Regional Level

The degree and topics of centralization vary considerably among the nine Forest Service regions. Timber values, timber yield tables, the treatment of Congressionally released roadless areas, and assessments of wildlife needs are among the decisions made for forest planners by some or all of the regions.

Planning began in earnest in 1980, when timber prices were at an all–time high. Even though prices soon fell to half or less of their previous levels, many regions continued to assume that timber prices were still at their prerecession levels. In fact, it is unlikely that prices will soon return to those levels since they were based in part on low mortgage–loan rates that are unlikely to be seen again and on the baby–boom housing boom which is nearly over.

Plans are extremely sensitive to timber price assumptions. On the Santa Fe Forest, computer models using pre–1980 data showed that higher timber harvests would increase the economic value of the plan. The Forest thus proposed to harvest 50 million board feet per year (USDA Forest Service 1983). After correcting timber prices, higher harvests reduced the value of the plan, leading the Forest to reduce proposed harvests to 42 million board feet (USDA Forest Service 1985). Similar reductions have been made on the Carson and Beaverhead national forests.

The draft and final plans for most forests in Regions 2, 4, 5, 8 and 9 are based almost exclusively on these high prices. Draft plans for most forests in Regions 1 and 3 are also based on the high rates, but they may be revised in some or all final plans. The assumption of high timber prices leads forests to dedicate more acres to timber management, as well as to propose higher levels of harvests.

Although the Forest Service has been preparing timber yield tables since the 1930s, this science is, in many ways, still in its infancy. Yield tables used by many forest planning teams greatly overestimate the rate at which timber can grow on their forests.

In Region 5, yield tables made by the regional office for all forests are extremely difficult to believe. Many predict that stands of old–growth timber will suddenly double in volume in the next 20–50 years (O'Toole 1983). Most project growth rates of older stands in the next 10 years that are far greater than actual measured growth rates of these same stands over the past 10 years. Although planners in most other regions may prepare their own yield tables, they often are required to use regionally approved models that may not represent the state–of–the–art.

Roadless areas remain a controversial issue even where Congress has passed wilderness bills "releasing" certain areas for multiple–use management. Although "multiple–use" can include primitive and semiprimitive recreation options in Region 6, Regions 3, 8 and 9 assume that all released areas must be developed. For example, the Chequamegon Forest in Wisconsin assumes that 4.5 miles of roads per square mile (2.8 km/km^2) of land must be built into all roadless areas (CHEC 1985b).

Fewer wildlife decisions are made at the regional level, but many regions must approve the lists of "management–indicator species" developed by the forests. The minimum requirements for each species are often developed by the regions as well.

For example, a regional wildlife model used in regions 8 and 9 assumes that only 50 effective individuals of a species are needed to maintain a viable population. In fact, the literature cited by the Forest Service in support of this indicates that 50 effective individuals are needed to maintain short–term viability, but that long–term viability requires 500 (CHEC 1985b). Use of this model may threaten many species in the Midwest.

A Region 5 model used to track timber/spotted owl relationships in California forests concludes that this old–growth dependent species reaches its optimum habitat in 100– to 200–year old timber. By the time timber is 240 years old, habitat effectiveness has declined by 60 percent. The conclusion is that timber management is needed to retain timber at the 100–year age class, while wilderness will allow timber to grow beyond optimum ages. In reality, the owl almost certainly prefers timber older than 250 years of age, but the model leads planners to eliminate such stands.

Planning Decisions Made at the Forest Level

Most national forest are allowed to design their own yield tables for nontimber resources, including tables describing the relationship between timber harvesting and recreation, wildlife and other resources. Due, perhaps, to pressures to meet high timber targets, these tables are often biased towards increased timber management.

For example, many forests assume that recreationists will benefit from the roads built for timber management. In fact, the capacity of the current road systems on most national forests far exceeds the expected demand for roaded recreation.

On the Hoosier National Forest, the recreation planner initially estimated that future recreation demands could be met with the current road system. He later revised this estimate to conclude that current recreation demand already required 10 times as many roads as were currently found in the forest. Planners used the value of this recreation to help justify money–losing timber sales. According to a memo written by the recreation planner, the revision was made against his better judgement because he was ". . . told by the forest planning team to make sure demand was greater than our capability" (CHEC 1985c).

It is ironic that, due to the frequency of this assumption, the environment would actually benefit from assumed low recreation values. It is doubly ironic that the Administration ordered recreation values reduced in RPA, thinking this would bias planning away from recreation.

Due to the paucity of data on timber/wildlife relationships, planners must be very creative in building wildlife yield tables. On the Flathead National Forest, planners assumed that a decision not to road a roadless areas would increase grizzly bear populations by 20 percent. Clearcutting would also increase bear numbers by about 20 percent due to the increase in habitat "diversity." Thus, timber management without roads (using long–span skyline logging systems) actually scored higher in grizzly bear production than did wilderness (CHEC 1983).

On the Gallatin National Forest, a significant acreage of prime grizzly bear habitat was placed in "grizzly–timber" management. Planners did not know how timber management would improve bear habitat, but in the meantime, they assumed the areas would produce 100 percent of normal timber yields (CHEC 1985a).

Research on wildlife habitat in managed forests of northeastern Oregon is selectively quoted by planners everywhere from North Carolina to New Mexico. In New Mexico, planners cited the Oregon research to show that heavy clearcutting is needed to improve forage–cover ratios. In reality, most forests in New Mexico fail to meet the 70–percent crown cover requirement for cover, and thus need cover far more than forage (CHEC 1985f).

Planners also make questionable assumptions regarding the effects of timber management on fish. On the Klamath National Forest, planners assumed that there would be no effects on fish if timber cutters and road builders met "best–management practices." They also assumed that it wouldn't matter if they didn't meet best–management practices, because these requirements were "rarely enforced." Thus they concluded that the same number of fish would be produced whether 180 or 310 million board feet of timber were harvested each year (O'Toole 1983).

Influencing the Planning Process

Given this overview of the planning process, it is possible to state a few simple rules for people, particularly professionals or people with expertise in some forestry–related field, who want to improve plans.

First, don't assume that you can't win. Despite the centralization of the planning process, forest officials are very willing to listen and to correct mistakes they have made (but usually not mistakes mandated by higher levels). For example, CHEC's forest plan reviews have led to major improvements in the Nantahala–Pisgah (NC), Santa Fe (NM), Carson (NM), Beaverhead (MT), Bridger–Teton (WY) and Chugach (AK) plans, among others.

Second, carefully review background data and documents relating to resources within your areas of expertise. Don't try to do an economic analysis, for example, if you have little or no training in economics. Concentrate instead on wildlife, fisheries, or whatever is your specialty. A number of publications are available to help you make such reviews (CHEC 1985g, 1985h).

Third, work with planners to determine which assumptions are most critical to the planning process. For example, it does not particularly matter if recreation values are too low if planners incorrectly assume that recreation benefits from timber cutting. Correct the latter assumption before worrying about the recreation value.

Finally, if you find something wrong, take your case to the officials who made the decisions. It does no good to argue about habitat requirements with local planners if the fundamental decisions about those requirements are made at the region. Arguments about recreation values at the forest or regional level are pointless when those values are set in Washington.

The forest planning process is extremely complex, but CHEC has shown that it is possible to have a significant effect on the results. These simple rules are the essence of CHEC's methods, and you should be able to use them to make major improvements on plans in your area.

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Land-use Planning in the Bureau of Land Management

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Introduction

The public lands—177 million acres (71.6 million ha) in the 11 western states and 114 million (46.1 million ha) more in Alaska—are managed by the Bureau of Land Management (BLM) through a land–use planning process called Resource Management Planning (RMP). These public lands are the remnants of the historical public domain, after individuals, industry, state and local governments, and other federal agencies acquired most of the "then–desirable" lands during the westward expansion.

These lands, once an unwanted stepchild of western settlement, have become a national heritage. Scattered unevenly throughout the West and Alaska, they sustain environmental and commodity resources of enormous value. Once neglected, these lands now continually face competitive and usually conflicting demands for fossil fuels, minerals, timber, livestock grazing, fish and wildlife habitat, wilderness, and recreation. BLM uses the RMP to allocate resources and select the uses of the public lands.

Evolution of the Planning System

The Taylor Grazing Act of 1934 (43 USCA 315) institutionalized uncertainty by specifying that public domain lands were to be managed "pending their final disposition." This uncertainty prevailed until 1964, when Congress established the Public Land Law Review Commission (PLLRC) (PL 88–606), enacted the Classification and Multiple Use Act (CMU) (PL 88–607), and Public Law 88–608—a law authorizing sale of large blocks of public lands if classified for disposition. All were temporary and expired in four years. From 1965 through 1969, BLM classified 140 million acres (56.7 million ha) in the 11 western states for retention.

The PLLRC report (1970) recommended that the public land agencies be required to plan land uses to obtain the greatest net public benefit. The Council on Environmental Quality (CEQ), in its first annual report (1970), further enhanced the case for a BLM planning system by identifying a national interest in effective land–use planning. The National Environmental Policy Act of 1969 (NEPA) further strengthened the need for a systematic land–use planning system.

BLM started to develop a planning system about 1964, when it established an Office of Program Development in its Washington Office. This centralized authority for designing and implementing a planning system. Initial efforts included subdividing districts into planning units and establishing a resource–inventory/data–storage procedure (URA). In 1969, planning manuals were issued that established the Management Framework Plan (MFP) as the central decision process. By 1970, the planning system was operational (Jones 1971).

The Federal Land Policy and Management Act of 1976 (FLPMA) (PL 94–579) set a number of milestones that both influenced and directly mandated land-use planning. Key points of FLPMA that drive the BLM planning system are:

- most of the public lands be retained in federal ownership;
- the public lands and their resources are to be periodically and systematically inventoried;
- mandates planning regulations and management on the basis of multiple use and sustained yield;
- management to protect the quality of environmental resources;
- receive fair market value of the use of the public lands;
- regulations and plans for the protection of areas of critical environmental concern (ACEC);
- defines public involvement;
- defines principle or major uses of the public land to include fish, wildlife and recreation;
- brings the public lands into qualification for the Wilderness System;
- use a systematic interdisciplinary approach to planning which provides for integrated considerations of physical, biological, economic and other sciences;
- priority to the designation and protection of ACECs;
- rely on the inventory, to the extent that it is available, for planning;
- stresses consistency of planning with state and local governments; and
- stresses public involvement in planning.

The existing planning system was the core for the planning regulations (43 CFR 1601) published in 1979. These regulations, as required by FLPMA, provided new planning procedures and incorporated the Council of Environmental Quality's NEPA regulations.

In July 1983, the planning system was revised to focus on issues to be resolved. There was major de-emphasis of extensive inventories. Another component of revision was to establish provisions for governor's review of proposed plans within a state.

In late 1985, BLM commenced issuing supplemental program guidance for the individual programs (range, wildlife, recreation, etc.). The intent of this guidance was to: (1) clarify the nature of program; (2) enhance the ability of individual program specialists to work effectively in an interdisciplinary mode; (3) assist administrators review of draft planning documents; and (4) allow a measure of comparability between RMP's BLM-wide.

Description of the RMP Process

The RMP is usually a single document that integrates planning and the Environmental Impact Statement (EIS). The RMP is often supplemented by detailed program activity plans, such as Wildlife Habitat Management Plans and Allotment Management Plans for domestic livestock.

The RMP establishes:

- land areas for limited, restrictive or exclusive use. Examples include identifying lands suitable for disposition, or areas for special management, such as the Idaho Birds of Prey Natural Area and ACECs;
- allowable resource uses and production levels;

- resource goals and objectives;
- program constraints and management practices;
- needs for more–detailed and specific plans;
- support actions necessary to meet goals, i.e., roads, cadastral survey and fire management; and
- standards for monitoring or evaluating the effectiveness of the plan.

Nine separate actions occur in the development of a RMP: (1) issue identification; (2) develop planning criteria; (3) collect inventory data; (4) analyze the management situation; (5) formulate alternatives; (6) estimate effects of the alternatives; (7) select the preferred alternative; (8) select the RMP; and (9) monitor. Step six—estimate effects—is the action where the requirements of NEPA are integrated.

Public Participation

A notice of intent to prepare a RMP is published in appropriate media. Those with interests should contact the BLM issuing office to have their names and addresses added to the mailing list for all future announcements. BLM requires participation in planning to qualify for protesting plan approval.

Public participation is outlined in the following nine separate components:

1. *Issue identification*. The plan manager solicits ideas through various public contacts to discuss issues and obtain comments. An official record shows who participated and becomes important later when opportunity is provided to protest plan decisions.
2. *Develop planning criteria*. BLM states for public review and comment what will or will not be done or considered during the planning process.
3. *Collect inventory*. This is primarily an internal process.
4. *Analyze the management system*. This is also an internal process.
5. *Formulate alternatives*. There is the chance for public review of alternatives and the analysis of alternatives when the draft RMP and EIS are completed.
6. *Estimate effects of the alternatives*. This parallels step five, where public comment is provided for during the comment period on the draft RMP and EIS.
7. *Select the preferred alternative*. This step is completed internally and public comments are provided for in the 90–day review period for the draft RMP and EIS. Availability of the draft RMP/EIS is announced to those on the mailing list and through the various media.
8. *Select the RMP*. The official date of the final EIS is important as it begins the protest period. Any member of the public, or any agency or group that has participated in planning, has 30 days after publication of the RMP and filing the final EIS, to file a protest with the BLM Director to object to approval of the plan or any part of it that affects their interest adversely. Also, the governor of the state has a last opportunity to identify inconsistencies between the proposed RMP and state and local plans or programs.
9. *Monitor*. No formal responses are provided for public participation in this planning phase.

Additional details on planning and public participation are available in a pamphlet available from BLM.[1]

[1] *A Guide to Resource Management Planning on the Public Lands*. 1983. U.S. Department of Interior, Bureau of Land Management, Washington, D.C., 22p.

Costs and Parameter

In the current 1986 budget year, BLM plans to spend a little over $9 million on planning. This contrasts to a planning budget of $16 million in 1981.

Preparation of the first nine grazing plans was costly. Nelson (1983) estimated a total cost, including various program support actions, such as inventory, of about $5 million per plan. In recent years, the cost–per–plan has stabilized in the $300,000–600,000 range. RMPs, in most cases, are prepared for resource areas that average about 1.1 million acres (445,000 ha) in size.

As of January 1986, there were 44 RMPs in draft, of which 39 were proposed and 18 approved. There are some 20 RMPs in progress, and BLM averages 10 new starts per year.

Discussion

Initially, there was an enthusiastic and optimistic outlook by many, both inside and outside BLM, for planning to format objective resource decisions by resource professions. This state of naiveté rapidly wilted to reality when the lands nobody once wanted proved to have modern–day resources and uses that everybody wanted. Intensive demand and political pressures surfaced at national and local levels to establish a climate of intense competition for public land values. Resources and land uses were bargained off to the most–effective and usually the most–vociferous competitors. The politically vulnerable administrator, under the guise of land–use planning, obfuscated where he could and mediated where he couldn't.

Initial costs of the land–use planning were staggering; Nelson (1983) estimated the *total* costs of the first nine grazing plans at about $50 million. In some of these early plans, the government could have bought out many of the grazing rights (the cause of range deterioration) for what it cost to prepare the plan. Unrealistic deadlines and workloads, associated with frustration over questionable results, exacted a toll on BLM personnel that resulted in numerous personal problems and the loss of a number of promising employees to other ventures.

Coming to grips with a present–day RMP is like trying to consume a 400–pound marshmellow in one sitting. What does it do? What does it say? And what firm decisions have been effected? Three years after the court–ordered grazing EIS program—Natural Resource Defense Council (NRDC) vs. Andrus—NRDC (1978) concluded that ". . . the Bureau has expended very substantive sums of money and manpower on these EIS's, but has produced little or nothing to show for it". NRDC further concluded, ". . . the evidence reveals that the inadequacy of the draft EIS's released to date by the BLM, were caused by its failure to address the issues which were central to proper grazing management rather than insufficient data".

In my travels across public lands with completed plans, I was unable to observe many significant changes. Livestock numbers seem to fluctuate more in response to market conditions than to any *real* reductions imposed by planning decisions. Cattle were still wallowing in the streams and chomping away on any vestiges of edible riparian vegetation. The old axiom, "Business as usual," prevailed for the most part.

My participation in a Headquarters review of the first Challis final EIS draft, saw an Agency and Department obsessed with the processes. At the same time, I saw little energy being directed toward improved stewardship. Hard questions on resolving the effects of years of livestock overgrazing were confused through a series of poorly designed, expensive and impractical rest–rotation grazing systems. An early commenter (Day 1979) described the range EISs as "pure busywork carried out in the name of decision making, but serving only to divert energy, attention, and effort from management functions to useless paperwork."

I attribute many of BLM's planning problems to a lack of organizational stability. Foss (1960) described frequent reorganization as a characteristic BLM approach to problems, uncertainty or personnel management. Reorganization bears a heavy cost—both in dollars and to public understanding, productivity and employee morale. The cartoon character Plutonius urging, "When in doubt, reorganize," appears to have established a BLM byword.

A series of frequent and continual changes in leadership, now institutionalized by FLPMA, have further contributed to agency instability. A change in directors inevitably results in changing policies, priorities, program emphasis and organizational structure. In contrast, the USDA Forest Service, with its stability and professionalism in leadership, has much to envy.

The professional ranks of BLM have also contributed to lack of stability, by enthusiastically adopting new methodologies, techniques and applied research, while at the same time, recklessly abandoning and purging, through neglect, the old. One consequence of this "trendiness" is a total lack of long–term data to measure changes in the health of the western rangelands. Only personal recollections, often biased, can relate to long–term changes in range vegetative and soil resources. Exceptions are a few scattered photo plots and exclosures.

This dilemma of instability is further enhanced by political motivations. An example, much to the relief of the livestock industry, is the Department's embargo on the use and access to computer files containing soil, vegetative, inventory and methodology data (SVIM). These data were intended to be used to allocate forage among various competing uses (livestock, wildlife, wild horses, burros and watershed cover). Incidentally, gathering and providing an elaborate computer storage system for this data cost the taxpayer a bundle.

Linked with instability are the inherent tendencies for the planning process to cloud the issues and foster procrastination. The classic example of procrastination was the Interior Department's enforced strategy to discontinue allocating forage resources among competing resources and, instead, maintain the status quo and rely upon a five–year monitoring program to adjust uses to meet resource goals. The availability of personnel, funding and technical wherewithall to do a good job in monitoring is suspect.

This concern for monitoring capability is shared throughout BLM and among the public. That capability was formally identified as an issue in a recent planning program evaluation (1984). My analysis of this situation, in viewing BLM's track record in dealing with the livestock industry, makes me extremely skeptical of ever seeing livestock numbers adjusted, unless upward, through application of monitoring data.

Further enforcing the concern over procrastination is the lack of progress in designating ACECs. Although FLPMA gives priority to the designation and protection of ACECs, little has been accomplished. In the 10 years since the passage of FLPMA, 186 ACECs have been designated. This totals slightly more than 1.5 million acres (607,000 ha) and represents less than 0.5 percent of the total public lands. As of October, 1984, the Washington Office was aware of only 18 plans completed for the 186 ACECs (Audubon 1985).

Procrastination, obfuscation, and rapid shifts in funding, priorities, leadership, organizational structures and roles, plus a domesticated internal-evaluation system have made managerial and employee accountability impossible. For example, the Nevada Report identified a series of livestock grazing-related ills, was sanctioned by the BLM directorate, and the Nevada BLM store office went as far as to develop an action plan. Since we are convened in Nevada, I look forward to being informed of the results and accomplishments as seen through the implementation of the Nevada Report recommendations. Also, while in Nevada, I look forward to visiting with those BLM employees who have had their careers enhanced through their objective participation in developing the Nevada Report. My apologies for not citing this reference, I couldn't find it in any of BLM's recent information sources. The final Challis plan provides further examples—how much riparian protection, as mandated by the Director, was ever accomplished?

Enforcing this lack of accountability is the present obsession with decentralization. The present emphasis is obviously driven by the current administration's desire to defederalize and, I suspect, a motive to vest decision at a local level where friendlier courts prevail. One effect is essentially to eliminate a national overview to ensure quality control and the application of national policy and standards. This has further enhanced the establishment of 11 separate and independent Bureaus in the 11 western states and Alaska. These separate agencies apply their own individual concepts of national policies and procedures as custom-tailored to local vested interests. It is little wonder that RMPs are so variable from state to state.

With the RMPs providing such vague guidance, a common concern has surfaced over activity plans preempting the RMP in making resource decisions and allocations. The Wildlife Management Institute (1981) found a tendency to endplay the land-use plan through later commitments to the rancher in the development of the AMP. A recent BLM planning system evaluation (1984) identified similar concerns among many of BLM's constituencies.

The dominance of the range and forestry disciplines within the BLM hierarchy and their philosophical links to these traditional uses have contributed immensely to the lack of objectivity in land-use planning. The cow, to manage vegetation, and the AMP, to manage the cow, have been oversimplified into the ultimate panacea, to cure *all* range-related ills. My concern over range discipline's bias also extends to many of those in academia. In several instances, I have observed a preponderance of range academia concern over the welfare of the public land grazing permittee and little, if any, concern for good rangeland stewardship.

By a similar perspective, application of the timber management plan, with token consideration for other resources, is hailed as an advancement in "environmental forestry." Examples of this are provided in the Wildlife Management Institute's (1982) comment on the South Coast-Curry Timber Management Plan proposed decision. Recent forest policies for the public lands have served to establish the dominance of forest production—*before land-use planning*—and to intimidate other uses of the forest lands through striving to reduce or eliminate "set-asides" that reduce or restrict the allowable cutting base.

Failure of BLM to apply its own policy is a common occurrence. Existing policy manuals on wetland/riparian protection and floodplain management stemming from 1977 Executive Orders (No. 11990, 3 CFR and 11988, 3 CFR) are commonly ignored in the development of BLM budgets, RMPs and program activities.

Lack of solid economic, analytical procedures and hard data continually handicaps planning by failing to portray objectively trade–off values to be gained or lost through managerial decisions. Commodity resources often make a persuasive case on opportunity costs, if their activities are either restrained or pre–empted by environmental resources. On the other hand, there are few hard data on opportunity costs for diminishment of an elk herd or loss of recreational visitor days. Consequently, the objectivity of the manager in making resource tradeoffs is severely handicapped.

Establishing priorities in rangeland–management investments is severely restrained by lack of adequate data on wildlife and recreation economics. Nelson (1983) estimated that BLM annually invests about $230 million in the public rangelands, for livestock, wildlife, recreation and overhead. This contrasts to $20–30 million per year in revenue from grazing and about $1 million in recreation fee income. Even if the livestock industry was to pay fair market value for public land forage, the total annual value would only be $100 million. On the other hand, the public benefits of recreation and wildlife are described at about $230 million annually. Within this formula of investment, it should be noted that most of the wildlife expenditures are directed toward mitigating damage from livestock grazing. The Wildlife Management Institute, in a series of comments on various rangeland land–use plans dating from 1982 to 1985, repeatedly concluded that the BLM investment in AMPs constitutes a major federal subsidy to the livestock permittee.

It would be unrealistic to conclude that improved economic procedures would eliminate all biases and establish total objectivity in the trade-off process. Nevertheless, such procedures would significantly help managers make more–objective decisions.

Conclusions and Recommendations

The preceding discussion outlines a number of problems influencing and often flawing BLM's planning process. Although improvement is occurring, it would be naive to anticipate eventual perfection. After all, the process operates in a biased and flawed arena, as shaped by greed and down–to–earth politics. Basically, BLM is between a rock and a hard place, as forged by changing political priorities, decreasing budgets and the strong, unyielding demands of the various competing advocacies. As a former BLM employee, I am continually amazed as to how skillfully the Bureau treads the maze of conflicting purposes.

Some improvements needed, as I see them, include:

- Better mechanics to resolve resource conflicts. Under today's climate, the judge is often elevated to being the resource manager. Legal decisions—once set—establish a course that is often unrealistic, expensive, inflexible and, in the end, unacceptable to most interests. I cling to the belief that the professional resource manager is far–better qualified for resource stewardship than is the judge.
- BLM should take advantage of the existing state of chaos and bitter advocacy to balance these extremes and forge a reasonable middle ground for improved resource stewardship.
- Plans must be designed to be more consistent, specific and understandable.

- Plans must accurately portray the tradeoffs in resource allocations. Hard decisions that resolve the issues must be made.
- BLM must seek stability through its personnel practices, use and development of scientific methodologies, organizational structure, and the development and application of budgets, policies and priorities.
- Defensible economic procedures and data bases must be developed for all significant resource values. This is vital to improving the objectivity of the decision process.
- Improved systems of accountability for managers and employees need to be established through realistic performance evaluation and internal and external evaluation systems.
- BLM must exert strong control and develop improved standards to ensure that national policies, laws and priorities are applied uniformally throughout the agency. At the same time, BLM must improve its quality–control procedures by providing a strong and effective agency–wide overview.
- Reasoned and persistent advocacy on behalf of the environmental resources is imperative if a balance is to be struck between commodity production and environmental protection. This requires knowledge of the public lands—it's laws, regulations and policies—as well as the issues and values at stake in planning decisions.
- The environmental community must do a better job of defining the significant issues and values at stake. Too often, precious resources, energies and funding are wasted in pursuit of trivia.
- BLM, guilty of designing a complex and difficult–to–understand planning system, should sponsor training in its use for its managers, employees, members of other federal agencies, state and local governments, and the public.

Recent growth during the 1960s and 1970s has seen BLM acquire many new employees with diverse professional backgrounds and personal orientation. Through time, many of these employees will fill key leadership positions. This will provide a broader resource orientation and enhance application of multiple–use principles and good resource stewardship.

Though imperfect, the RMP is still the only game in town. Effective public participation, as focused by informed and reasoning advocacy on the substantive issues, can effect positive changes and better decisions.

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Land-use Planning on the Kenai National Wildlife Refuge, Alaska

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Introduction

On 2 December 1980, the purposes and name of the Kenai National Moose Range were changed, and 69 percent of the refuge was designated wilderness by passage of the Alaska National Interest Lands Conservation Act (ANILCA). The Kenai National Wildlife Refuge (NWR) became one of 16 wildlife refuges in the state of Alaska, all of which encompassed over 77 million acres (31.2 million ha) of wildlife habitat. ANILCA mandated that all wildlife refuges in Alaska conduct a comprehensive conservation–planning process by 1988.

The Kenai NWR was relatively small (1.97 million acres: 800,000 ha) compared to other Alaskan refuges, but received considerably more public use than all other Alaskan refuges combined—approximately 500,000 visits annually—and with a projected increase to 800,000 by the early 1990s. Most of the projected increase was associated with fishing, tourism, wildlife viewing and sightseeing opportunities. The Kenai NWR was selected as the first refuge to undergo the comprehensive conservation–planning process, because of its diversity of habitats, wildlife and human uses.

This paper discusses the process used to develop the draft Kenai NWR Comprehensive Conservation Plan (CCP), public input, the final CCP and how the concepts used in the Kenai CCP affected other refuge plans in Alaska.

Study Sites

The Kenai NWR in southcentral Alaska is readily accessible by road, air and water, and is within 100 miles (161 km) of one–half of Alaska's human population. The Kenai Peninsula's history, habitats and wildlife are presented in Bangs et al. (1982). The diversity of habitats, wildlife and recreational opportunities have been recognized as the outstanding characteristics of the Kenai NWR. The wildlife habitat is diverse, ranging from relatively barren landscape, such as ice fields and glaciers, to more productive areas, including lowland forests, extensive wetlands and an estuary. Because of this habitat diversity, most Alaskan furbearers and big game species are indigenous to the refuge. The Kenai Peninsula is also famous for its excellent salmon fishery.

Recreational activities range from car camping, shoulder–to–shoulder salmon fishing and moose hunting at densities over 10 hunters per square mile ($3.9/km^2$), to wilderness treks where little sign of other humans is present, pristine wilderness fishing, and trophy moose hunts. Tourism on the Kenai Peninsula is already at relatively high levels (500,000 visits annually) and expected to continue to increase rapidly (McDowell 1985). Commercial uses of the refuge include oil and gas production, logging, trapping, and various guiding activities, which annually produce about $93 million worth of resources.

Increased human use of the refuge and the attempt to address resource problems on a case–by–case basis resulted in inconsistent protection of refuge resources. Some hunting and trapping programs had significantly impacted wildlife populations by altering sex and age ratios, numbers or distribution on the refuge. Some lynx (Bailey et al. 1986) and wolf (Peterson et al. 1984) populations had been overexploited or controlled by human harvest. Hunting, in some areas, had produced a sex ratio in the moose population of less than 15 bulls: 100 cows, and adversely affected the viewing opportunities for other refuge users (Bangs et al. 1984). Human recreation use had impacted bald eagle and trumpeter swan distribution and productivity (Bangs et al. 1982). Disturbance from recreational fishermen, canoeists and aircraft users had impacted the distribution and production of other wildlife, particularly near road or trail–access areas. Oil development had created numerous unplanned access corridors. Refuge facilities had deteriorated as human use exceeded maintenance capabilities.

Methods

ANILCA established the basic strategy for NWR planning in Alaska. CCPs would identify and describe fish and wildlife populations and their habitats, special values of the refuge, potential visitor services, potential access and utility needs, and significant problems affecting the refuge. The CCP would then designate areas within the refuge and specify those management programs, recreational opportunities and compatible uses that could occur within each area. Throughout the planning process, public planning bulletins were issued and public meetings held.

The draft CCP presented five management alternatives that were mixes of various management categories, ranging from intensive management (e.g., visitor centers, developed campgrounds) to pristine wilderness management (e.g., few trails or signs). These alternatives represented a range of options from the most wilderness–oriented to the highest level of compatible human use. The Kenai NWR planning was conducted so that the final CCP would also serve as the formal Wilderness Review for the refuge and an Environmental Impact Statement; combining these three requirements into one document avoided duplication of effort and made the plan more comprehensive. After reviewing all public comments, the plan was revised, all comments were published, and pertinent public issues and refuge positions were clarified.

A management alternative of the CCP was selected and scheduled for implementation through cooperative agreements with state agencies, state and federal regulatory procedures, and joint management actions.

Results and Discussion

Master planning on the Kenai NWR was actually underway a year before the refuge was redesignated in 1980. Master planning was converted to Comprehensive Conservation Planning soon after ANILCA was passed. The Kenai NWR was selected to be the first refuge to undergo the planning effort because it had a much larger data base than other refuges, a greater diversity of uses and a relatively large staff. Because of budget restrictions and personnel shortages, the Kenai refuge staff became the planning team, under the leadership of a professional resource planner stationed in the Anchorage Regional Office but detailed to the refuge. The importance of an experienced professional planner as team leader cannot be overemphasized. Wildlife managers, recreation specialists and biologists typically do not have the experience or expertise to conduct large–scale or complex planning projects efficiently.

The Kenai NWR CCP effort started by compiling all the information available on land status (wilderness boundaries, transportation and utility easements, inholdings, native land selections, and oil and gas leases), fish and wildlife populations and habitats (distribution, numbers and status), and public recreational developments and opportunities (visitor–use patterns, trends and needs). Vegetation mapping was conducted by analyzing Landsat imagery (Talbot et al. 1985), and this information was used to describe wildlife habitats and their associated life forms (Bailey 1984). The special values of the refuge were also identified. Meetings were held in local communities to solicit public and other government agency opinion of significant management issues.

One of the first steps was to determine and state clearly the goals and objectives of the refuge. These goals on the Kenai NWR were already established by ANILCA, which listed the five major purposes of the refuge: (1) to conserve fish and wildlife populations and habitats in their natural diversity; (2) to fulfill the international treaty obligations; (3) to ensure water quality and quantity; (4) to provide opportunities for scientific research, interpretation, environmental education and land–management training; and (5) to provide opportunities for compatible fish– and wildlife–oriented recreation. Purposes 3–5 were to be carried out in a manner compatible with purpose 1. The selection of the preferred management plan was based on how well each alternative met the major purposes of the refuge. Like all other Alaskan wildlife refuges, foremost of these was purpose (1)—the conservation of "fish and wildlife populations and their habitats in their natural diversity."

A matrix, or "planning logic," was developed to provide the basic reasoning behind the CCP and to describe the goals or minimum conditions that could exist in each five management categories (Table 1). The matrix addressed four basic components of every area on the refuge: (1) its physical setting (what it looks like); (2) the role of natural process (the level of management required); (3) its fish and wildlife populations (age and sex ratios, wildlife diversity); and (4) the available recreational opportunities (type of public use expected).

At one extreme of the management matrix was intensive management, where (1) the physical setting could be noticeably altered and dominated by man, (2) natural processes could be substantially altered through habitat and population manipulation, (3) fish and wildlife populations could emphasize species of high public interest, and (4) recreational experiences could focus on affiliation with individuals or groups with

Table 1. Planning matrix for management categories on the Kenai National Wildlife Refuge, Alaska.

	Condition(s) by management category				
Characteristic	Intensive management	Moderate management	Traditional management	Minimal management	Wilderness management
Physical setting	Noticeably altered and dominated by the works of man	Natural appearing, balancing the works of man and nature	Natural and dominated by the works of nature	Pristine and unmodified	Pristine and unmodified
Natural processes	Substantially altered through habitat manipulation	Occasionally altered through habitat manipulation	Play a primary role	Dominant	Dominant
Fish and wildlife populations	Emphasize species of high public interest	Balance species of high public interest and natural population dynamics	Emphasize natural population dynamics	Dominated by natural population dynamics	Dominated by natural population dynamics
Recreational focus	Affiliation with individuals or groups, with convenience of both access and sites	Equal opportunity for either group involvement or isolation, with convenience of access	Solitude, risk, challenge, and reliance on outdoor skills, in an accessible setting	Solitude, risk, challenge, and reliance on outdoor skills	Solitude, risk, challenge, and reliance on outdoor skills

convenient access and sites. Intensive–management categories would be labor and capital intensive and include year–round roads, campgrounds and other hardened sites necessary to accommodate large numbers of people.

At the opposite end of the management matrix was wilderness management, where (1) the physical setting would be pristine and unmodified, (2) natural processes would be dominant, (3) fish and wildlife populations would be characterized by natural population dynamics, and (4) recreational experiences focus on solitude, risk, challenge and reliance on outdoor skills. Wilderness management categories would generally require little cost or labor, since even signing would be minimal. Due to the lack of trails and other accommodations, recreational use would be dispersed and generally have little impact on the natural surroundings. An example of matrix application to wildlife population management is presented in Table 2.

By varying the acreages in each of the management categories, five management alternatives were created. The first use of the management categories was to describe the current situation on the refuge. Next, the outer limits of management options were determined by designing an alternative that allowed the highest possible level of compatible human use while still meeting the purposes of the refuge. Then, an alternative was developed that maximized wilderness values and natural diversity on the refuge. Finally, two other alternatives were developed to provide a range of potential management strategies. These two were compromises between the most development–oriented and the most protective alternatives.

The draft plan was in an EIS format and consisted of:

1. Introduction that discussed the purpose and need for action, legal context, planning process, special values of the refuge, significant problems, and management issues;
2. Affected environment that presented refuge land status and wilderness suitability, physical environment, biological environment, and human environment;
3. Management alternatives and environmental consequences that discussed the management categories, management policies common to all alternatives, the alternatives—A (current situation), B (maximum use), C (preferred), D (minimum use) and E (wilderness)—and the effects of each alternative, a comparison of all alternatives and the rationale used to select the preferred alternative.

In addition, a map showing the zoning of each management alternative was prepared (Figure 1). Each map also listed the management strategy and effect of each proposed alternative.

The draft CCP was made available for public review in January 1984, for a 90–day comment period. In addition, public meetings were held in the Kenai Peninsula cities of Soldotna, Homer and Seward, and a formal public hearing was also held in nearby Anchorage. The Service received 468 written comments from local, state and federal agencies, industry, local interests, conservation groups, and other interested parties and individuals. One hundred and ninety people attended the public meetings and 62 made statements. Public comments on the alternatives indicated that 23 percent expressed no preference and generally commented on a specific issue. Public comment on the draft alternatives indicated that 7 percent supported alternative A (the current situation), 12 percent alternative B (maximum use), 7 percent alternative C (the preferred), 13 percent alternative D (minimum use) and 12 percent alternative E (wilderness). In addition, 14 percent of the comments suggested the plan violated ANILCA by being too development–oriented, and another 11 percent suggested that

Table 2. Comparison of the effects of management categories on fish and wildlife populations, using moose as an example, on the Kenai National Wildlife Refuge, Alaska.

	Effect by management category				
Characteristic	Intensive management	Moderate management	Traditional management	Minimal management	Wilderness management
Fish and wildlife populations	Emphasize species of high public interest	Balance species of high public interest and natural population dynamics	Emphasize natural population dynamics	Dominated by natural population dynamics	Dominated by natural population dynamics
Average overwinter density of moose[a]	4–7 per square mile (1.5–4.3/km^2)	4–10 per square mile (1.5–3.9/km^2)	2–10 per square mile (0.8–3.9/km^2)	1–10 per square mile (0.4–3.9/km^2)	1–10 per square mile (0.4–3.9/km^2)
Bull/cow sex ratio	20–30:100	20–50:100	30–50:100	50–100:100	50–100:100
Large antlered bulls	Rare	Common	Abundant	Moose up to 20 years old present	Moose up to 20 years old present
Trophy bulls	Absent	Rare	Common	Abundant	Abundant

[a]Overwinter densities reflect midwinter conditions in high quality moose habitat, 50 square miles (129.5 km^2) or larger in size, located between sea level and 400 feet in elevation. The narrower density ranges reflect increased population stability brought about by regularly scheduled habitat manipulation and intensive population management.

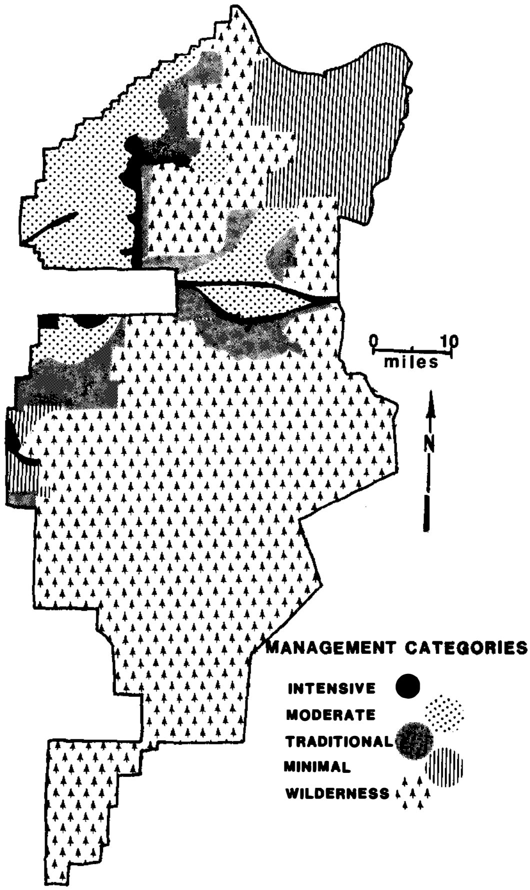

Figure 1. Distribution of management categories, in Alternative C, on the Kenai National Wildlife Refuge, Alaska.

an alternative presented by the National Audubon Society, the National Conservation Interest Alternative, which was between D (minimum use) and E (wilderness) alternatives, be selected.

Three issues stood out as particularly controversial, as identified by public comments: (1) Skilak Loop viewing area; (2) Kenai River motorboat closure; and (3) acquisition of refuge inholdings. Based on comments that specifically addressed those issues, 21 percent supported and 12 percent opposed establishing a wildlife viewing area at Skilak Loop, and 15 percent supported and 5 percent opposed closing the upper Kenai River to motorboat use. A misunderstanding led to the third "issue," which was falsely perceived as "Should the refuge immediately acquire private inholdings?" This question was opposed by 12 percent of the comments and supported by 1 percent.

Collectively, public comment indicated that 19 percent supported more use and less protection of refuge resources than would occur under the preferred alternative,

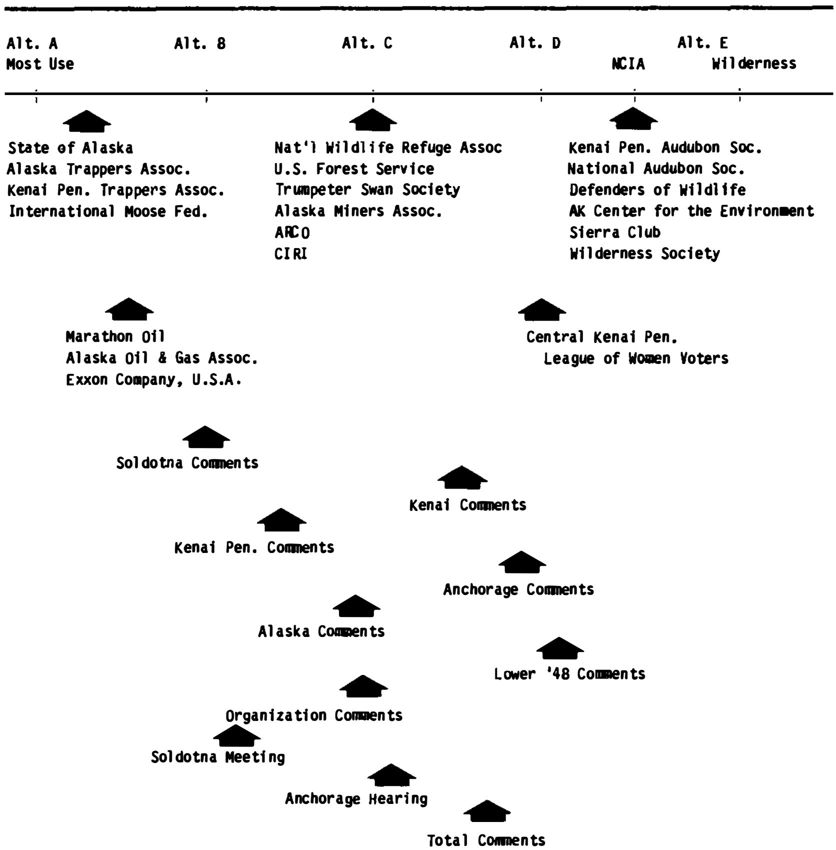

Figure 2. Relative stance of public commentators on management alternatives of the draft Comprehensive Conservation Plan for Alaska's Kenai National Wildlife Refuge. The bottom 10 arrows, representing comments by geographic area or other factor(s), reflect a median stance of accumulated comments. NCIA = National Audubon Society's National Conservation Interest Alternative.

7 percent supported the preferred alternative, and 36–50 percent preferred more protection of wildlife resources and less use. One–third of the public comments were from the Kenai Peninsula, one–third from elsewhere in Alaska and one third from other states. Locals favored more development–oriented and less–protective management strategies relative to the responses from elsewhere in Alaska. Comments from outside Alaska strongly supported less development and more resource protection. The refuge's draft preferred alternative generated little public support, but fell between two strongly different resource management philosophies. Figure 2 shows the relative stance of public comments on the draft plan. Alternatives A through E provide a spectrum of management alternatives. Alternatives A and B represent the most motorized use and intensive management, while D and E represent the highest level of resource protection and natural diversity.

After public comment, the draft plan was reviewed and changed to clarify technical aspects and to address public concerns. Alternative C was modified by: (1) special restrictions on hunting and trapping to enhance wildlife viewing in the Skilak Loop Special Management Area; (2) the boundary of a "float only" boating area on the upper Kenai River moved by 1 mile (1.6 km) downstream; (3) only select wilderness lakes were designated for aircraft use; (4) lands recommended for wilderness designation were expanded to connect existing wilderness units; (5) areas open to oil and gas leasing and development were reduced; and (6) wildlife populations would reflect more natural, social, behavioral and genetic characteristics. These changes made the preferred alternative more protective of the refuge's natural resources.

In addition to revision and clarification of the plan, all public comments were published. Formal responses were prepared to 228 public comments that suggested misinterpretation of data, omission of significant data or procedures, or the need to clarify and improve understanding of the Service's position. The public review and comments document became part of the final CCP. After a 90–day public protest period, the CCP's preferred alternative was accepted as the management strategy for the Kenai NWR by the Alaska Regional Director in a Record of Decision of June 27, 1985. Included in the Record of Decision were a Clarification of Issues raised by the State of Alaska and a Subsistence Section 810 determination.

Conclusions

The Kenai NWR CCP was a combination EIS, Wilderness Review and Comprehensive Conservation Plan. Planning on the Kenai NWR was simplified by having clearly identified goals established by ANILCA. The steps required to complete the plan were also described. Unlike other Alaskan refuges, the Kenai NWR already had numerous transportation and utility corridors, developed facilities and designated wilderness that aided in zoning the refuge.

The Kenai CCP concept was based on a modification of the U.S. Forest Service ROS planning concept (Clark and Stankey 1979). The concept behind the management matrix was to provide general guidance on all aspects of wildlife/habitat/human interactions in each area of the refuge. The zoning/compatibility concept is commonly used in urban planning, where some areas are designated as single–family dwelling, while others are zoned commercial or industrial. By using the matrix, associated tables and maps designating each respective area on the refuge, a manager can quickly determine what activities may be compatible with any specific area on the refuge. Analyzing potential impacts in light of the overall management of the refuge prevents the refuge being "nickel and dimed to death" by the constant demands of special interest groups. The plan also provided a clearer understanding of the refuge's role in the overall management and recreational opportunities of southcentral Alaska.

The *three* most–innovative approaches taken in the Kenai CCP were:

1. Recognition that wildlife population diversity, quality and composition (age and sex ratios) are just as critical components of the refuge as are wildlife abundance, human development or vegetative manipulation. This is particularly true in wilderness or minimal–management zones. Diversity of wildlife populations and their habitats includes preserving natural genetic variation, natural social

structure, natural behavior and natural processes, such as predation and plant succession.

2. Land–management zoning allows wildlife managers to direct future use on the refuge rather than react to it. Zoning also allows refuge users a clear choice to the type of experiences the refuge offers and allows them to select the recreational experience they want. Alaskan wildlife refuges have a broader responsibility than other refuges within the U.S. Fish and Wildlife Service. The level of development and types of human uses considered by ANILCA are greater than normally occur on refuges. This results in more wildlife/human conflict, unless managers find innovative measures to deal with both. The planning effort left no doubt that the U.S. Fish and Wildlife Service in Alaska is a large land–management agency.
3. A major purpose of Alaskan wildlife refuges—to conserve fish and wildlife populations and their habitats in their natural diversity—is closely related to the purposes of designated wilderness. Managers in Alaska will find that wilderness designation can be one of the most effective management tools in conserving wildlife and fulfilling refuge purposes.

Management plans for other Alaskan wildlife refuges are in preparation and, since the Kenai NWR CCP was approved in June 1985, plans for the Izembek, Alaska Peninsula, and Becharof National Wildlife Refuges have been completed. These plans follow the same format as the Kenai Plan, using an extensive public involvement process, a management matrix, similar categories and compatibility zoning. Other refuge plans differ from the Kenai NWR CCP because those refuges have subsistence and recreational use as a major purpose.

Comprehensive Conservation Planning on the Kenai NWR is now completed and the most difficult work begins. The critical component of any planning exercise is implementation of a management strategy and a continual examination of its effectiveness. Planning will not resolve the problems associated with encroaching civilization adjacent to the refuge boundary, exotic diseases and parasites transmitted to wildlife from domestic animals, and the endless demand for private development of public lands. Nor will it eliminate the desire by special interest groups to manipulate refuge resources for maximum use. Planning is merely a tool that can assist wildlife managers in carrying out their legal responsibilities and assure that they are publicly accountable for their actions. It also allows managers to look back over our successes and mistakes and anticipate the future. And it gives them the chance to conserve resources, while saving effort and money by preventing problems rather than curing them.

Conservation of large functioning ecosystems for the benefit of future generations will require sacrifices by every user group, innovative management techniques to address an array of new problems, and a clear concept of where Alaskan wildlife refuges are going and how to get there.

Acknowledgments

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Integrating Habitat Management in Pennsylvania's State Forest Resource Plan

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Introduction

Pennsylvania, or Penns Woods, is blessed with a healthy supply of forest land. According to the latest statistics (Considine and Powell 1980), Pennsylvania contains 16.8 million acres (6.8 million ha) of forests that account for 58 percent of the Commonwealth's land area. One-fourth or 4.2 million acres (1.7 million ha) of these forests are publicly owned—a large portion (2,068,000 acres/836,920 ha) of which is managed by the Pennsylvania Department of Environmental Resources, Bureau of Forestry, as State Forests. As the single largest ownership in Pennsylvania, State Forests represent the greatest opportunity for the public to enjoy animal–related recreational activities within the Commonwealth.

The State Forests of Pennsylvania have been under "scientific" management since 1955, when the first Forest Management Plans were adopted. These initial Plans outlined the policy and objectives for the management of State Forests for the period 1955 to 1969. Most forest resources were merged to fit in with timber management as time and money allowed. In the early 1960s, it became apparent there must be a formal plan for the protection, development and use of all forest resources.

Between 1965 and 1970, the Forest Resource Plan for the 1970–84 management period was completed. It established objectives for all forest resources and attempted to coordinate their use and development. For the first time, the Plan specifically addressed wildlife and fishery resources. It was divided into sections with wildlife and fishery considerations contained within the Recreation section. General information on this Resource Plan and specific details describing how wildlife needs were blended into forest management systems were presented at the Fortieth North American Wildlife and Natural Resources Conference (Nelson 1975).

The Planning Process

The Bureau of Forestry has recently completed the planning process for implementation of a new Forest Resource Plan for the 1985–99 management period. The planning process consisted of seven steps:

1. determining public needs from State Forest lands and public desires about how such lands should be used and managed;
2. redefining management goals and objectives;
3. conducting inventories of the resources;
4. developing operating guidelines based on public input, current scientific/technical knowledge and anticipated future demands;

5. balancing the interactions of the operating guidelines;
6. determining the acceptability of draft Plans to the public, and revise if needed; and
7. preparing a final Plan that ensures the natural resources of the State Forests are managed and maintained for the benefit of all the people.

The first step—determining public needs and wants—was accomplished through a series of 24 meetings held throughout the state. Public input via written correspondence was solicited and accepted. Input was summarized and evaluated as to the impact on the resource, cost to implement or forgo, potential benefit, and effect on other uses. After its evaluation, public input was used as a reference. However, the Bureau retained the final decision to meet its responsibility to the public. Estimates of public needs were obtained using the available data to project future demands on the forests.

Based on the needs and wants of the public as well as legal mandates, the Bureau established management goals and objectives. A specific goal statement and a set of objectives to refine the goal were developed for each resource.

Inventories of forest resources are essential to the planning process. Every acre of State Forest land was placed in a management zone and assigned a stand classification. Management zones were even–aged commercial forest, uneven–aged commercial forest, noncommercial forest, nonforest, natural areas, wild areas and special use areas. Stands included 192 timber type/site/size/stocking, 9 upland open, 3 water, 4 wetland, 1 road, 7 right–of–way, 5 leased area, 7 mineral site and 9 recreation site classifications. Resource base maps were completed using this management and classification scheme. Inventories for the various forest resources were initiated, revised or completed.

Based on existent inventories, operating guidelines were developed and designed to achieve management goals and objectives. Operating guidelines were developed for each resource that provide the framework for a balanced and positive program. Balancing the interactions among operating guidelines provides the planner and manager the most challenge. Steps were taken in the draft Plan to ensure coordination among the protection, use and development of all forest resources.

Public input was solicited through public meetings and written comment to review the draft Forest Resource Plan. Public acceptance led to the last step in the planning process—preparation of the final Forest Resource Plan.

The Plan

The 1985–99 Resource Plan is divided into six major sections to address various resources and uses. These sections are: The Report; Watershed Management; Timber Management; Fauna and Flora Management; Minerals Management; and Recreation. The Plan structure denotes a change or departure in management philosophy and strategy from the previous Plan.

No longer are animals considered as a resource to be managed in terms of recreational potential and use. Animals are recognized as distinct forest resources, and guidelines for their management were removed from the Recreation section and placed in a new section of the Resource Plan—Fauna and Flora Management. Use of the term "fauna," as opposed to "wildlife and fish," denotes a broadened view for managing animal resources. Fauna includes animals that range from large mammals, such as black bear (*Ursus americanus*) and white-tailed deer (*Odocoileus virginianus*), to invertebrates, such as honey bees (*Apis mellifera*).

The Fauna and Flora Management section includes a goal, a set of objectives, history/past accomplishments, inventories, and operating guidelines to manage animal resources on State Forest land. The management of fauna and flora is predicated on both protection and use to meet man's needs and wants.

The goal of the Fauna and Flora Management section is to provide for and maintain a diversity of animal and plant communities through coordination with the management of the other forest resources. "Diversity," as used in the goal statement, is the distribution and abundance of different animal and plant communities and species. Six objectives were developed to support this goal.

- To protect and improve the habitat for all species of animals occupying the forest, by developing and implementing habitat guidelines.
- To develop and maintain cooperative agreements with the Pennsylvania Game Commission and Pennsylvania Fish Commission to promote proper coordinated management of animal species and their habitats.
- To provide for the management of specific animal and plant species by designating Special Management Areas and Wild Plant Sanctuaries.
- To provide for the protection of federal– and state–listed animal and plant species, or habitats critical to their survival.
- To set aside unique and representative areas of scenic, historic, geologic or ecological significance through the establishment and maintenance of Natural Areas.
- To coordinate the use and development of all forest resources so as to protect and enhance the animal and plant species occupying the forest.

To give perspective on what has been accomplished during the last Plan, a brief historical account was included in the Plan. In addition, a summary of field accomplishments was included for each of the 20 Forest Districts throughout the state.

Inventories affecting animal resources in the Fauna and Flora Management section are currently being updated or completed. These inventories will include habitats present, species of special concern, animals present—listed by habitat components they normally use, special management areas and Natural Areas.

The Operating Guidelines in the Fauna and Flora Management section of the Forest Resource Plan provide the framework for habitat management on State Forest lands. Animal diversity, which is the Bureau's goal, is accomplished through the management of habitats on which their welfare depends.

Compartment Guidelines

The Fauna Operating Guidelines provide the guidance and direction for implementation of a positive program for managing animal resources. To effect this program, habitat guidelines have been developed to promote a forest suitable for the maintenance of a diversity of animal species. Habitat guidelines constitute objectives to strive toward, on a compartment basis, during the 15–year management period. Compartments are management units that are permanently identifiable on the ground and range between 500 and 1,500 acres (202 and 607 ha).

Compartment habitat guidelines direct the management of terrestrial, wetland, aquatic and riparian habitats. Guidelines identify important habitat features or components and specify desired actions. Actions include size and spacial distribution of components or protective measures needed.

Guidelines have been outlined for the following terrestrial habitat components: upland herbaceous openings and orchard stands; evergreen habitat; deciduous brush–stage habitat; pole–size timber; mast production; large, old trees; access roads, skid trails and land clearings; wildlife food shrubs, vines and fruit trees; down woody material; snags and trees with cavities; spring seeps; rights–of–way; artificial nest/den structures; cliffs and rubble land; caves; disturbed areas; and edge/ecotone.

As an example, guidelines for upland herbaceous openings and orchard stands are as follows.

- Develop and maintain 3–5 percent of the compartment in openings or orchards, of which a minimum of 2 percent is in cultivated or natural herbaceous vegetation.
- Stands should range from 0.5–10.0 acres (0.2–4.0 ha), but preferably 1–5 acres (0.4–2.0 ha).
- Maintain all existing cultivated and natural herbaceous openings < 10 acres (4 ha). Openings > 10 acres (4 ha) may be broken into smaller openings through planting or may be considered as a Special Management Area.
- These stands should be not more than 0.5 mile (0.2 km) apart.
- Openings and orchards may include upland openings, orchard stands, rights–of–way and well sites.
- For specific seeding and maintenance recommendations, see the Fauna Operating Manual.

Wetland habitats were separated from aquatic habitats due to their unique properties and values and to give them special attention. Guidelines provide for the protection, inventory, evaluation and, in some instances, development of wetlands on State Forest lands.

Aquatic and riparian habitats were considered as a unit because of the interrelationship between water and adjacent land. Both the water and land along or surrounding water affect each other's character. Characteristics such as water temperature and chemistry are affected by surrounding vegetation and, likewise, the vegetation in riparian zones is dependent or affected by the presence of water.

Guidelines for the following have been outlined for aquatic and riparian habitats: in–stream restoration and improvement; litter; streamside maintenance, restoration and improvement; water quality; remote trout streams; wilderness trout streams and exceptional–value waters; and high–quality waters.

The compartment guidelines for terrestrial, wetland, aquatic and riparian habitats represent a strategy or design for the overall habitat management of State Forest lands. However, the purpose behind any Plan is to implement a method of carrying out the design. The procedure that has been defined in the Resource Plan entails the use of a computerized form—the compartment habitat plan.

Compartment Habitat Plan

The compartment habitat plan is an operating system designed to identify habitat needs, set priorities for habitat projects, plan annual activities, record accomplishments and provide continuity in forest resource management. The compartment habitat plan is completed during scheduled compartment examinations in unison with the timber operating plan. Simultaneous completion of the compartment habitat plan and the timber operating plan ensures coordination between these resources.

The compartment habitat plan notes habitat components or features present, states desired guidelines, and determines deficiencies. This record calls attention to those habitat components that need to be addressed during field inspection of the compartment. The presence and degree of deficiency for each habitat component are used to set priorities for future habitat–improvement projects.

Compartment field inspections evaluate habitat components while examining timber–management alternatives. Habitat–development recommendations are noted on the compartment habitat plan and integrated with timber plans where feasible. Habitat component needs that cannot be met through timber operations are noted and planned through alternative methods.

There are four general avenues the Bureau of Forestry uses for implementing compartment habitat plan recommendations—coordinated, funded, cooperative and volunteer implementation. Coordinated implementation is the backbone of the Bureau's habitat program. Commercial cutting is the most important tool at the Bureau's disposal to attain diversity. Habitat plan recommendations are designed around and implemented through commercial harvests. Funded implementation is directed at those recommendations that cannot be accomplished through timber harvests and require specific allocations of time or money. Cooperative implementation is aimed at those recommendations that can be executed by the Game or Fish Commissions, as dictated by cooperative agreements. Volunteer implementation is the participation of private organizations in certain habitat–improvement projects on State Forest lands.

Upon completion, the compartment habitat plan represents a picture of present habitat condition and planned activities. Accomplishment of activities is noted on the compartment habitat plan when completed. Revisions are noted on the resource maps as well.

A flow chart (Figure 1) depicts the approach for fauna management on State Forest lands, as contained in the Forest Resource Plan.

Special Management Areas

The compartment guidelines established for terrestrial, wetland, aquatic and riparian habitats represent the Bureau's normal operating procedures on State Forest lands. In conjunction with these guidelines, certain areas have been designated as special management areas. These areas are given this designation either because they are managed for a particular species or group of species (featured–species management) or they represent a unique ecosystem or habitat type (featured–habitat management). Because of the nature of these areas, the Bureau's management strategies deviate from the normal operating guidelines. Specific plans are established for these areas.

Special management area designation has also been established for 28 of the 44 current State Forest Natural Areas. These Natural Areas, in cooperation with the Pennsylvania Fish Commission, have been designated as reptile and amphibian protection areas. The taking, catching, killing and possession of any species of amphibian or reptile is prohibited within the boundaries of these Natural Areas.

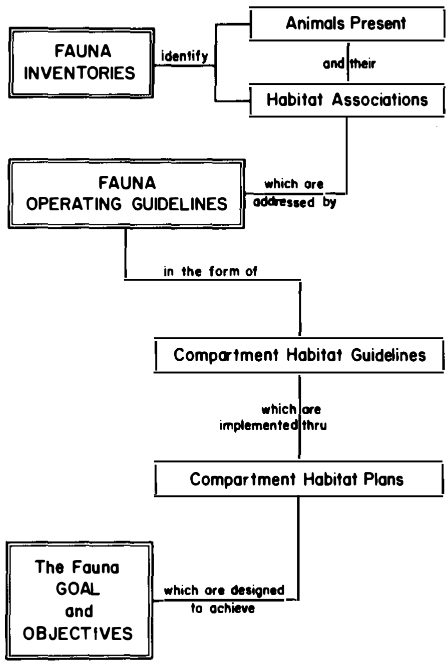

Figure 1. Strategy for managing animal resources as contained in Pennsylvania's State Forest Resource Plan.

Species of Special Concern

Paramount to the protection of endangered, threatened, and other federal– or state–listed species is the identification of its presence or occurrence. Known occurrences of federal– and state–listed animal species have been identified and recorded in a computerized data base—the Pennsylvania Natural Diversity Inventory. Inventories are currently on–going to verify historical records and investigate additional occurrences.

Where a listed species is known to occur on State Forest land, appropriate measures are taken to ensure against adverse manmade or man–caused disturbances to the species or habitats critical to their survival. Appropriate actions depend on the species involved and are developed on a case–by–case basis.

Cooperative Agreements

Pennsylvania is unique in many ways, but specific to natural resource management, unlike most states, Pennsylvania has no one state agency in charge of managing natural resources. The actual management of many of the fauna resources on State Forest lands is under the jurisdiction of the Pennsylvania Game Commission (mammals and birds) and the Pennsylvania Fish Commission (fish, reptiles, amphibians and aquatic organisms). The Bureau has management responsibility for the habitat on which these animals depend. Agencies must cooperate in their resource–management endeavors to attain the goals and objectives of the respective agencies.

To promote coordinated resource–management endeavors, separate cooperative agreements have been developed with the Pennsylvania Game and Fish Commissions. These agreements are currently being revised and updated. They are essential to sound resource management in the state and an integral part of the Forest Resource Plan.

Coordination With Other Resources/Uses

Pennsylvania's State Forest Resource Plan is just that—a resource plan. It is not a timber–management plan. It is not a wildlife–management plan. It is a resource plan because it attempts to coordinate the protection, use and development of the various forest resources. Coordination and integration are key to a successful total resource–management endeavor.

Several steps were taken in the Plan to ensure this coordination. The first step was to develop operating guidelines for each resource that were compatible with the other resources and then identify who is responsible for ensuring that those operating guidelines are followed. The next step is to ensure that any management applied to a given area is in accordance with the area's designated land–use or management zone criteria.

Procedures are also established in the Resource Plan to review any project on State Forest lands that may or will disrupt, alter or otherwise change the environment. In brief, normal activities will receive an informal review of at least 20 items of concern to see that each has been adequately considered and addressed.

In addition, the simultaneous completion of compartment plans for timber management and habitat management help assure integration among these resources.

Summary

The 1985–99 Pennsylvania State Forest Resource Plan is a third–generation plan. Two previous 15–year Plans were developed and implemented. The 1985–99 Resource Plan draws from experiences gained during the previous Plans. Pennsylvania State Forest Resource Plans may be viewed as an evolutionary process—each Plan refining or re–defining management strategies.

The current Plan establishes goals, objectives and operating guidelines for all forest resources, coordinates their protection, use and development, and attempts to reduce conflict among competing uses.

The Plan contains several changes in philosophy and strategies concerning the management for animal resources on State Forest lands. All animals (fauna) are recognized as distinct and valuable resources, and guidelines for their management were removed from the Recreation section of the previous Plan and placed in a new section—Fauna and Flora Management.

Operating guidelines were improved for managing animal resources, and coordination among other resources and uses was strengthened. The Plan is a "resource" plan in that it coordinates and integrates management strategies for various forest resources. It also contains a methodology for implementation and a mode to coordinate management of animal species, which is entrusted to other agencies, and their habitats.

The goal of the Fauna and Flora Management section of the Forest Resource Plan is to provide for and maintain a diversity of animal species and communities. This diversity is accomplished through the management of habitats on which the animal's welfare depends. The key to managing habitats on State Forest lands is coordination—coordination with the protection, development and use of the other forest resources, and with the other agencies involved in resource management in Pennsylvania. Pennsylvania's Forest Resource Plan is a step toward this end.

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Multiagency Regional Resource Planning for Nonpoint Source Pollution Control

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Introduction

It is now recognized that nonpoint sources of pollution degrade more of our nation's waters than do discharges from point sources. It is also widely recognized that agricultural activities are responsible for polluting more waters than any other nonpoint source. A recent assessment of the nationwide impact of nonpoint pollution, conducted for the U.S. Environmental Protection Agency (EPA) (Association of State and Interstate Water Pollution Control Administrators 1985), substantiates this situation. Of waters assessed by the states, 47 percent of rivers and streams in the country and 53 percent of lakes and reservoirs are threatened or impaired by nonpoint sources of pollution. Agriculture was determined to be responsible for 64 percent of the use impairment in rivers and streams and for 57 percent in lakes and reservoirs.

The Tennessee Valley region has been particularly hard–hit by nonpoint source pollution problems, especially those related to agriculture. However, this widespread water pollution is only a symptom of a larger crisis involving the lack of proper management of land and water resources in the seven–state region. Cropland erosion averages 11 tons per acre (24,700 kg/ha) per year, more than twice the national average and double the rate scientists say can be tolerated without severely reducing crop yields. Yields of major crops are well–below the national average in the region—with corn being one–half and soybeans being two–thirds of the national average. Farm income is also lower than the national average, and for some crops the gap is getting wider each year. This eroded soil clogs rivers and streams and increases flooding damage—causing up to an estimated $100 million each year in west Tennessee alone.

In the late 1970s, the U.S. Department of Agriculture (USDA) and the Tennessee Valley Authority (TVA) recognized that this land and water crisis was occurring, and signed a new Memorandum of Understanding to develop a national demonstration on how to correct these closely related, rural, land and water management problems. This paper: (1) highlights the lessons learned with regard to the need for targeting resources to those lands most contributing pollutants to surface waters; (2) describes a cooperative initiative involving nonpoint source pollution control; and (3) identifies opportunities for targeting funding available under the conservation reserve provisions of the 1985 Farm Bill, for both water quality management as well as soil erosion control benefits. Targeting funds available under the Farm Bill to watersheds with priority nonpoint source water pollution problems related to agriculture is proposed as a cost–effective approach for not only controlling agricultural sources of water pollution and soil erosion, but also for maximizing the benefits of public funds expended by the federal government.

Description of the Tennessee Valley Region

The Tennessee Valley region consists of 201 counties served by the TVA power–production network. It includes all of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Virginia. Eleven of the USDA's Major Land Resource Areas (MLRAs) are located in the region, as shown in Figure 1. The area is quite typical of the South, with a variety of physiographic areas ranging from the steep forested mountains of the southern Blue Ridge (MLRA 130) on the east, to the flat alluvial lands bordering the Mississippi River (MLRA 131) on the west.

The MLRAs outlined in Figure 1 are identified in Table 1. Table 1 also presents information from the 1982 National Resources Inventory concerning estimated soil loss in each MLRA of the region. Note that the westernmost MLRAs of the region are those most intensively used for cultivated cropland and present the greatest concern for water pollution related to cropland. Animal waste presents a greater concern than cropland in the MLRAs 122, 123, 128 and 129. Overall, rural lands in the 201–county region are 52 percent forest, 24 percent cropland and 21 percent pasture. The region's cropland is primarily (88 percent) cultivated, with 60 percent in row crops.

Severity of Agricultural Soil Erosion–Related Problems

The most widespread nonpoint source pollutant in the Tennessee Valley region is sediment from soil erosion—much of which originates from croplands in areas better suited for permanent vegetation or which need soil erosion prevention. Among the region's cropland, about one-half is eroding at a rate greater than tolerance (i.e., the maximum per–acre annual erosion at which soil productivity can be maintained) and about one–third is eroding at two times tolerance. Figure 2 indicates the average

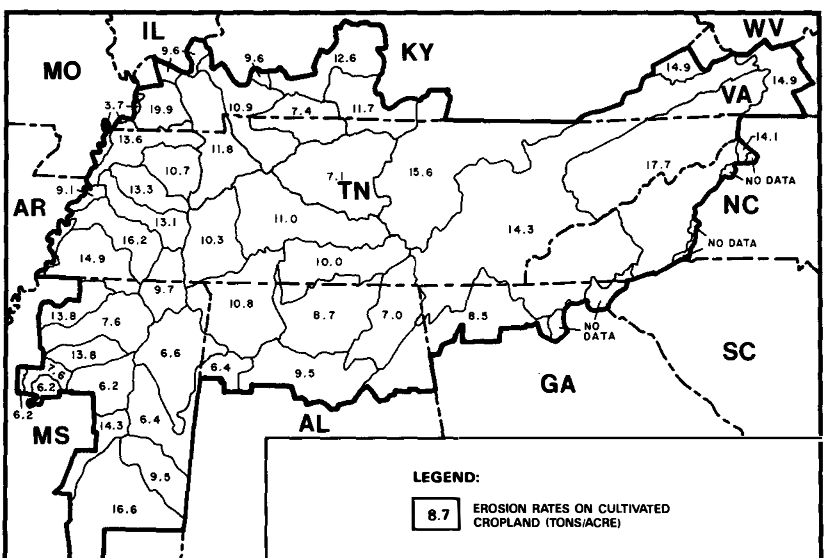

Figure 1. Major Land Resource Areas (MRLAs) in the Tennessee Valley region.

Table 1. Average annual soil loss in the Major Land Resource Areas (MLRAs) of the Tennessee Valley Authority region.[a]

MLRA	Region name	Percentage of MLRA in cultivated crops	Annual soil loss from cultivated cropland (tons per acre)
120	Kentucky Sandstone and Shale	26	23.8
122	Highland Rim	24	9.8
123	Nashville Basin	13	8.5
125	Cumberland Plateau	3	10.4
128	Ridge and Valley	13	9.9
129	Sand Mountain	17	8.7
130	Blue Ridge	4	17.3
131	Mississippi Alluvium	74	4.7
133	Coastal Plain	19	9.5
134	Silty Uplands	51	15.0
135	Blackland Prairies	43	6.8
Mean		21	10.9

[a]Source: 1982 National Resources Inventory Summary for the 201 county region (November 1984).

erosion rates on cultivated cropland in selected watersheds in the Tennessee Valley region. Note that high cropland erosion rates occur throughout the region, with average rates ranging from 6–20 tons per acre (13,500–44,800 kg/ha) per year. All of the seven states represented in the Tennessee Valley region rank among the ten states with the highest levels of sheet and rill erosion. Annual soil loss from sheet and rill erosion in the region is approximately 187 million tons (380 billion kg) per year. While three-quarters of the region's soil loss comes from cropland, 70 percent of this loss is the result of erosion from the one-quarter of the croplands with erosion rates greater than three times tolerance (Baxter et al. 1984). In other words, 54 percent of the total soil loss in the region can be attributed to 6 percent of the total land base.

These statistics clearly show much of the region's soil loss is attributable to the use of steep, erosive land for cultivated cropland. Some of these areas in west Tennessee have soil erosion rates of 200 tons per acre (448,000 kg/ha) per year—40 times the national average. While about two-thirds of the rural lands in the region do not have adequate conservation protection, clearly most of the erosion in the region is controllable through better management on a relatively small land use area—cropping on marginal land.

This erosion is seriously affecting water quality and fisheries throughout the region. Figure 3 identifies areas with surface waters that have been reported by state water quality regulatory agencies to be impaired by nonpoint source pollutants. Many of these problems can be directly attributed to agricultural runoff. Thus, because of soil erosion, many of the region's streams and rivers do not meet the Clean Water Act goal for the protection and propogation of fisheries populations. This erosion has also seriously reduced drainage capacity, causing extensive flooding and swamping of formerly productive cropland and pasture, damage to bridges, and massive timber kills.

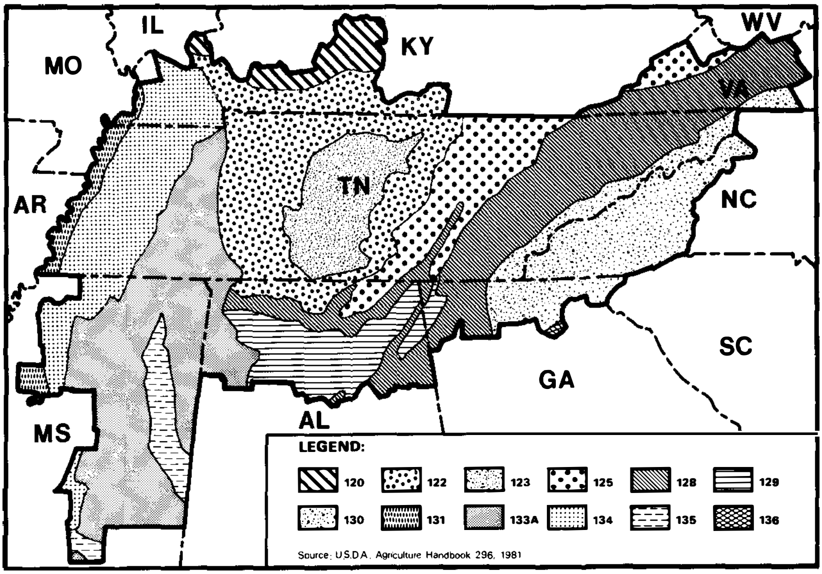

Figure 2. Erosion rates on cultivated cropland in selected watersheds in the 201–county TVA region.

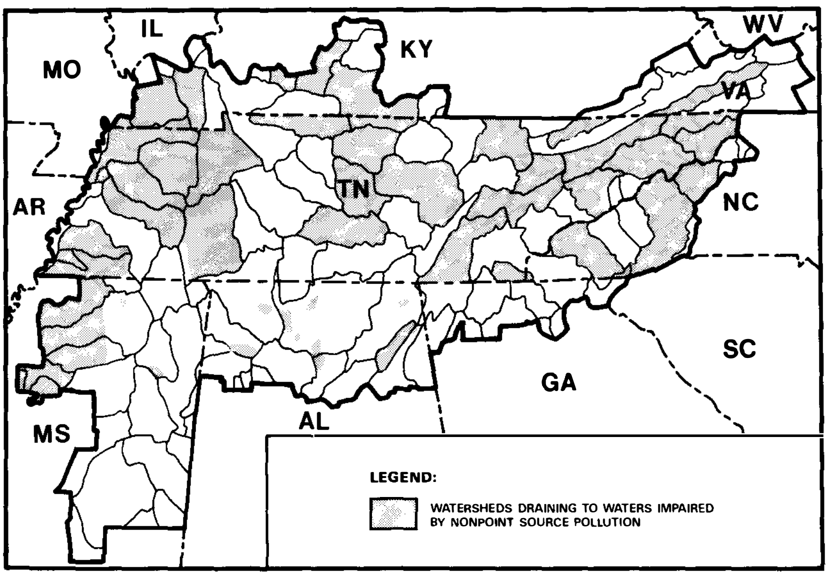

Figure 3. Watersheds with known impaired uses resulting from nonpoint source pollution in the 201–county TVA region.

The off–site impacts of sediment, mostly from erosion on agricultural land, have been estimated to be over $6 billion per year nationally (Clark 1985). In the Tennessee Valley region, sediment has caused $11 million in damage each year to agricultural and timber resources in one eight–county area in western Tennessee. Another example of this damage and resulting economic burden on taxpayers involves the Obion–Forked Deer River Basin in western Tennessee (USDA 1980). The 3 million acre (1.2 million ha) river basin is highly agricultural (50 percent cropland) and has suffered significant water quality and fisheries damage from accelerated soil erosion. Upland cropland erosion, averaging 44 tons per acre (98,560 kg/ha) per year, is filling river channels and raising water tables; floods are damaging bridges, crops, and riparian forests. The off–site damage related to sedimentation is conservatively estimated at $74 million (1974 dollars) a year, excluding the damage to 27,000 acres (10,900 ha) of bottomland forests that already have been killed by swamping.

In addition to these off–site impacts, soil erosion leads to large losses in soil productivity in the region. While the Tennessee Valley region accounted for $3.9 billion in farm products in 1982, the region's percentage contribution to the nation's agricultural production has been declining—especially in crop production. Yields for some crops have actually decreased in the region over the past several years. Preliminary research indicates that erosion is responsible for declines in yields of cotton and soybeans, from one–fourth to one–third of potential levels.

Approximately $20 billion have been spent for soil and water conservation in the U.S. since the 1930s, yet erosion rates remain high and, in some cases, are getting higher (Clark 1985). Soil erosion throughout the U.S., and particularly in the Tennessee Valley region, became significantly worse in the early 1970s when farmers began to produce dramatically more row crops. Smaller farms were often converted to large tracts of leased farms; more crops were planted "fencerow to fencerow"; more soybeans were planted on soils highly susceptible to erosion; and large equipment often tore up the old terraces. The result has been that cropland erosion in the Tennessee Valley region has continually gotten worse since the early '70s, even though cropland soil erosion decreased in most areas of the country.

The continued demise of family farming, increased leasing of farmlands, commodity subsidies and price supports, improvement in productivity with super fertilizers and farming techniques, and use of marginal land for agricultural production have adversely impacted soil erosion and led to serious off–site impacts. In some cases, U.S. government farm policy and programs have been a major cause of increases in agricultural soil erosion (Cook 1985). Government programs that increase exports, provide price supports and control production can often result in increased pressure to bring more marginal land into row crop production. The current severe financial pressure on farmers is leading to incorporation of farming operations and may further contribute to soil erosion as a result of pressures on corporate management for short–term profits.

Lessons Learned in Controlling Rural Nonpoint Sources

Based on experience in the Tennessee Valley region over the past several decades, the following are some of the reasons that need to be considered in correcting the current nonpoint source problems.

Water Quality Can be Greatly Improved Following Control of Soil Erosion

In its early years, TVA, in cooperation with other agencies, conducted several small watershed studies to demonstrate good management practices in land use. As summarized in Table 2, the demonstrations clearly showed the major reduction in sediment load to streams was achievable using technologies that were available in the 1940s and 1950s (Garrison and McLemore 1984). In each case, severe soil erosion was occurring as a result of poor agricultural and forest management practices on marginal lands. Through programs that included critical area revegetation, soil erosion–control practices and conversion of cropland to pasture, up to 96–percent reductions in sediment transport were achieved. In the Chestuee Creek watershed, the impact of these improved land–use practices on farm income was monitored closely from 1953–1958 and showed that average net cash income on the demonstration farms rose 350 percent. In the case of Parker Branch in western North Carolina, annual suspended sediment transport decreased 78 percent within five years, as a result of implementing agricultural soil conservation practices.

Cooperative Programs with Generous Cost–sharing Can Stimulate Implementation of Agricultural Erosion–control Measures

In the late 1970s, USDA and TVA initiated a cooperative soil erosion–control program targeted to 21 counties in western Tennessee, known as the Save Our Soil (SOS) program—a six–phase mix of programs involving resource–management conservation–demonstration farms, small and large conservation–demonstration areas established on a watershed basis. Soil surveys and special educational activities were used to address serious agricultural soil erosion problems. The conservation needs in just one of the river basins exceeded $90 million (USDA 1980). The first four years of the effort and plans for the fifth were summarized in a report published by the Tennessee State Rural Development Committee (1983), and annual progress reports have been prepared by the U.S. Soil Conservation Service (SCS) for this, the first of USDA's "targeted" programs.

About $35 million was spent in the 21 counties by cooperating agencies over the first five years (1979–83). This initiative was quite successful in stimulating a five–fold increase in no–till operations during the time period, and resulted in a three–

Table 2. Results of TVA case histories in small watershed demonstrations.[a]

Watershed	Area (acres)	Location	Practices implemented	Monitoring period	Reduction in percentage sediment transport
White Hollow	1,715	E. Tennessee	Natural revegetation	1935–1958	96
Pine Tree Branch	88	W. Tennessee	Reforestation and agricultural erosion control	1941–1960	96
Parker Branch	1,060	W. North Carolina	Agricultural erosion	1953–1962	71
Chestuee Creek	85,000	E. Tennessee	Wide range of agricultural and forest practices	1944–1962	45–70

[a]Adapted from Garrison and McLemore (1984).

fold increase by 1983 of cropland "adequately protected" against erosion each year and in "total erosion prevented" each year, compared to the base year of 1977. Table 3, assembled from SCS progress reports, presents the numbers of acres treated and amounts of erosion prevented for fiscal years 1982 and 1983 for three erosion–rate classes.

Targeting Resources to Highly Eroding Lands in Priority Watersheds Provides a Greater Return on Erosion Control

During the two–year period covered by Table 3, 113,200 acres (45,800 ha) of land eroding less than its tolerance level (T) were treated, compared to 138,500 acres (56,100 ha) of land eroding at a rate greater than twice the tolerance level. However, note that more than 10 times more erosion was prevented as a result of the efforts on the highly eroding lands. An average of 1.5 tons of erosion per acre (3,400 kg/ha) of treated land eroding less than tolerance was prevented, compared to 14.5 tons per acre (32,500 kg/ha) for lands eroding at twice tolerance. Targeting cost–sharing, technical assistance and informational programs to problem lands seems to be a more–effective use of resources in terms of erosion prevention. While much effort was devoted in the SOS program to all lands (both cropland and pasture), the effort seems to be focused now on the more highly eroding lands, if the April to September 1983 data in Table 3 is indicative of a trend. Such targeting to problem lands would be even more cost–effective if watersheds with pollution problems related to erosion were given high priority for resources. The SOS program used this approach with its small and large conservation–demonstration areas established on a watershed basis.

Federal Funding Will Not Be Sufficient to Cost–share Erosion–control Measures for Water Pollution Control

The SOS program resulted in an average of 30,000 acres (12,200 ha) of cropland eroding at more than "2T" and an average of 35,000 acres (14,200 ha) of cropland eroding at between "T and 2T" being adequately protected each year during 1982

Table 3. Cropland treated and erosion prevented, by erosion rate class, for years 4 and 5 of targeted effort in western Tennessee.[a]

		Acres benefited (× 1,000) and average annual erosion prevented (in tons × 1,000)					
		Less than T[b]		T to 2T[b]		More than 2T[b]	
Reporting period		Acres	Tons	Acres	Tons	Acres	Tons
FY 1982	October–March	20.0	29.8	12.4	52.1	18.1	291.6
	April–September	29.2	33.3	24.7	110.2	42.4	667.1
FY 1983	October–March	31.8	39.8	22.0	104.6	23.7	451.3
	April–September	32.2	63.9	34.3	171.0	54.3	592.3
Total		113.2	166.8	93.4	437.9	138.5	2,002.3
Tons/acre prevented		1.5		4.7		14.5	

[a]Source: SCS Annual Progress Reports for FY 1982 and 1982.
[b]T = soil–loss tolerance.

and 1983. However after 10 years, the job is less than 10 percent done in western Tennessee. At the present rate of about $7 million each year in the 21 counties, it would take 30–40 years to address the 900,000 acres (364,000 ha) of cropland eroding between "T and 2T" and the 1.2 million acres (486,000 ha) of cropland eroding at greater than "2T."

Water quality and aquatic life in the rivers of western Tennessee are impaired by eroded soil, and massive blockages of sediment are estimated to cause more than $100 million in damage from flooding/sedimentation each year. It is clear that, while providing significant improvements, the present effort does not provide enough funding for western Tennessee to meet Clean Water Act goals.

A National Demonstration Involving a Multiagency Approach

In October 1984, a regional resource conservation program was established to solve the alarming soil erosion and rural water pollution problems in the 201–county Tennessee Valley region. While the program is intended to focus on solving regional problems, it was also designed to serve as a national model. The objectives of this program are to: (1) reduce soil erosion to acceptable levels and improve water quality; (2) increase farm income; (3) serve as a national demonstration for multiagency cooperative soil and water conservation programs; and (4) serve as a national model for achieving Clean Water Act goals through nonpoint source pollution control. The cornerstones for the effort are cooperation and coordination, and targeting to the worst problem areas.

This cooperative program, known as the Land and Water 201 program, includes the seven Valley states, food and agriculture councils, USDA, EPA and TVA as equal partners. The program's overall thrust is to achieve solutions to resource problems through example, inspiration, education and cooperation. The program provides support for major conservation–demonstration projects by identifying common problems, needs and opportunities, identifying alternative solutions, and seeking financial assistance for implementation. The program is managed by a committee made up of representatives from each of the partners in the program. The following outlines the approach being taken to develop a strategy to demonstrate solutions to some of the more severe agricultural nonpoint problems in the region.

A water quality committee, made up of representatives from water quality and agricultural interests in each state, EPA, USDA and TVA, has developed and is pursuing an initiative aimed at providing cost–effective improvements in water quality in priority watersheds within the Tennessee Valley 201–county region. The initiative is intended to demonstrate how Clean Water Act goals can be met through interagency cooperative efforts under existing authorities and through the use of remote sensing techniques that target resources to the lands contributing the most pollutants. Much as EPA's Chesapeake Bay nonpoint source demonstration project is providing valuable information on nonpoint source controls, this Tennessee Valley demonstration will provide information for areas with a different socioeconomic and environmental setting, where problems and solutions are much different than those in the Chesapeake Bay watershed.

A three–phased approach is planned for the Tennessee Valley region demonstration. This approach focuses on implementation of best–management practices on "high-payoff" areas by targeting resources, and it follows the screening processes recommended by EPA in its 1984 report to Congress (EPA 1984). Phase 1 has the water quality committee working with each state to identify and rank priority watersheds with impaired uses caused primarily by agricultural nonpoint sources. To maximize effectiveness of available funds, ranking of watersheds will consider whether the water body has the potential for meeting Clean Water Act goals, if nonpoint sources are controllable, whether future activities in the watershed will deteriorate water quality if not properly managed and the costs of needed nonpoint source controls. Phase 2 will identify and rank factors contributing to nonpoint source pollutants within the priority watersheds and evaluate alternative management practices. During Phase 3, best-management practices will be implemented by targeting them to the most critical areas, and the results will be monitored and assessed to establish the cost-effectiveness of targeting, and the resulting water quality and farm income benefits. Targeting here refers to a farm, field or even portions of fields where the most pollution control per dollar can be attained.

The Land and Water 201 Program is now in Phase 1, which should be completed by November 1986. Agricultural and water quality representatives from each state have identified priority nonpoint source watersheds. Information on watershed land use, water quality and use impairment, erosion rates, and current conservation practices is being compiled. This information will be used to select approximately 10 key demonstration sites for Phase 2 and Phase 3 follow-up.

Much of the information necessary to identify and evaluate best-management practices with the priority watersheds is not likely to be available. A tool that will be relied on heavily and demonstrated in the Tennessee Valley program is remote sensing, together with computer-based geographic information systems. Aerial photography will be used to quantify important land features, such as livestock and poultry operations, cropland and pasture surface waters, septic tank failures, soil loss areas, and the nearness of these pollution sources to receiving streams. This approach will increase the accuracy and greatly reduce the amount of time needed for field data collection for watershed inventories. The geographic information system will be used to analyze inventory information and develop mitigation and sampling plans.

Opportunities in the 1985 Farm Bill for Targeting for Nonpoint Source Water Pollution Control

The 1985 Farm Bill, signed by President Reagan in late-December 1985, contains several provisions related to conservation and provides a major opportunity for the Land and Water 201 Program to lead the way in demonstrating effective soil erosion control for the nation. The most potentially significant provision is the Conservation Reserve Program (CRP) for placing highly erodable cropland into grass, legumes or trees for a 10- to 15-year period. Rental payments of up to $50,000 per landowner will be made for up to 45 million acres (18.2 million ha) over the five-year life of the program, which may cost up to $11 billion. USDA is given the authority to give priority to owners and operators in financial stress. Eligible lands, as of early January 1986, were those eroding at greater than twice tolerance, land that poses an off-farm environmental threat, or land where continued use threatens to reduce production because of salinity. Farmers will submit bids on the annual rental payments they would accept; the Agricultural Stabilization and Conservation Service (ASCS) will accept or reject the bids. Interim regulations for the program are scheduled to be promulgated by mid–February 1986.

If the regulations implementing the CRP provide direction that a priority be placed on bid acceptance in targeted watersheds with cropland erosion–related water quality problems, a very cost–effective use of the public funds would be made (Duda and Johnson 1985). Such direction would encourage state and county Agricultural Soil Conservation Service Committees to use off–site water quality damage as an eligibility factor in setting priorities for CRP funding. In this way, not only would cropland erosion control and wildlife benefits be obtained, but also water pollution–control benefits would be achieved. Expenditures of these resources in watersheds without nonpoint pollution problems would not represent the best use of public funds and would be contrary to the intent of the Soil and Water Resources Conservation Act, which was reauthorized by the 1985 Farm Bill. For example, the State of Texas has the most land area eligible for the CRP. Yet, the national nonpoint source pollution assessment, prepared by the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA 1985) indicates that Texas reports only two small river segments impaired by nonpoint sources. The $11 billion should be targeted to where it will do the most good for all soil and water resources and, based on the results of the ASIWPCA report, Texas, for example, should not be one of the places receiving targeted funds. States like Illinois, Iowa, Kansas, Minnesota, Oregon, South Dakota and Tennessee—with significant use impairments from agricultural nonpoint sources—should receive the majority of the funding to be applied to watersheds with impaired use.

In addition, funding available from USDA under the Agricultural Conservation Program (ACP) and the PL–566 small watershed program should be targeted to those lands responsible for the greatest delivery of pollution problems. Animal waste management should be a high priority. Unfortunately, these programs have been either drastically scaled down or eliminated in the President's proposed 1987 budget. Targeting these programs, when coupled with aggressive "conservation compliance" in the "Swampbuster" and "Sodbuster" provisions of the 1985 Farm Bill, could represent the change in national policies needed to address our land and water resource problems. Such a policy change will need to be implemented to deal effectively and decisively with the awesome pollution problems that many of our most–valuable surface waters are experiencing.

Conclusions

The nation is experiencing one of the greatest challenges ever in the area of water pollution control—the control of nonpoint pollution sources. Recent reports indicate that the problem—large though it is—is manageable. Evidence shows that not all land will have to be treated to make substantial improvements in the nation's water quality. It is also recognized that the federal government has limited resources to expend on correcting this serious and growing problem. In fact, new resources are almost unthinkable at this time. However, there are existing federal pollution–control and resource–conservation programs that can, if properly focused and linked with state, local and private efforts, lead to substantial progress in correcting this problem.

Recent enactment of the 1985 Farm Bill, with its authority to establish a 45–

million acre (18,200 ha) conservation reserve, must be an integral part of the program to combat nonpoint pollution problems. It represents perhaps one of the last large federal authorizations for spending in the area of resource protection and enhancement. It can be tailored to meet the specific objectives established in the law to combat serious erosion problems and improve wildlife habitat and, without diminishing its effectiveness in accomplishing these objectives, also help achieve the water quality goals of the nation. To do so, national policies controlling program design and administration within the U.S. Department of Agriculture, Department of the Interior and the Environmental Protection Agency must be changed. TVA has conducted demonstrations over the past two decades that conclusively show the wisdom of integrating natural resource management and pollution–control objectives. The current Land and Water 201 Program established in 1984 among USDA, EPA, TVA and Valley states continues the example of integrating objectives with demonstrable results.

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Successes and Challenges in Guiding Development in Morro Bay, California

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Introduction

This case study deals with man's influence on Morro Bay, one of three purportedly pristine estuaries remaining on the California coast. Human presence is traced from the time of the Chumash Indians through the modern era, and land–use patterns and jurisdictional authorities that have shaped the present natural environment are identified.

A new unifying approach is recommended for maintaining environmental quality. The approach is based on the premise that all interested parties utilize the natural and physical resources of Morro Bay and that they therefore demand perpetuation of those resources. The process is applicable to other small communities.

The responsibility for daily management of the Morro Bay estuary is divided among private landholders, the city of Morro Bay, the county of San Luis Obispo and the state of California. Jurisdictional and managerial authorities were identified and investigated, but due to the complexity of the interagency network, the list of authorities is not exhaustive.

The dilemma of the degradation of the Morro Bay estuary has grown out of earlier efforts to mitigate environmental damage. These efforts have been ineffective, as evidenced by the gradual but continual deterioration of the area. The cumulative damage results from the implementation of directives from a multitude of jurisdictional and private authorities. Consequently, the integrity of the Morro Bay ecosystem is jeopardized by (1) the complex and diverse nature of public and private managerial systems, (2) the profit motive within the local economy, and (3) the lack of an overriding philosophy of development.

The goal is that the estuary maintain its integrity and again become a naturally functioning ecosystem. This is particularly important inasmuch as it is the natural resources of the area that drive the local economy.

Location and Description of the Estuary

The estuary is adjacent to the city of Morro Bay on the central coast of California, in San Luis Obispo County, midway between San Francisco and Los Angeles. It is the only natural landlocked harbor on the coast (CDFG 1966). Incorporated 17 July 1964, it is home for approximately 9,750 people (Figure 1).

The unincorporated area known as the South Bay is on the southeastern shore of the estuary; it encompasses the communities of Los Osos and Baywood Park. In 1985 the South Bay, which is under county jurisdiction, had a population of approximately 13,000.

The estuary is a submerged seaward depression adjacent to the Los Osos Valley on the south and the Chorro Valley on the east. It lies in a north–south direction and

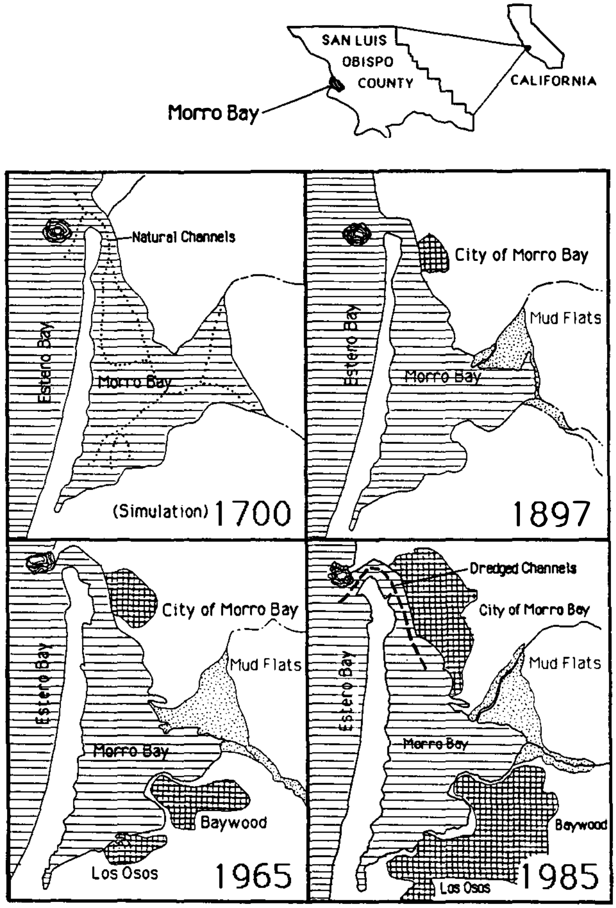

Figure 1. The changing faces of Morro Bay estuary, California.

is approximately four miles (6.4 km) long and one mile (1.6 km) wide. It occupies some 2,500 acres (1,012 ha)—472 acres (191 ha) being salt marsh. Gerdes (1970) reported 2,101 surface acres (850 ha) of water at high tide. At low tide, the surface water is reduced to 649 acres (263 ha), leaving 1,452 acres (588 ha) of mud flats.

The drainage basin includes Chorro Creek with 30,080 acres (12,173 ha), Los Osos Creek with 18,000 acres (7,284 ha), and Morro Creek with 17,272 acres (6,990 ha). The hydrological conditions resulting from the confluence of these two creeks are responsible for the bay's mud flats. The Conservation Planning Collaborative, Inc. (1975) estimated that an additional 3,250 acres (1,315 ha) drain directly into the estuary (Figure 2).

The estuary is bordered on the west and south by a sandspit four miles (6.4 km) long and 1,000–2,000 feet (305–610m) wide, with a maximum elevation of 90 feet (27.4 m), and covering 800 acres (324 h) (CDWR 1979). Its shape suggests formation by littoral drift moving from south to north (USACOE 1975). The dunes on the sandspit are sparsely covered with shrubs and succulents.

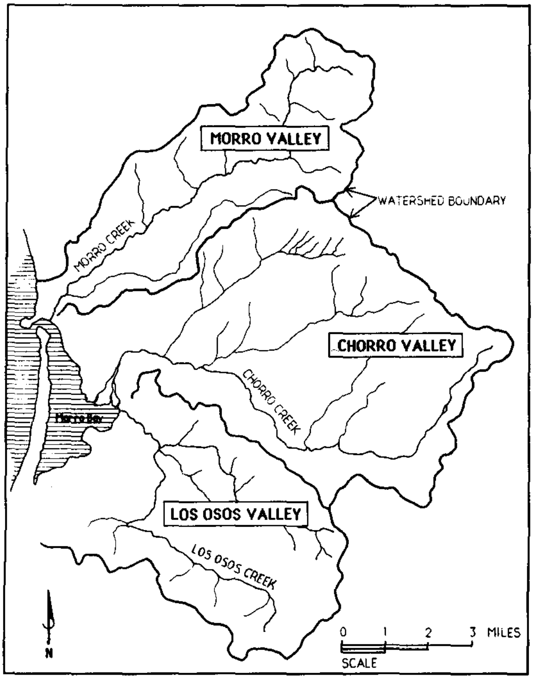

Figure 2. The basins and watersheds of Morro Bay, California.

Topography

Geologically, the region has been characterized by intense folding and fracturing that resulted when the Pacific plate collided with and slid under the North American continental plate. Part of the oceanic crust was accreted to the continent, forming much of coastal California. Marine sedimentary rock was uplifted in this region. At the end of the Pleistocene epoch, when the last ice age ended, ocean levels, which had been lowered, rose approximately 300 feet (91 m) (Hamblin 1982). With the rising sea level, the area that is now Morro Bay was flooded (Figure 1).

The study area is rimmed by the Santa Lucia Mountains (about 3,000 feet/914 m above sea level) to the east and north, and the Irish Hills (12,000 feet/3,658 m above sea level) to the south. The southern part of the study area contains Tertiary shales, claystones and siltstones of the Pismo formation.

The northern part of the study area is primarily Franciscan melange, serpentinite, Tertiary sedimentary deposits of the Monterey formation and Quaternary landslide deposits on the steep slopes of the Santa Lucia Mountains. The valleys contain recent alluvial deposits.

Park Ridge separates the Chorro Valley from the Los Osos Valley. The ridge consists primarily of serpentinite and metavolcanic rocks, and contains several prominent volcanic neck remnants, one of which is Morro Rock. The creeks in both valleys flow in a northwesterly direction. The Chorro Valley slopes a distance of about 10 miles (16.1 km), from an elevation of 500 feet (152 m) above sea level down to the eastern edge of the estuary, while the Los Osos Valley slopes from an elevation of 200 feet (61 m) down to the bay, over a distance of seven miles (11.3 km). Morro Creek flows in a southwesterly direction from an elevation of approximately 2,400 feet (732 m) down to the northern edge of the estuary.

The South Bay area is composed of high sand dunes which were trapped by the natural groin at Point Buchon during Pleistocene times (CCZCC 1975). Similar sand dune deposits are found north of the estuary.

Three broad categories of soils are present in the basin:

1. Soils on alluvial fans and plains—the Chorro, Los Osos and Morro Valley soils formed on mixed alluvial material from sedimentary rock sources. These soils, including Salinas silty clay loam and Cropley clay, are very deep and are well-drained to moderately well-drained. They have high shrink–swell and water-holding capacities.
2. Windblown deposits—the soils on the south and north of the bay formed on old, stabilized sand dune deposits (Baywood fine sand series). They are very deep and excessively well-drained. The surface texture is sand, loamy sand, sandy loam or silt loam. These soils are dry and subject to wind action.
3. Soils on hills and mountains—on the hills and mountains that border the watershed and that split the Chorro from the Los Osos Valley, the soils vary depending on the rock from which they formed. Most common are the Los Osos loam, Lodo clay loam and Diablo clay series. These formed in residual material weathered from sedimentary rocks. The soils are shallow to deep, and well-drained to excessively well-drained. The surface texture varies from loam to clay. When saturated, the Los Osos and Diablo soils are subject to slippage, due to high clay content and low shear strength.

The natural vegetation can be broadly classified into grassland, woodland, wooded grassland and chaparral. The sandspit and South Bay areas are considered coastal chaparral and wooded grassland. The valley floor and lower slopes are primarily grasslands, with woodland occupying the moister sites. Chaparral is found primarily on upper slopes and ridges.

Climate

The study area enjoys a Mediterranean climate, with relatively warm, moist winters and cool, dry summers. The mean annual temperature ranges from 54 degrees Fahrenheit (12.2 degrees C) along the coast to 60 degrees Fahrenheit (15.6 degrees C) inland. Daily and seasonal ranges are moderate.

Yearly rainfall patterns affect the freshwater flow into the estuary, with the most precipitation occurring from November to April. Topographical characteristics influence the amount of precipitation, which is lowest along the coast and which rises as the elevation of the mountains increases. For example, the mean annual rainfall for Morro Bay is 19.8 inches (50.3 cm); for the South Bay, 17 inches (43.2 cm); for the Chorro watershed, 22 inches (55.9 cm); and for the ridgetops, 30–45 inches (76.2–114.3 cm). Fog, which occurs at all times of year but particularly in the summer, adds 1–2 inches (2.5–5.1 cm) to the annual precipitation.

During the day, the prevailing winds are westerly to northwesterly 5–20 miles per hour (8.1–32.2 km/h); in the spring, they are stronger than normal. At night, winds from the east are 0–10 miles per hour (0–16.1 km/h), but they vary with the season. During fall and winter, occasional Santa Ana winds (from the east) average 20–24 miles per hour (32.2–38.6 km/h).

Water

The estuary receives both freshwater and saltwater. Freshwater comes from the three main watersheds and from groundwater flow (Table 1), while saltwater enters by intrusion through the sandspit and by way of tidal prism at the north end of the bay, where Morro Rock is located.

The estuary experiences two high and two low tides daily. The mean diurnal tidal range is 5.2 feet (1.6 m), with a maximum of 9.6 feet (2.9 m). The difference between the high and low tides produces a tidal prism of approximately 13,500 acre–feet. The movement of the prism is influenced by the near–shore components of density and littoral currents, as well as by the tides (USACOE 1975). The deepwater currents stabilize the coastal water temperature around 55 degrees Fahrenheit (12.8 degrees C) (Wieman 1980).

Two streams, Chorro Creek and Los Osos Creek, enter the bay from the southeast; Morro Creek enters from the northeast. The lagoon also receives drainage from 450 acres (182 ha) of the sandspit that forms its western boundary (CDFG 1974).

Reports indicate that the bay's high water level (covering approximately 2,500 surface acres (1,012 ha) has been relatively constant for over 100 years (USACOE 1873).

Values and Unique Features

The California Senate's Resolution No. 176 in 1966 was the initial step by the state legislature to identify and plan for Morro Bay's resources. The resolution recognized that the unique features of the bay were important not only to the local population but also to the state and the nation. The California Resources Agency was assigned the work of identifying the unique natural resources of the area and of preparing a plan for their preservation. That same year, the California Department of Fish and Game prepared the *Report of the Natural Resources of Morro Bay and Proposal for Comprehensive Area Plan* (1966). It details the following values and unique features of the area:

- Scenic quality and natural beauty.
- A varied shoreline, with the lagoon and its link to the ocean providing for a wide range of recreational activities.
- Wildlife habitat for a diversity of migratory and resident fish and wildlife.
- The only landlocked harbor between San Francisco and Los Angeles.
- Commercial fisheries based on the abundance of fin fish and shellfish.
- Scientific and educational concerns. The area is home to various rare, threatened and endangered species. It also possesses unique archaeological, historical and geological characteristics.

History

The development of Morro Bay was a function of the natural resources of the area. Periods of impact can be divided as follows: (1) the Indian (pre–settlement) era prior to 1500; (2) the Hispanic (settlement) era, from 1542 to 1861; and (3) the modern

Table 1. Watershed basin characteristics for Morro Bay, California.[a]

Watershed	Acres (ha)	Inches (cm) of annual precipitation	Miles (km) of stream		Total water in acre-feet (ha-ft) per year		Number of stream-renovation permits since 1977
			Main	Feeder	Supply	Demand	
Chorro	30,080 (12,173)	22.0 (55.9)	39.9 (64.2)	60.2 (96.9)	55,000 (22,258)	1,143 (463)	43
Los Osos	18,000 (7,285)	17.0 (43.2)	17.3 (27.8)	54.5 (87.8)	27,000 (10.927)	1,900 (769)	31
Morro	17,272 (6,900)	21.5 (54.6)	14.8 (23.8)	51.7 (83.2)	36,000 (14,569)	581 (235)	17

[a]Most figures are approximations.

era, dating from 1861. These periods are similar to those presented in the 1974 CDFG report.

The Indian (Pre–settlement) Era

Prior to the 1700s, the Morro Bay area was largely unspoiled and teemed with plants and wildlife. Only two species of land animal, the California grizzly (*Ursus arctos*) and the rabbit (*Sylvilagus* spp.), have been positively placed in pre–settlement times. However, local experts surmise that species diversity was about the same as now, only much denser. Species that may have once been present include: the California clapper rail (*Rallus longirostris obsoletus*); the California condor (*Gymnogyps californianus*); the black rail (*Laterallus jamaicensis centurniculus*); and the aforementioned grizzly (Persons 1986). Species that are threatened today but were once plentiful include the peregrine falcon (*Falco peregrinus*), the Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*) and the banded dune snail (*Helminthoglypta walkeriana*).

The rich habitat was sketched in an account of Gaspar de Portola's September 1769 expedition through what is now the Los Osos Valley: ". . . we came to another vale, spacious, with many ponds of water, whose banks were so muddy as to prevent our horses from approaching to drink. . . . following the same cañada westward to the sea, meeting on our way some impediments because of deep water–courses. . . . we halted upon a hill within sight of the sea, and near a rivulet of good water, upon which grew water–cress. It is a pleasant locality, with many trees and good pastures" (from Father Juan Crespis diary, quoted in Morrison and Hayden 1917).

The foothills and mountains were covered by chaparral, which the early Spanish explorers described as an impenetrable wall of vegetation. The chaparral's dominant plants were manzanita (*Arctostaphylos* spp.), buckbrush (*Ceanothus cuneatus*) and yucca (*Yucca whipplei*). The valleys were home to oaks (*Quercus* spp.) and digger pine (*Pinus sabiniana*), while the very moist area immediately adjacent to the bay supported many plants, particularly the willow (*Salix* spp.).

Morro Bay lies within the northern area of settlement of the Chumash Indians, whose culture supplanted those of earlier Indian tribes about 1,000 years ago. The Chumash relied heavily on the sea for food, as well as acorns of the coastal live oak. All their needs were satisfied by the area's plants and animals, yet, like other native Americans, they lived well–within the limits of the ecosystem, and their presence did not significantly alter the area's natural state.

The Hispanic (Settlement) Era

The Spaniard Juan Cabrillo explored Morro Bay in 1542; 60 years later, Sebastian Vizcaino visited what is now San Luis Bay and named the Santa Lucia Mountains. But most information about exploration during the Hispanic era is taken from accounts of the Portola expedition, which set out overland from San Diego in 1769. Portola and his men camped 7 and 8 September 1769 in what they named the "Cañada de Los Osos," because of the large numbers of grizzly bears they saw there (Bancroft 1884). The expedition followed this valley, now the Los Osos Valley, down to Estero Bay and Morro Rock. The men later journeyed to Monterey, where they established a presidio in 1770.

The large Spanish land grants, which lasted up to 1872, sustained a small population of Hispanics and were responsible for only minimal trade and commerce

(CDFG 1974). Missions were established approximately a day's journey apart and each one served as a focal point for settlement and a resting place for travelers.

The land–use patterns adjacent to the missions significantly changed the landscape. Spanish settlers brought in horses, donkeys, sheep and cattle, and cultivated primarily beans, corn, wheat and barley. In the San Luis Obispo area during the 1830s, there were approximately 3,700 cattle, 1,500 horses and mules, and several thousand sheep (Bancroft 1884). Richard Henry Dana, in his 1840 book, *Two Years Before the Mast,* described California's cattle industry and the heavy trade in hides and tallow that took place all along the coast. The area became overgrazed and was subject to wind and water erosion (CPC, Inc. 1975). Agriculture added to the problem—because the bottomlands were cultivated, every flood washed soil into the bay (USACE 1873).

The Modern Era

The modern era of Morro Bay's settlement began in 1861 when its population grew large enough to justify appointing an Inspector of Moro Precinct (Angel 1883). At this time, government land was available to private individuals, and Spanish land grant parcels were subdivided to encourage development of farms, towns and seaports.

The town. Franklin Riley arrived in 1864, and is credited with founding the town of Morro on land that had been part of the Morro y Cayucos land grant, which extended from the bay to what is now the town of Cayucos. Riley established the Morro Embarcadero by subdividing 160 acres (64.75 ha) along the waterfront. His subdivision prompted the first wharf and warehouse to be built, and development continued slowly as the town grew into a city (Morro Bay Bulletin 1970).

During the 1890s, the area now known as South Bay was subdivided. In the 1920s, lots there were sold to midwesterners through magazine advertisements (CCZCC 1975).

The harbor. The top–left diagram in Figure 1 illustrates navigational channels prior to development. Access and egress were influenced by shoaling. Morro Rock was in open water, and the channel into the lagoon forked at Stocking Wharf on the El Morro waterfront. Both segments of the channel ran south. Morro Creek, draining 17,272 acres (6,990 ha), entered the estuary across from the south channel, at approximately the site of the present Pacific Gas and Electric plant.

Small steamers and schooners entered the bay (Morrison and Hayden 1917) and, in 1877, two wharves were built out over 14 feet (4.3 m) of water to accommodate loading and unloading (Morro Bay Bulletin 1970). But shoaling rendered the estuary inaccessible for continuous use, and a dangerous surf contributed to an unsafe situation at the harbor entrance. In a preliminary examination of the harbor of El Moro in 1894, W.H.H. Benyard of the U.S. Army Corps of Engineers recommended that the south channel be closed by dike extension from the rock to the sandspit because of exposure to winter gales.

Around 1910, attempts were made to close the north channel. Shoaling of the east channel along the waterfront was caused by a partial revetment built from Morro Rock to the mainland (Wiegel 1967) and by an attempt to close the north entrance.

By 1919, the revetment was in need of major repair, but it was not rebuilt until 1935–36. This repair work closed the north channel and redirected the natural currents, so that the U.S. Coast and Geodetic Survey of 1938 shows only one channel along the sandspit. This closure reduced the freshwater inflow into the estuary by 36,000 acre–feet per year.

Around this time, modifications were made in the estuary to facilitate the shipping of stone quarried from Morro Rock. These alterations influenced tidal flushing and shoaling patterns and, indirectly, the ecology of the estuary.

In 1941, the Navy Department expressed a need for a coastal defense harbor (USHR 1941). This justified later federal work in the bay and set the stage for the County Board of Supervisors and the local Chamber of Commerce to press for accommodations for small pleasure and commercial craft.

The following is a chronological listing of harbor development since 1941:

1941—Dredging of the east channel and closing of the west channel.

1942—South breakwater and reconstruction of Morro Rock revetment completed.

1944—Completion of retaining seawall, marginal fill along waterfront and dredging of the channel to deepen the estuary.

1945—River and Harbor Act provided for frequent dredging of the estuary by the Army Corps of Engineers. Dredging took place every two years through 1974, with approximately 300,000 cubic yards (229,366 m^3) of sand spoil being deposited on the sandspit. As a result, the northern tip of the sandspit has been widened on the lagoon side.

1946—Morro Rock breakwater finished.

1956—Dredging of navigation channel by the Corps.

1957 to present—Reconstruction work on the breakwater.

Morro Rock. Morro Rock is the last visible section of the volcanic plug called "Park Ridge." It is 581 feet (177 m) high, covers approximately 36 acres (14.6 ha) and is composed of porphyritic–aphanitic dacite. Originally owned by the U.S. government, it was used as a lighthouse site from 1867 to 1935, and was declared a state historical landmark in 1968.

Industry. With the 1910 attempts to close the north channel and create a safe harbor, Morro Bay was established as a fishing port and recreational area. Morro Rock Inn, the first year–round resort, opened around 1915 (Morrison and Hayden 1917), but fishing did not emerge as economically significant until after the Corps of Engineers completed construction of the harbor in 1946. The area's benevolent climate and natural beauty continue to attract tourists and retirees, who constitute much of Morro Bay's economic base.

The Present

The Morro Bay region is experiencing environmental pressures related to rapid growth. Among those pressures are:

1. Population growth—The South Bay's population increased 213.5 percent from 1970 to 1980, while Morro Bay's increased 127.5 percent. Public institutions in the drainage basin are also expanding, most notably the medium–security prison

known as the California Mens Colony, and Cuesta College, a two–year community college.

2. Pollution—The water quality of the estuary was reported to be excellent for the shellfish industry in 1963 (Barrett 1963), but today the commercial harvest is threatened by pollution. That pollution is attributed to the Morro Bay wastewater treatment plant, to septic leachate, and to discharge from pleasure and commercial boats. Nitrate pollution in the groundwater of the South Bay has mandated the development of a wastewater facility to be completed in 1988.
3. Declining water quality and quantity—Domestic water shortages occur during dry years and have led to the mixing of unacceptable quality water with good quality water to produce a greater volume of acceptable water.
4. Biological problems—Continuing development puts further pressure on the habitats of threatened and endangered species. Accelerated erosion is forming mud flats and reducing the volume of water in the estuary. Still other problems include shoaling of the estuary, dredge disposal, a decreased flow of freshwater from feeder streams and groundwater, and stream channelization (Table 1).
5. Political problems—Single–purpose jurisdictional authorities continue to mushroom.

All these problems are man–induced, and even our best efforts seem to create more problems than they solve. But perhaps a unified approach to problem solving can improve the results of management efforts. This unified approach will be treated later in this paper.

Jurisdictional Authorities

Given the diverse and uncontrolled land–use history of Morro Bay, it seemed important to identify all agencies influencing resource utilization in the study area. I considered mission statements, type of involvement, responsibilities, intergovernmental relations, and specific plans or programs for these entities. Based on their functions rather than on their organizational structure, I divided the agencies into two categories.

1. Authorities that utilize specific resources in carrying out their mission directives, but that have no administrative or managerial role over those resources. The nine agencies in this category are listed in Table 2.
2. Administrative, enforcement and managerial authorities, as well as agencies that are advisory or give technical assistance. The 57 jurisdictional authorities in this category are listed in Figure 3, and each is identified in three ways.
   a. By whether the agency's participation is direct or indirect. "Direct" participation assumes the agency is involved in daily management and has a visible impact on the study area. "Indirect" participation is defined as being in a more remote capacity. This may occur by way of specific projects or may take the form of providing input, but not necessarily having much authority—advisory commissions, for example.
   b. By the agency's functions and responsibilities. Table 2 lists 14 functions in order of decreasing importance.
   c. By the general resources. Eight general resource groups (air, water, etc.) were identified. They are listed in alphabetical order within the table, since they are not prioritized by any other criterion.

Table 2. Jurisdictional authorities involved with direct land–use activities of the Morro Bay area of California, 1986.

Name	Public or private	Year established	Acres (ha)	Land use
California Mens Colony	Public	1955	346 (140)	State prison
California Polytechnic	Public	1902	5,903 (2,389)	Education and related
California State Parks	Public	1932	4,800 (1,943)	Recreation
Cuesta College	Public	1966	275 (111)	Education
National Guard	Public		4,100 (1,659)	Military, grazing, share-cropping
Pacific Gas and Electric	Private	1956	168 (68)	Power plant
San Louis Obispo County Parks and Beaches	Public		755 (306)	Recreation, grazing
San Luis Obispo County Superintendent of Schools	Public	1968	252 (102)	Outdoor education
Whale Rock Reservoir	Public	1957	1,344 (544)	Water

Discussion

Environmental problems are created by such human demands as housing, transportation, employment and domestic water supply. Humans try to solve environmental problems by setting standards and establishing agencies to enforce those standards.

The presence of 57 jurisdictional authorities in the Morro Bay area attests to the human population's desire to protect the environment. The people in these organizations are well–intentioned and try hard to solve the problems under their jurisdiction. But these attempts at problem solving generally involve compromise, and the problems are often mitigated rather than solved. Furthermore, methods used tend to be ones that may have worked in the past, but which are no longer effective. Attention is paid to the more–obvious components of the physical system, yet there is no regard for the more–subtle processes of the natural system. And once a jurisdictional authority has addressed a problem, we tend naively to assume that the problem no longer exists.

Even more serious is that fact that most of these 57 agencies are single–purpose agencies, and their efforts at problem solving occur in relative isolation. Single–purpose agencies are rarely able to look at the whole picture, and since they are not unified around a common philosophy of resource use, efforts at problem solving are often piecemeal. It was with a piecemeal approach that we created the harbor, the embarcadero, the city of Morro Bay, the South Bay community, the Pacific Gas and Electric plant, the wastewater treatment facilities, the state park and other projects with intended social or economic benefits. In doing so, we solved a lot of problems, but created others. For example, the series of harbor "improvements" that closed the north entrance channel to the harbor was made in order to facilitate navigation. But this meant that traffic in the south channel was exposed to the prevailing winds and high waves of winter gales, and all too often since those modifications, the Morro Bay harbor entrance has been the site of accidents due to heavy surf.

Another example is the Pacific Gas and Electric plant, which was built in 1955–56 to meet increased energy needs. Today, the plant takes in approximately 137 acre–

Agencies	Participation		Functions and Responsibilities														General Resources							
	Direct	Indirect	Board of Directors	Emergency Planning	Policy Making	Regulatory	Administrative	Planning	Permitting / Enforcement	Resource Protection & Conserv.	Resource Management	Public Development & Maintenance	Interagency Tech. Advice, Assistance	Envir. Monitoring & Data Collection	Public Education & Assistance	Advisory	Utilities/Public Facilities	Air	Water	Land	Biological	Recreation	Fiscal/Funding	Agriculture
United States Government:																								
Fish and Wildlife Service	●					●		●	●	●			●	●							●			
Army Corps of Engineers	●									●	●	●	●	●			●		●	●				
Forest Service	●							●	●	●	●		●	●	●				●	●	●	●		
Nat'l. Oceanic Atmospheric Admin.		●		●	●			●	●	●	●		●	●					●		●			
Coast Guard		●		●					●			●			●				●					
Soil Conservation Service		●		●						●	●		●	●	●				●	●				●
Coastal SLO Resource Cons. Service		●			●			●		●	●		●			●				●				
Ag. Stabilization and Cons. Service		●								●					●				●	●	●		●	●
Geological Survey		●											●	●							●			
Environmental Protection Agency		●	●		●				●	●			●	●				●	●	●	●			
Food and Drug Administration		●			●				●				●	●					●	●	●			
State of California:																								
Water Quality Control Board	●					●		●	●	●	●		●	●	●				●					
Caltrans	●							●				●					●							
Coastal Commission *	●	●				●		●	●		●					●			●	●	●			
Dept. of Parks and Recreation	●				●			●			●				●					●	●			
Dept. of Fish and Game	●				●	●		●	●	●	●		●	●						●	●			
Fish and Game Commission		●	●		●	●														●			●	
Conservation Corps		●								●			●							●	●			
Office of Planning and Research		●			●			●					●			●								
Dept. of Forestry		●							●	●	●					●				●	●			
Air Resources Board		●				●		●						●					●					
Transportation Commission		●	●																	●		●	●	
Waste Management Board		●				●		●	●				●	●			●			●				
Department of Water Resources		●		●				●		●		●	●	●			●		●		●	●		
Water Commission		●	●																●					
Division of Mines and Geology		●											●	●	●					●				
Dept. of Health Services		●				●			●	●			●	●	●				●	●	●			
Energy Commission		●			●	●		●	●	●							●			●				
Boating and Waterways		●										●	●				●					●	●	
State Lands Commission	●				●	●			●	●									●	●				
Wildlife Conservation Board		●								●			●	●						●	●		●	
County of San Luis Obispo:																								
SLO Area Coordinating Council	●							●				●	●	●		●	●	●		●			●	
Environmental Health	●					●		●					●	●					●	●		●		
Environmental Coordinator	●					●		●		●			●	●			●	●	●	●	●	●	●	●
Department of General Services	●				●		●	●	●		●		●		●		●			●		●		
County Board of Supervisors	●		●		●	●	●	●		●		●			●		●	●	●	●	●	●	●	●
Planning Commission	●				●	●		●		●						●								
County Administration		●					●		●				●		●								●	
Local Agency Formation Committee		●			●	●		●					●		●								●	
Emergency Services		●		●									●		●		●	●	●	●	●			
County Department of Agriculture	●					●	●	●	●	●	●		●	●	●									●
Planning Department	●					●	●	●	●	●			●		●									
Air Pollution Control District	●					●		●	●	●			●	●				●						
County Engineering Department	●						●	●	●	●	●	●	●	●	●	●	●		●	●			●	
County Assesser		●					●													●			●	
Farm and Home Advisors Office		●												●	●	●		●	●	●	●			●
County Counsel		●											●											
Fish and Wildlife Committee		●								●					●	●			●	●	●		●	
Water Advisory Committee		●												●		●			●				●	
Local Watershed:																								
Harbor Commission		●														●	●		●	●		●		
Planning Commission	●				●				●							●	●			●				
Parks and Recreation Commission		●														●	●			●		●		
CSA 9 Advisory Board		●														●	●		●					
South Bay Community Council		●												●			●		●					
Water Advisory Commission		●														●	●		●					
Whale Rock Commission	●				●			●			●	●					●		●					
City of Morro Bay	●		●		●	●	●	●	●	●	●	●	●	●	●		●		●	●		●	●	

* Coastal Commission involvement is direct prior to dispute of Local Coastal Plan and indirect thereafter

Figure 3. Matrix of jurisdictional authority for resource management and use in the Morro Bay area of California, 1986.

feet of water per day from the estuary, uses it for cooling purposes, and cycles it into Estero Bay at a temperature higher by 15–23 degrees Fahrenheit. Local citizens as well as visitors to the area complain about the way the plant's three smokestacks dominate the landscape, and the discharge from these towers is notoriously hard on automobiles' paint and chrome.

Still other problems have resulted from the upgrading of the wastewater treatment plant, which was modified in 1982 to handle a larger volume of effluent so that improperly treated sewage would not enter Morro Bay. The community elected to cut costs by using an ocean outflow, and rejected the option of recycling the water into a water–deficient area. A pipe was laid 5,000 feet (1,524 m) from the treatment plant out into Estero Bay, where the effluent was not to be a threat. But a stretch of sand dunes between the plant and the ocean was completely destroyed by the construction work of laying the pipe, and it now appears that the effluent may be impacting Morro and Estero Bays.

Each of these measures was well–intentioned and did indeed solve some problems. But each created other problems, altering the estuary and its surroundings, adding to the responsibilities of managerial authorities, and passing the responsibility for estuarian husbandry to jurisdictional authorities.

If we are to manage the natural resources of Morro Bay successfully, we must recognize the following points.

1. We are dealing with an ecosystem extensively altered by human use and misuse.
2. Control of the land determines land use for an area.
3. Planning has been directed at physical systems; biological systems were considered to be independent, even though their functions have always been controlled by the physical environment.
4. The estuary in Morro Bay has wrongly been addressed as a physical object, not as a living system dependent on the physical environment.
5. At present, mission and goal statements of jurisdictional authorities deal with the management of people, places and things as they relate to an objective. They *should* deal with the management of living systems as they relate to people, places and things.
6. The jurisdiction of management agencies is becoming more narrowly defined.
7. The system of management becomes more complex as we try to solve specific problems.
8. No single environmental agency has been given the power to coordinate the efforts of the jurisdictional authorities in the area.
9. We cannot assume that a problem is solved simply because it has been tackled by one of these agencies.
10. Environmental damage is cumulative.
11. Environmental mitigation does not reduce environmental damage to zero.

After considering these points, we should ask ourselves a very serious question: Who should be responsible for restoring and managing the resources of Morro Bay—the users, the managers or the people? The best answer may lie in having all authorities and interested parties cooperate in an overall strategy for protecting Morro Bay.

Traditional Approaches

There are various traditional approaches to the problem. One is to coordinate the activities and programs of all 57 agencies through an already–existing organization.

This method is unlikely to succeed because of present budgets, workloads and staffing problems.

A second approach would be to create a new level of government that would deal solely with the bay's environmental problems. I don't see this as a viable approach, due to the structural complexity of existing jurisdictional authorities, the amount of vested interest, the cost and time necessary for a new agency to become effective, and the legal and political in–fighting that would result.

A third approach, and the one recommended by CDFG (1966), is to develop a comprehensive management plan that would recognize the limits of the natural environment. Implementation would require integrating the mission statements of all the jurisdictional agencies and meshing individual programs into a workable common plan. This task, although a worthy one, would require a massive planning effort and unprecedented cooperation. Other drawbacks include questions about who would initiate such a project, who would oversee its development and who would pay the expenses.

The last of the traditional approaches would be a master land–use plan. This would be helpful in guiding development if the users' activities could be checked against the intent of the master plan. But it would be difficult to find an agency that would lead the effort and establish acceptable evaluation criteria. In addition, it would be inappropriate for those involved with management on a daily basis also to be charged with monitoring activities of the other jurisdictional agencies.

A single, simple problem may be adequately solved by an individual agency. But finding solutions to complex problems requires understanding both the structure of the problem as well as the institutional framework that must respond to the problem. Such complex problem solving requires a web of agencies continually coordinating activities in pursuit of a common goal. Full implementation is difficult. And even if the goal is reached, unanticipated and undesired environmental consequences may ensue.

The 1966 Department of Fish and Game report stressed that earlier studies had focused narrowly on sponsors' vested interests, and that none had included an overview of all interests. I am convinced that this narrow focus, and the perpetuation of multiple–agency, single–purpose jurisdiction, is the major cause of Morro Bay's environmental problems.

Solution

In response to this dilemma, I am proposing a new approach to managing Morro Bay's natural resources. It draws the positive elements of the traditional solutions mentioned earlier, and it unifies all agencies by its emphasis on maintaining the area's physical and biological resources in a stable condition. Its purpose is to serve as a guide for the jurisdictional authorities and as the common thread linking government and private concerns. I will call this the "Unifying Concept" approach, and it will have a "Directional Statement" as a product. Each agency, in carrying out its mission, would be allowed the freedom to implement its procedures within the confines of this Direction Statement. If the agency's activities were not consistent with the Direction Statement, the activities would be reviewed before a fact–finding commission. I propose this method because it is easier to get a group of agencies to agree on a concept and to work within a common framework than to get them to agree on a specific problem–solving approach.

The concept, expressed in the unifying Direction Statement, is not a goal statement, for the intent is not to arrive at an end, but to cope with problems on a continuing basis. The concept must be realizable within the political, social and economic structure in question. If each agency adheres to the Direction Statement, its actions will not conflict with the overriding concept.

Although this approach is neither difficult nor expensive, some time is required to educate all persons involved. This can be done in roughly two weeks by one individual skilled in the process. That person would be called the "group leader."

How do we arrive at the concept? And how is it to be implemented? The first step is to establish an ad hoc task force, the sole purpose of which would be to agree on the situation and to develop a unifying concept related to managing the area's resources. The task force would be composed of representatives from the jurisdictional authorities and of individuals representing the public. The task force would have no decision–making power and would be under the jurisdiction of the city of Morro Bay, since the city has the most at stake in the process. (It is assumed that the city's long–range goals are consistent with the county's.)

The success of this "concept" approach is dependent on the participants understanding and accepting the process. To keep the number of participants manageable, only those authorities having a continuing direct use of the area should be involved. Participants should be briefed on the principles of resource planning, as well as on the proposed process.

To start the process, the task force must first articulate its perception of the area's environment. As a starting point, let us assume we have agreed on the following: "All interested parties utilize the resources of Morro Bay and therefore demand perpetuation of those resources."

The group leader needs to walk the task force through the following two–phase exercise, observing two requirements: (1) that all responses by the task force be acceptable; and (2) that discussion be directed by the group leader.

Phase I is concerned with the team's conceptualizing and categorizing all events taking place in the study area. The process helps reduce the seeming complexity of the environment, and organizes jurisdictional activities in a comprehensible way. Components of Phase I are as follows:

List the events. Based on the responsibilities associated with each agency, the committee would create a list of events that take place in the study area. The list does not have to be organized, but all events should be identified, for they provide potential information about characteristics and values of the unifying concept.

Sort the events. Based on common characteristics, sort the events into broad groups, and then subdivide those groups into categories. Each category will serve as a building block for the unifying concept. In some cases, it may be necessary to establish a range for events within one category, such as a range of water use to be classified under "groundwater."

Phase II is directed at understanding relationships among events and at synthesizing those relationships into a workable concept. Components of Phase II are as follows:

Link the events. Search each category of events for attributes common to each event. These are the critical attributes and, when combined, they serve as building blocks in the unifying concept.

Define the concept. Discuss the merits of the critical attributes and group them into a range from similar to less similar. This will help establish linkage among components. Then, based on the intent of the combined critical attributes, define the concept for Morro Bay.

Once the concept has been defined, how is it to be implemented? All agencies would use the concept as a set of guidelines for their actions. By adhering to the concept, agencies would maintain a condition rather than achieve a goal. Since there is no question of attaining a goal in the traditional sense, implementation is never completed. The advantage of this approach is that the process is open-ended and keeps all participants actively involved; there is no temptation to consider a problem definitively solved.

The unifying concept process would encourage greater responsibility on the part of the jurisdictional authorities. It requires that each entity function within the limits of the natural environment, and that all agencies work under a common directive. A comprehensive approach such as this could do much to safeguard Morro Bay's delicate ecosystem. Other communities concerned about threats to their natural environment would do well to adopt a similar approach.

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Waterfowl: Population Status, Subsistence Harvest and Restoration Needs and Efforts for Geese in Alaska and Canada

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Waterfowl Management and Subsistence Harvests in Alaska and Canada: An Overview

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This session is titled "Waterfowl: Population Status, Subsistence Harvest, and Restoration Needs and Efforts for Geese in Alaska and Canada." Its purpose is not to place blame for the startling declines in certain goose populations. Rather, it is intended as an opportunity for us to understand better the complex biological and socio-economic problems related to management of these birds. The following speakers will discuss the status of goose populations, some of which figure importantly in subsistence harvest. They will also describe from different viewpoints what is being done or what they believe should be done about this spring-summer harvest of waterfowl.

Providing an overview of the session puts me in the awkward position of either not fully explaining what will follow or explaining in such detail that my fellow speakers will accuse me of plagiarism. I will not argue whether subsistence hunting is legal, proper or even necessary—this likely will be done by others. I will, however, try to provide background on how we got to where we are, and examine the consequences of subsistence harvests on waterfowl and its management.

Seventy years ago, on 16 August 1916, Great Britain, on behalf of Canada, and the U.S. formally signed the "Convention Between the United States and Great Britain for the Protection of Migratory Birds," which I will refer to as simply "The Treaty." It was ratified in both countries that same year. Enabling legislation followed, with the Migratory Birds Convention Act of 1917 in Canada and the Migratory Bird Treaty Act of 1918 in the U.S. Three features of The Treaty that are germane to today's session are: (1) a hunting season may not exceed 3.5 months; (2) the hunting season on migratory game birds shall be closed between 10 March and 1 September, except that Indians may take at any time scoters for food; and (3) Eskimos and Indians may take at any time certain alcids (classified as being nongame migratory birds) and their eggs for food and their skins for clothing. The U.S. and Mexico signed a migratory bird treaty in 1936 which reinforced the U.S. position of a closed season between 10 March and 1 September.

I frequently but unconvincingly try to explain to my two daughters that many things in life will not be fair and that some inequities must be accepted. Like my daughters on family issues, some waterfowl hunters of the Far North (both Native and non–Native) contend that The Treaty unfairly discriminates against them and that those inequities must be rectified. However, other hunters resent those who would hunt outside the prescribed seasons and exceed prevailing bag limits.

From a strictly biological standpoint, The Treaty makes sense, in that waterfowl fall flights should be the greatest if birds are protected during their mating, nesting and brood–rearing periods. From the standpoint of equity among the users, The Treaty favors more southerly hunters along migration routes and in wintering areas. Certainly the framers of The Treaty could not be accused of ignoring subsistence needs of Natives, because the two previously stated provisions show that those needs had been given consideration. However, the framers could be accused of tokenism. If any Indian from interior Alaska or Canada—even some coastal Eskimos—had ever seen, much less traditionally hunted, a murre, puffin or auklet, it would have been an ornithological wonder.

To any cook, a fat goose is preferred table fare over a skinny pin–feathered bird—such is the difference between a goose in spring and a goose in fall in the Arctic. Apart from the pleasures of being afield after the doldrums of winter, it is easy to understand why subsistence hunters would prefer waterfowl in spring to those later in the year and why they seek to legitimize this harvest.

The Supreme Court of Canada has ruled in three important cases—i.e., those against Daniels, Sikyea, and George—that the Migratory Birds Convention Act and regulations apply equally to all Canadians, including Indians hunting out of season on reserves, unoccupied Crown Lands and in the Prairie Provinces. Notwithstanding these decisions, Canada has exercised leniency toward application of regulations to Indians and Eskimos (Inuit) of northern Canada.

The most notable, well–known, but still illegal, subsistence harvest in Canada is that by Cree Indians in the Hudson–James Bay lowlands. Prevett et al. (1983) estimated that the average spring harvest during 1974–76 included about 19,100 Canada geese (*Branta canadensis*), 9,300 lesser snow geese (*Chen c. caerulescens*), and 11,300 ducks. Fall harvests were additional. Those hunted Canada geese in the Hudson–James Bay lowlands are of the Tennessee Valley and Mississippi Valley populations, and the snow geese are of the Midcontinent population. While the two populations of Canada geese are fraught with various distributional problems in the wintering grounds, none of the three populations appears to be impacted adversely by the Cree's subsistence harvest. Graham Cooch will describe the status of these and other goose populations that breed in Canada, and characterize some of the subsistence harvests.

Through 1960, U.S. enforcement of the ban against spring–summer hunting, with respect to Alaska Natives, was lax. However, in the summer of 1961, U.S. Fish and

Wildlife Service (USFWS) agents unleashed a storm of protest when they arrested several Eskimos at Point Barrow for shooting eiders during the closed season. Two days after the arrest about 100 Eskimos gathered at a meeting, each bringing eiders that they had shot and signed statements admitting to their action. A subsequent mass meeting resulted in a petition being sent to President Kennedy, asking him to issue emergency regulations permitting the Eskimos to hunt migratory waterfowl for food at any time of the year. Ernest Gruening, U.S. Senator for Alaska and former Territorial Governor, championed the Eskimos' cause. The Senator argued in Congress and before both the Secretaries of State and the Interior that The Treaty needed to be changed to address the needs of Alaskan Natives. He also let it be known, both in Alaska and through the halls of Interior, that should any Native be prosecuted for taking waterfowl during the closed season that he personally would defend them in court. The U.S. Attorney chose not to prosecute the Barrow hunters, and USFWS agents made no further arrests. The USFWS had no evidence at that time that subsistence hunting anywhere in Alaska was or was not adversely affecting either eiders or any other waterfowl population.

The Point Barrow incident flamed interests among Native communities throughout Alaska for changes in The Treaty. This, in part, prompted the Secretary of the Interior to form the Task Force on Alaska Native Affairs, whose broad-based study concluded (among other things) that there was an urgent need for reexamination of the terms of The Treaty to determine whether relief for Natives could be obtained administratively or whether the Department of the Interior should seek to have The Treaty amended.

To obtain a better fix on the magnitude of the existing subsistence harvest of waterfowl, the USWFW initiated an investigation of waterfowl in the economy of Eskimos on the Yukon–Kuskokwim Delta in western Alaska. Klein (1966), in his assessment of the 1963 spring–through–fall harvest, estimated that approximately 83,000 geese and brant and 38,000 ducks were taken annually, most during spring, and 40,000 eggs being additional. While economists assessing subsistence harvests today might regard Klein's data as being "soft," because of survey design and extrapolations, it nonetheless provided first indication of the relative magnitude of the harvest and species involved. (I admonish the reader not to extrapolate these 1963 estimates to the Delta today or to the whole of either Alaska or Canada.)

After considerable internal review, the Department of the Interior acknowledged a need to accommodate and legitimize subsistence harvests in Alaska. Efforts towards that end are reflected to varying degrees in the bilateral migratory bird treaties between the U.S. and Japan (1971) and U.S.S.R. (1976). Congress, in the Fish and Wildlife Improvement Act of 1978, authorized the Secretary of the Interior to ". . . issue such regulations as may be necessary to assure that the taking of migratory birds and the collection of their eggs, by the indigenous inhabitants of the State of Alaska, shall be permitted for their own nutritional and other essential needs, as determined by the Secretary of the Interior, during seasons established so as to provide for the preservation and maintenance of stocks of birds."

Neither of the U.S. migratory bird treaties with Canada or Mexico would permit spring–summer subsistence harvests. And while the treaty with Japan would, its language differed from that in the treaty with the U.S.S.R., which was the basis for language in the Fish and Wildlife Improvement Act of 1978. The U.S. sought to amend the treaties with Canada, Mexico and Japan to bring about a degree of uniformity, but only Canada expressed interest. On 30 January 1979, the Minister for the Environment and the Secretary of the Interior signed a "protocol amendment" to The Treaty of 1916. This amendment would authorize by statute, regulation or decree the taking of migratory birds and their eggs by "indigenous inhabitants of the State of Alaska and the Indians and Inuit of Canada" during any period of the year in accordance with seasons established by each country, so as to provide for the preservation and maintenance of the birds. This protocol amendment ran headlong into opposition on both sides of the border, from wildlife administrators, hunters and politicians who perceived it as being akin to Pandora's box. Congress has not considered its ratification and will not until a negotiating report spells out in detail how that amendment would be implemented. This report is being prepared by both countries.

Is The Treaty protocol amendment really necessary to legitimize and regulate a spring–summer subsistence harvest? Apparently not from the standpoint of Alaska, according to a recent (26 January 1986) ruling by Judge James S. vander Heydt of the U.S. District Court for Alaska. The judge ruled in favor of Native intervenors on behalf of the defendants in a suit brought by the Alaska Fish and Wildlife Federation and Outdoor Council and the Alaska Fish and Wildlife Conservation Fund against the directors of USFWS and Alaska Department of Fish and Game. The suit was aimed at stopping the spring–summer subsistence harvest of waterfowl by people of the Yukon–Kuskokwim Delta. Judge von der Heydt concluded that the USFWS could, whenever it chooses, implement regulations for such seasons as authorized by the Fish and Wildlife Improvement Act of 1978. Furthermore, until such regulations are issued, Natives (and prospectors and travelers) are authorized under the somewhat obscure and long–forgotten Alaska Game Act of 1925 to harvest waterfowl during any season of the year when in absolute need of food and other food is not available, but only if those species of birds are not in danger of extinction. The argument given by the intervenors and accepted by the judge was that: (1) the Migratory Bird Treaty Act of 1918 was superseded by the Alaska Game Act of 1925 as it pertained to migratory bird regulations; and (2) the Alaska Game Act was not nullified by the Alaska Statehood Act of 1958. Messrs. Cook and Mitchell will undoubtedly cover the details and merits of this ruling and discuss the status of the current appeal.

Two years ago, at the 49th North American Wildlife and Natural Resources Conference, Raveling (1984) chronicled the dismaying downward trends in numbers of cackling Canada geese (*Branta canadensis minima*), the Pacific Flyway population of white-fronted geese (*Anser albifrons frontalis*), Pacific brant (*Branta bernicla nigricans*), and emperor geese (*Anser canagicus*) that nested either mainly or entirely on the Yukon–Kuskokwim Delta. He contrasted these four populations with other geese that also nest in Alaska but were faring better. A common denominator to the four declining populations was that they were subjected to both recreational and subsistence hunting. Recreational hunting was perhaps the least on emperor geese that winter mainly in the sparsely populated Aleutian Islands, and greatest on elements of brant and white–fronted goose populations that conceivably could be subjected to seven months of recreational hunting, beginning on 1 September in Alaska and ending in late April or early March in Mexico.

The Yukon–Kuskokwim Goose Management Plan of 1985 and its predecessor—the Hooper Bay Agreement of 1984—were cooperative efforts to eliminate both the recreational and subsistence harvests of cacklers and to reduce substantially the harvests of the other three geese. Lew Pamplin will explain those efforts. While it appears that the downward trends for most populations have been stopped, it is too early to say if these trends have been reversed. Jim King and Dirk Derksen will discuss the status of these and other populations of Alaska–breeding geese.

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Alaska Goose Populations: Past, Present and Future

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Many people think Alaska remains a pristine wilderness and that wildlife populations are still at prehistoric levels. This very likely is not true for the 11 species and subspecies of geese that nest in Alaska. Large, widely dispersed populations of geese were observed near the turn of the century. Even in the early 1970s, it was estimated that Alaskan habitats were used by 915,000 nesting and 100,000 additional migrating geese each year (King and Lensink 1971). Since then the Alaskan populations of most of these species have declined, some to dramatically low levels (Raveling 1984), even though habitats within the state have remained largely unaltered by man.

The U.S. has treaties with Canada, Mexico, Japan and the Soviet Union to protect geese and other shared migratory birds, confirming international concern for the welfare of this resource. Cooperative research on Alaskan geese during the past several decades has given understanding of their migration corridors, staging and wintering habitats, and the principal places where they are hunted, thereby providing information needed to develop effective management plans. The only attempt to reintroduce geese in Alaska has been in the Aleutian Islands. Other opportunities exist.

It is our intent here to: (1) review the historic and current status and important habitats of geese that occur in Alaska; (2) identify existing and potential threats to these populations; and (3) offer alternative management approaches for geese in Alaska.

Distribution of Alaska Goose Habitats

Six biogeographic regions (Kessel and Gibson 1978, Armstrong 1980) characterize distribution of geese in Alaska (Figure 1). The three southern regions have marine climates that permit geese and other water birds to over–winter. By contrast, the three northern areas are very cold from mid–October to mid–April, thus geese from those areas are forced to migrate. Eastern regions of Alaska are forested, while the western and northern regions are essentially treeless. All regions are mountainous, with geese using alluvial outwash plains, deltas, river valleys and, occasionally, hillsides below the 2,000–foot (610 m) contour. The highest densities of nesting geese occur in the western region. The three southern regions are part of the northern temperate zone, have the longest ice–free period and provide important staging areas where geese build fat reserves during spring and fall migrations. High tidal fluctuations on the north Pacific and southern Bering Sea coasts, often 20 feet (6.1 m) or more, result in one of the richest and most–extensive intertidal habitats of the world. The river system of the central region, which reach peak flows during snow melt,

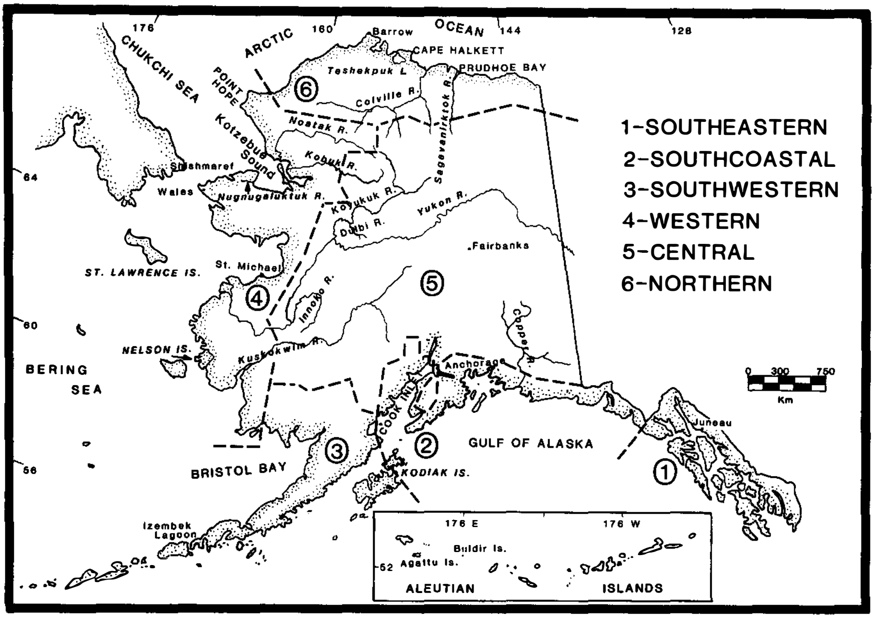

Figure 1. Biogeographic regions of Alaska (adapted from Kessel and Gibson 1978, Armstrong 1980).

have a shallow gradient, and portions of their floodplains drain slowly. This precludes growth of shrubs, but allows sedges and grasses that provide goose forage to develop in midsummer. The main stem of the Yukon River has thousands of eroding and accreting islands dominated by early successional plants favored by geese.

Status of Alaska Goose Populations

Ornithologists have described the status of Alaskan goose populations over the past century (Nelson 1887, Bailey, 1948, Gabrielson and Lincoln 1959, Palmer 1976, Bellrose 1980). These accounts, plus our knowledge of the requirements of geese, provide insight about the decline and potential for expansion of these populations. This paper does not address whether there are resources and habitat to support more wintering geese outside Alaska, but Raveling (1984) stated that available areas and food supplies used by greater white–fronted geese (*Anser albifrons frontalis*) and cackling Canada geese (*Branta canadensis minima*) are more than adequate to sustain much larger populations.

Greater White–fronted Goose

The greater white–fronted goose is circumpolar in distribution and nests in Alaska in the central, western and northern regions. Virtually all Yukon Delta whitefronts migrate to the Pacific Flyway (Bellrose 1980, Lensink personal communication), while less–dense populations from the forested interior and the coast north of the Yukon River winter in the Central Flyway. Nesting densities vary from scattered pairs to moderate concentrations of up to 10 pairs per square mile ($3.9/km^2$) (King and Dau 1981, Ely and Raveling 1984).

Dall and Bannister (1869) and Nelson (1887) reported nesting whitefronts at St. Michael and Dall (1870) found their eggs all along the Yukon River to Fort Yukon. Nelson (1887) also described the whitefront as "the most widely distributed and abundant goose throughout northern Alaska." Whitefronts no longer nest in the marshes near St. Michael. Studies for the Rampart Canyon Dam in the early 1960s disclosed no nesting whitefronts along the Yukon River, although they still nest from the edge of the Flats into the hills along Beaver Creek, Birch Creek, Black River and other tributaries (USDI 1964). Sidney Huntington (personal communication) of Galena informed us that whitefronts on the Dulbi River have increased in recent years, ever since hunting molting birds there has ceased. Reports from wintering areas indicate a steady decline in Yukon Delta nesting whitefronts (O'Neill 1979, Timm and Dau 1979, Raveling 1984).

Because of their wide distribution, white-fronted geese have survived over most of Alaska, but they are reduced in number in some areas from the levels early explorers found. Hunting, egging and molting drives may have eliminated them from the smaller deltas of western Alaska, such as at St. Michael, and reduced them greatly on the Yukon Delta. Shooting and egg gathering associated with heavy boat traffic in the early part of the century may have eliminated nesting whitefronts along the major navigable rivers particularly the Yukon (Dall 1870). Excessive kill in Alaska—see Klein (1966) and Copp and Roy (1986) for harvest data—and during fall and winter outside Alaska (Timm and Dau 1979) probably reduced Pacific Flyway whitefronts in recent years. If summer hunting is eliminated, as at the Dulbi River, and winter harvest is not too intense, whitefronts should re-occupy former nesting habitats throughout western Alaska and increase their numbers.

Tule Goose

The tule goose (*Anser albifrons gambelli*) is a large, dark whitefront that was first described by Hartlaub (1852). However, it was 1980 before the nesting habitat of tule geese was located at Redoubt Bay in Cook Inlet, Alaska. Banding confirmed that they winter in central California. Breeding ground estimates of 1,500 tule geese in Cook Inlet (Timm et al. 1982) do not correspond with counts of about 5,000 birds estimated on their wintering grounds in California (Wege 1984). Timm et al. (1982) suggested that habitats near Redoubt Bay could harbor the remainder of this population. Tule geese are not subject to hunting on the nesting grounds. They were probably more widespread and abundant when first described in California in 1917 (Bauer 1979). Hunting restrictions in California have enabled this population to expand in recent years (Bauer 1979, Wege 1984). There appears to be adequate habitat for a larger nesting population in Cook Inlet. Potential threats to nesting (Timm et al. 1982) and wintering (Gilmer et al. 1982) habitats should be monitored to avoid a reversal in this trend.

Lesser Snow Goose

Lesser snow geese (*Chen caerulescens caerulescens*) nest in the Artic, from eastern Siberia to eastern Canada, and winter primarily in central California and along the Gulf of Mexico. Wintering populations in the U.S. averaged 1,277,000 birds during 1955 to 1974 (Bellrose 1980). Snow geese stage on river deltas, floodplains and uplands in all regions, but are considered rare nesters in Alaska. There are isolated nesting records from the Yukon Delta (Gabrielson and Lincoln 1959), and there have been a few broods east of Point Barrow near Smith Bay and Cape Halkett (King 1970, Derksen et al. 1981). In recent years, a small colony of 50–100 breeding pairs has become established on Howe Island in the Sagavanirktok River delta near the Prudhoe Bay oilfield (Johnson 1983, Johnson et al. 1985). Hansen (1957) reported 1,300 nonbreeding birds near Cape Halkett in 1957, but intermittent counts since 1977 have disclosed less than 300 molting snow geese there. Gabrielson and Lincoln (1959) suggested that lesser snow geese nested more abundantly east of Barrow in the early 1900s and were possibly extirpated by reindeer and their herdsmen. It seems clear that coastal Alaska habitats could support additional nesting snow geese.

We are not aware of a successful man–induced snow goose colony, but it may be possible to establish colonies in Siberia and in Alaska on the Yukon–Kuskokwim Delta, the Seward Peninsula and the North Slope. Since the Yukon Delta is used by staging Wrangel Island snow geese in spring and fall, there is potential for resource competition between this population and a new colony. If successful, an expanding colony might short–stop Siberian birds in a pattern that seems to have occurred in several places in Canada (Bellrose 1980). Alternatively, birds produced on the Yukon–Kuskokwim Delta might follow the main migration to Wrangel Island in subsequent years, as may be the case with the few snow geese that presently nest there.

Emperor Goose

Emperor geese (*Chen canagica*) have a restricted distribution—they nest on the shores of the Bering and Chukchi seas, and winter from Kodiak through the Aleutian and Commander islands to the Kamchatka Peninsula. Nelson (1887) thought they nested most abundantly along the coast between the Yukon and Kuskokwim rivers. Other observers reported that their primary nesting areas were on the east side of Kuskokwim Bay, the south side of Kotzebue Sound and on St. Lawrence Island. Emperors were also found nesting at Port Clarence and St. Michael (Gabrielson and Lincoln 1959). Some emperors nest on the northern coast of Siberia where Dement'ev and Gladkov (1952) described their numbers as "low" and "extremely depleted," and suggested the need for a ban on shooting "which locally threatens to annihilate this form completely."

The Alaska fall population of emperors was estimated to be about 150,000 in 1971 (King and Lensink 1971). More–recent surveys indicate there has been a decline to about 100,000 birds in fall 1982 (Petersen and Gill 1982), and 58,800 in spring 1985 (Dau and King 1985). Bailey (1948) listed the emperor as a common nester from Wales east along the north side of the Seward Peninsula in 1921. Thayer (1951) found nine emperor nests on the Serpentine River near Shishmaref. King (1982) could only find 133 emperors on the entire Peninsula during an air search in June 1982. Fay (1961) reported 10,000–20,000 emperors molting along the southern coast of St. Lawrence Island, and up to 2,000 in the breeding population. Fay and Cade (1959) noted that molting birds were formerly captured in large numbers by hunters, but that this practice had been discontinued. King and Derksen (1986) conducted an extensive aerial survey of St. Lawrence Island in July 1984 and counted fewer than 4,000 molting emperors and only two broods.

There are vast stretches of seemingly good emperor goose nesting habitat that are unoccupied or used only by remnant populations. The legal harvest has averaged only a few thousand birds per year with 1,188 killed in 1984–85 (Campbell and Rothe 1986). In winter, they are dispersed across more than 1,500 miles (2,400 km) of remote island shores and reefs in Alaska and Siberia. Although emperors could be subjected to oil spills or other pollutants from foreign and domestic fishing fleets in western Alaska waters, there is no evidence that this has occurred. For more than 100 years, observers have reported heavy kill of emperors on the nesting grounds and during the molt (Dall 1870, Turner 1886, Nelson 1887, Nelson 1914, Gillham 1941, Jenness 1970). Fall harvests have been at low levels for some time, while spring and summer kills on the Yukon Delta have been greater. Although it appears that hunting has been a major factor contributing to the decline of these geese, the effects of other mortality factors are poorly understood.

Black Brant

Black brant (*Branta bernicla nigricans*) nest near the coast of the western and northern regions of Alaska (Figure 1) and Arctic Siberia and Canada. Spencer et al. (1951) described brant nesting on the Yukon Delta in a large colony extending 100 miles (160.9 km) from the northern side of Nelson Island to the Askinuk Mountains and a smaller colony on the southern side of Nelson Island. Much of the original nesting habitat is now unoccupied, and the remaining brant are largely confined to three remnant colonies. The Tutakoke River colony has recently experienced additional significant losses, from an estimated 14,000 pairs in 1981 (Byrd et al. 1982) to 1,100 pairs in 1985 (Sedinger et al. 1985). Banding has shown association between Alaskan, Canadian and Siberian brant (Uspenski 1965, King and Hodges 1979). Virtually the entire world population feeds on protein–rich eelgrass (*Zostera marina*) at Izembek Lagoon in fall, and stores reserves for transoceanic flight (Hanson and Nelson 1957) to wintering areas from British Columbia to western Mexico. In the past 10 years (1975–85) winter population counts in Mexico have fluctuated between 105,000 and 182,000 (Conant and Eldridge 1985).

We are unaware of any brant colonies along the shores of Norton Sound or Kotzebue Sound, except at a few islets near the Nugnugaluktuk River. Thayer (1951) found 24 brant nests at Shishmaref Lagoon, but brant seem to have ceased using this area for nesting in recent years. There is little habitat available at the Nugnugaluktuk and it is probably saturated with some 400 pairs (King and Conant 1983). The Serpentine River on Shishmaref Lagoon has more–extensive habitat and should be able to support a substantial nesting colony of brant. The principal difference between these two areas, besides size, is that the Serpentine is occupied throughout the spring and summer by hunters and fishermen, whereas the Nugnugaluktuk is far from any village and probably seldom visited by man. Other small western Alaska deltas north of the Yukon River appear suitable for brant colonies but are not now used. Small colonies and scattered pairs nest on the Arctic slope in Alaska, and up to 22 percent of the entire brant population molt near Teshekpuk Lake in July (King and Hodges 1979). Protection on the Cape Halkett/Teshekpuk Lake area from development is advisable because of the unique combination of large, isolated lakes that afford security to molting geese, and abundance of nutrient–rich foods (Derksen et al. 1979, Derksen et al. 1982).

Vancouver Canada Goose

The Vancouver (*Branta canadensis fulva*) is a large, dark goose that nests secretively within the coastal rain forest (Lebeda and Ratti 1983) of northern British Columbia and southeastern Alaska (Van Horn et al. 1979). It is unclear what limiting factors preclude this subspecies from inhabiting contiguous, similar habitat in southern British Columbia. Vancouvers winter on the tidal flats near nesting areas. There is a small population of Canadas that nest on the islands in Prince William Sound and winter in nearby estuaries that might be of this subspecies (Islieb and Kessel 1973). Although Vancouvers are hunted in fall, the kill appears to be low. The Vancouver may be the last Canada goose in North America that is limited primarily by natural causes, and whose summer and winter habitat is still mostly unaltered by man.

Since the Vancouver winters almost exclusively on vegetated tidal flats—a limited and specialized habitat—we are concerned about other uses of these areas. Log rafting and deposition of logging debris at the high tide line has covered extensive areas of goose–foraging habitat in some locations. The Mendenhall tideflats in Juneau, now a State Game Refuge, support a winter population of about 600 Vancouvers that are easily visible along the main highway to Juneau. Saving this urban flock may be a major conservation test, as habitat is threatened by highway crossings, gravel mines and airport expansion. The town of Hoonah also has a tidal flat airport that destroyed a Vancouver feeding area. Substantial numbers of Vancouvers make a molt migration to glacial or other open coastal areas in July, and protection of these sites is needed (Lebeda and Ratti 1983).

Most of the present Vancouver Canada goose range was ice–covered during the most–recent glaciation, and Ploeger (1968) suggested that these geese occupied habitats south of the ice. They continue to pioneer northwestward as retreating glaciers expose habitat along the Gulf of Alaska, as at Glacier Bay. Kodiak and Afognak islands have no nesting or wintering Canada geese, although the climate and habitat seem similar to southeastern Alaska. Thirteen Vancouvers were released on Kodiak in 1973 to determine whether this subspecies would become established, and recent observations of a few large Canadas at Uyak Bay indicate that there is potential for further successful translocations. It is not clear why Canada geese have not occupied Kodiak Island since the last glaciation, but perhaps additional introductions of Vancouvers from southeastern Alaska could accelerate use of these habitats. There has been some objection to establishing a new population of Vancouvers separated from the parent stock by a population of duskies at the Copper River and a splinter population of lessers at Cook Inlet. This is less of a problem to those who accept Palmer's (1976) classification that combines Vancouvers with duskies.

Dusky Canada Goose

Dusky Canada geese (*Branta canadensis occidentalis*) nest within a 125–square mile (324 km^2) area on the Copper River Delta, and winter in the Willamette Valley of Oregon. Once overharvested in Oregon, they responded to the creation of refuges that provided winter protection, and the population more than doubled to about 26,000 in 1975 (Timm et al. 1979). Recent counts indicate the dusky population declined from 23,000 in winter 1981 to about 13,000 in summer 1985. The Copper

River Delta was uplifted about 6 feet (1.9 m) during the 1964 earthquake, causing drainage of many waterways (Timm et al. 1979), which may have reduced protection of duskies from terrestrial predators. Studies are in progress to assess the impact of predation and examine the response of nesting pairs to artificial nest platforms and islands (Pollard 1984).

Duskies nesting at Egg Island off the mouth of the Copper River have 30–50 percent higher success than those using the mainland (B. Campbell personal communication). Other nearby islands appear suitable for nesting, and perhaps duskies will or could be induced to nest on these areas. Several unvegetated islands are subject to storm tides and unsuitable for nesting geese. It may be possible to create goose habitat in these areas by stabilizing sand dunes and introducing grasses and sedges.

Lesser Canada Goose

The lesser Canada goose (*Branta canadensis parvipes*) is widely scattered throughout forested valleys of the central region and to the coast only at the head of Cook Inlet. Pairs and small flocks occur in marshlands and along river courses in summer. Several hundreds molt on the islands in the mid–Yukon River and along the Innoko River. Dall and Bannister (1869) listed them as abundant breeders on Yukon River islands from the Delta to Fort Yukon. Biologists working on the Rampart Canyon Dam study found lessers nesting near large lakes but not on the Yukon River, and estimated a breeding population of 8,000 for the Yukon Flats (USDI 1964). In recent years, lessers have nested on Yukon River Flats islands where 19 broods were seen in 1985 (S. McLean personal communication). Some lessers have a molt migration to the Artic slope, where nonbreeders mix with Taverner's Canada geese (*Branta canadensis taverneri*) (King and Hodges 1979).

Timm (1978) estimated 2,000 lesser Canada geese in Upper Cook Inlet. This expanding population (Timm et al. 1979) apparently did not exist prior to 1964. A few pairs nest at the Potter Point State Game Refuge in the city of Anchorage, where a marsh was created by a railroad embankment. Ten lesser Canada goose families were observed at the Lake Hood seaplane base in 1985. Increasing agricultural development and deforestation for pastures and small grain fields have provided additional new foraging areas for lessers near Anchorage. Banding has shown that some of the lessers nesting near Anchorage winter in the Willamette Valley in Oregon where they flock with duskies (Timm 1978).

The presence of a goose flock in Anchorage suggests that lessers can adapt to a close association with man and enhance the urban environment. There are opportunities in the Anchorage area to improve habitat and increase goose production (Bader 1983). Ducks Unlimited completed an enhancement project in the Palmer Hay Flats State Game Refuge near Anchorage, where dikes, ponds and islands were developed on a tideflat.

In the interior, a State Game Refuge in the center of Fairbanks attracts migrant lesser Canada geese in spring, and it may be possible to establish a nesting flock there. Elsewhere throughout their nesting range, lesser Canadas are so widely distributed that habitat enhancement and other management opportunities are limited. If the kill is maintained at reasonable levels on their winter range, lesser Canada geese will probably continue to succeed.

Taverner's Canada Goose

The Taverner's Canada goose is similar in size, appearance and habits to the lesser, except that it occupies tundra nesting sites often far from the coast in the northern and western regions, from Bristol Bay to Canada. This subspecies is not recognized by Palmer (1976), who includes it with lesser Canada geese. The Taverner's geese nest on the Yukon Delta, where their range meets that of the cackling Canada goose. Taverner's Canada geese stage on the north side of the Alaska Peninsula in fall, and more than 73,000 have been tallied at Izembek Lagoon in October (Timm et al. 1979). Banding at Izembek and also near Cape Halkett on the North Slope has shown they are widely scattered in winter from Washington through central California (Johnson et al. 1979, King and Hodges 1979).

The Taverner's Canada goose population appears to be stable, although no precise techniques have been developed to identify this subspecies in surveys. Nests are widely dispersed throughout their range, making mass depredations unlikely. About 100 pairs nest within the Prudhoe Bay oilfield, where hunting is prohibited. They are seen occasionally during migration on the deltas of Kotzebue Sound (King 1982) and possibly once nested on the Kobuk, Noatak, Buckland and other deltas. The Taverner, like the lesser Canada and the whitefront, may be capable of reoccupying former nesting range if summer harvests are regulated carefully. As with the lesser Canada and the whitefront, Taverner numbers could be adjusted by manipulation of recreational hunting regulations in the Pacific Flyway.

Aleutian Canada Goose

The Aleutian Canada goose (*Branta canadensis leucopareia*), recently thought to be in danger of extinction, was once abundant throughout the Aleutian, Commander and Kuril islands, but was eliminated from most of its range when Arctic foxes (*Alopex lagopus*) were introduced to nesting islands (Springer et al. 1978). Fox farming failed prior to World War II and the stock was abandoned on the uninhabited islands where introduced. Fewer than 800 Aleutian geese were counted in the mid–1970s. Banding on Buldir Island (Figure 1) revealed harvest locations in California and Oregon, and hunting closures in these areas have enabled the population to increase to about 4,000 (Hofmann et al. 1986). Removal of foxes and an intensive program of releasing captive–reared birds with relocated wild birds from Buldir Island have resulted in the reestablishment of nesting geese on Agattu Island. There is evidence that the abandoned foxes have disappeared from some islands where foods have been exhausted or rabies outbreaks have occurred (E. Bailey personal communication). Small populations of Aleutian–like Canada geese were recently discovered in the Semidi Islands (Hatch and Hatch 1983) and in the eastern Aleutians on Chagulak Island (Bailey and Trapp 1984). Mitochondrial DNA sequence analysis of tissues from these geese confirmed their taxonomic status as *B. c. leucopareia* (Shields 1985). Continued efforts to eliminate foxes and protect geese from fall hunting offer hope that the Aleutian Canada goose population can be restored.

Although reintroduction of hand–raised Aleutian geese failed and progress toward recovery has been more costly and time–consuming than expected, several lessons have been learned. California responded with season closures on all migration and wintering areas where Aleutians mix with other geese. Traditional migration behavior was maintained despite the problem of "teaching" migration corridors to relocated

Agattu Island birds. Propagation, handling, holding and releasing techniques in a remote area have been enhanced. In short, Americans have demonstrated the will and commitment to restore a wild goose population.

Cackling Canada Goose

Early explorers described the cackler as the most–abundant nesting goose along the shores of western Alaska (Nelson 1887, Gabrielson and Lincoln 1959). Gabrielson and Lincoln (1959) cited nesting records from Point Hope to the head of Bristol Bay prior to 1930. Cacklers were most numerous from Kuskokwim Bay to the head of Kotzebue Sound. Oddly, there was a gap on the Seward Peninsula where this species was not regularly recorded. Nelson (1887) reported *B. c. minima* abundant at St. Michael, and cited others who found them nesting on the lower reaches of the Noatak and Kobuk rivers. In 1946, on a flight along the Bering Sea coast from Bethel to St. Michael, Gabrielson and Lincoln (1959) reported that cacklers outnumbered all other geese combined, including emperors, whitefronts and brant. Recently, cackling geese have been confined to a more–limited area between the Kuskokwim and Yukon rivers. Fall migrants stage in large flocks on about 30 square miles (77.7 km^2) near Ugashik Bay on the Alaska Peninsula to build reserves for flights to winter habitats. In 1985, an estimated 39,000 cacklers (R. E. Gill, Jr. personal communication) used this area for about three weeks in September/October (Bollinger and Sedinger 1985). Canada goose hunting was prohibited at this important staging area in 1985, and we recommend additional state–designated critical habitat for those areas not presently protected. Spring staging areas on the Copper River Delta and Cook Inlet estuaries provide new–growth grasses and sedges necessary to attain peak weights for reproduction (Raveling 1979). Fall and winter counts in Oregon and California show that cacklers have declined by 93 percent since the mid–1960s, from near 400,000 to less than 30,000 in 1983 (O'Neill 1979, Raveling 1984). Factors responsible for the decline are unclear, but excessive summer and winter hunting are most likely the primary causes. Restoration of the cackling goose to former abundance should be a high priority.

Goose Colonies

Geese are large, hardy birds and strong flyers that generally cope well with the dangers of their environment, but there are times in summer when they are vulnerable to predators. Incubating females, goslings and molting adults are relatively defenseless, so must use special strategies to aid survival. Solitary nesting species conceal their nests as defense against predators. All but the largest geese migrate to far northern latitudes for nesting and molting, where predators are relatively few in number and variety. Colonial nesting and communal brood rearing is advantageous to survival in areas where predators are present. Lesser snow geese and brant are considered colonial–nesting species. Arctic–nesting emperors, whitefronts and Canada geese can sometimes attain nesting densities almost as great as snow geese and brant at certain favorable sites.

There are a few places, mostly in the treeless Arctic, with abundant food and few predators, where geese nest in colonies with potential for very high production. The clipping and manuring of vegetation by grazing geese stimulates growth of food plants (Marriott 1973, Cargill and Jefferies 1984). Gulls and other predators that occur in these areas can be mobbed and put to flight (Barry 1967). Bears and canids may be attracted to goose colonies in summer and prey on peripheral nesting birds, but normally these predators are limited by winter conditions, and colony damage is sporadic (Uspenski 1965, Barry 1967). Predation by humans at goose colonies can cause significant losses or complete destruction, as has occurred on Arctic river deltas and Wrangel Island in Russia (Dement'ev and Gladkov 1952, Uspenski 1969, Portenko 1971, Owen 1980, Bousfield and Syroechkovskiy 1985).

The greatest goose–nesting concentration in the world may once have been on the 26,301–square mile (68,120 km^2) (King and Dau 1981) Yukon–Kuskokwim Delta (Spencer et al. 1951, Ogilvie 1978). We have documented the decline of four Delta–nesting species from nearly 1 million geese in the 1950s to less than half that in the 1980s (Raveling 1984). Even in the 1950s, only a portion of what appeared to be good habitat was occupied, and prehistoric populations may have been several times larger and more widespread.

The U.S. Fish and Wildlife Service (USFWS) has conducted systematic aerial waterfowl breeding pair surveys across the Yukon Delta as part of an international program since 1956. There are 65 segments, each 16 miles (25.7 km) long, including 5 that cross portions of the Delta goose–nesting concentration area, although only 1 segment is entirely within it (Figure 2). This survey was designed to enumerate ducks, which, unlike geese, normally remain on the water or shore as the plane flies over. Figure 3 shows geese counted on five transect segments in the dense nesting habitat described by Spencer et al. (1951), compared with counts from 20 segments outside the colony. The peak in 1964 reflects an influx of spring migrants that remained on the delta much longer than usual because of prolonged snow and ice cover in northern nesting areas. The trend within the concentration area has been a precipitous decline for all species (brant, white–fronted, emperor and cackling geese). Areas beyond the main concentration have supported small, stable populations of geese over the same time period (Figure 3). Nesting populations of geese have been reduced substantially. The collective impact of harvests throughout the Flyway resulted in a situation that allowed disturbance, predation and other factors to inhibit population growth.

Early explorers in western Alaska described an abundance of the same four species of geese north of the Yukon–Kuskokwim Delta along the coast of Norton and Kotzebue sounds where the geese are now scarce (Turner 1886, Nelson 1887, Bailey 1948, Gabrielson and Lincoln 1959). It seems likely that the smaller northern deltas also supported concentrations of nesting geese in precolumbian time. The Nugnugaluktuk River, remote from any villages, still supports a colony of several hundred pairs of brant and emperor geese (King and Conant 1983). Small nesting colonies of Pacific Flyway geese continue on the northern rim of the continent at the Colville, Sagavanirktok, Mackenzie, Anderson and other rivers (Bellrose 1980). No regular nesting–season hunting occurs in any of these colonies.

Management Alternatives for Yukon Delta Geese

Progress has been made with management of western Alaska geese (Pamplin 1986), but there has been relatively little discussion of long–term management alternatives and population objectives. What should we do for the next 10, 20, 50 or 100

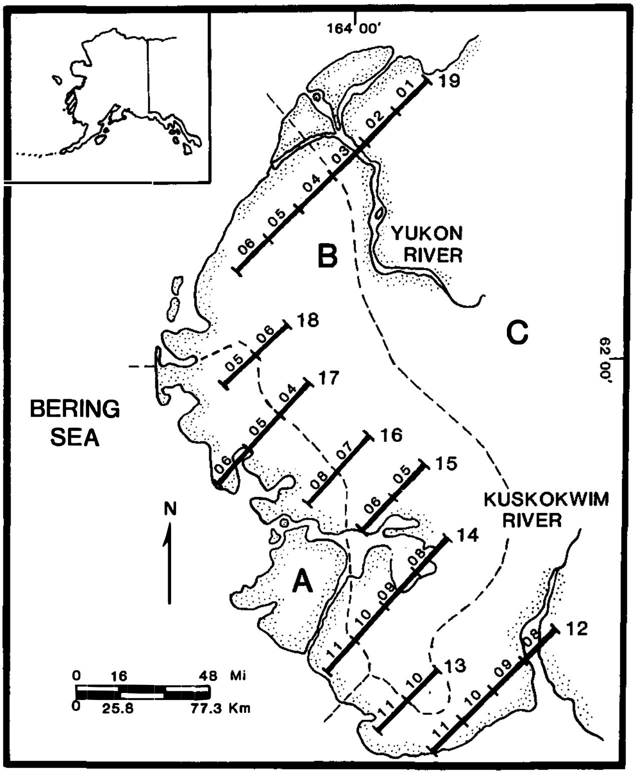

Figure 2. Yukon–Kuskokwim Delta waterfowl population survey transects. Numbered transects are subdivided into 16-mile (25.7 km) segments. A = the densest goose-nesting area surveyed from 1956–85; B = upland habitats surveyed from 1956–85; C = upland habitats surveyed from 1964–85.

years? We have identified several management options for geese that occur in the southern and central regions. However, it is the thousands of square miles of underutilized and unoccupied nesting habitat in western Alaska that represent the greatest challenge and opportunity. Should we apply management techniques that will allow these geese security to rebuild populations to some previous level of greater abundance?

As a first step in developing a management program for western Alaska, it is imperative to review the alternatives and establish goals. Alternatives include:

A. No management. This alternative would minimize the need for public funds. However, the cost would be a continued decline of geese, loss of a food resource, reduction of recreational opportunities and diminished revenues from recreational hunting activities.

B. Maintain present population. This option may not be possible on the Yukon Delta. Some nesting populations have been reduced by 50–90 percent and may continue to decline from natural causes unless intensive management is initiated.

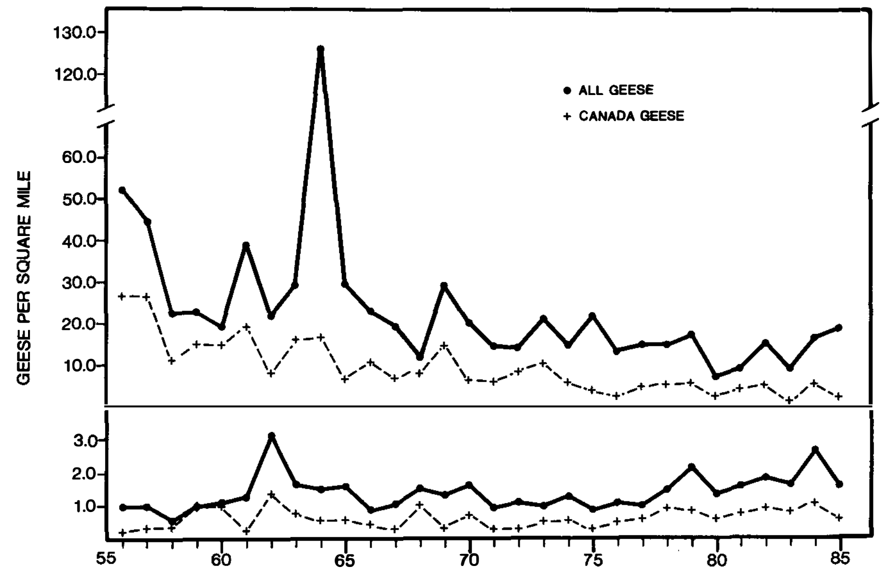

Figure 3. Population index of geese on the Yukon–Kuskokwim Delta from 1956 to 1985. Upper graph compares the status of all species (brant, white–fronted, cackling Canada and emperor geese) with Canada geese in the densest, coastal, goose–nesting habitats. Lower graph is a plot of annual counts of geese from upland habitats adjacent to the main colony.

C. Restore populations to 1950 levels. Restoring the Yukon Delta colony to about 1,000,000 birds could be accomplished by designating inviolate nesting sanctuaries in areas formerly occupied by geese. Reduction of fox, gull and jaeger predation within these areas could accelerate restoration.

D. Double the 1950 level. Building Yukon Delta geese to a population of 2,000,000 or more would require extensive control of hunting and disturbance on the Yukon Delta, additional reduction of fall and winter hunting, and perhaps some improvement or increase in winter feeding refuges.

E. Establish goose–nesting colonies. Using wild birds from the Yukon Delta or captive stock, whitefront, emperor, cackler and brant nesting populations could be established on vacant river deltas bordering Kotzebue and Norton sounds and on the arctic slope. This would require protection of nesting and wintering areas until populations became well–established. Using stock from Canada or Siberia, it might be possible to establish a major Alaskan snow goose colony.

F. Maximum goose–nesting populations. Establishing maximum goose populations on all available western and northern Alaska habitats would entail protection and restoration of nesting habitat as previously described, and probably selective protection and improvement of migration and wintering habitats. Eventually, a major increase in hunter recreation, subsistence harvest and in the hunter–support industry could be expected.

Conclusions

State and federal wildlife management agencies have the expertise and authority to increase populations of geese in Alaska. Restoration would require a commitment by the public to provide funds, and by people living near goose habitat, particularly nesting habitat, to cooperate in preventing disturbance or destruction of the breeding stock. It would not be necessary to end hunting to rebuild populations, but nesting security would be essential. If the Migratory Bird Treaty Act is amended to permit spring hunting by rural Alaskans, areas outside designated nesting sanctuaries could be managed for hunting. As goose populations increased, hunting opportunities for everyone would improve.

If the public supports restoration, are we collectively willing to accept initial sacrifices in anticipation of the benefits larger populations of geese can provide? We believe that depleted populations can be increased to any level desired.

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The Current Status of Goose Populations in Canada

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The Migratory Bird Convention (1916) has been successful in meeting its original objective. But from a Canadian perspective, it has had two obvious deficiencies. The first was that, while Native people could take alcids and scoters at any time of the year for food and clothing, that provision had little bearing on the situation in Canada, where traditional subsistence use of migratory birds was different from the situation in Alaska and where the closed season from March 10 to August 31 largely prevented people in many areas from legally taking waterfowl for essential subsistence. Since 1979, Canada and the U.S. have been attempting to modify the Convention of 1916 to regularize and legalize the long–standing Native practice of taking eggs and killing waterfowl during closed season in both Alaska and Canada. In both Canada and the U.S., the widely publicized but perhaps exceptional situation in Alaska's Yukon–Kuskokwim (Y–K) delta has been interpreted by some to be the norm of hunting by native people in all areas that might be proposed to be covered by the Protocol. My intent is to demonstrate the different situation existing in Canada when compared with Alaska, to comment on the current status of goose stocks breeding in Canada and to describe their present exploitation.

A geographic and demographic comparison shows that the area of Alaska is 500,000 square miles (1,295,000 km^2), while that of the two territories and the James Bay Agreement Area in Canada is 2,000,000 square miles (5,180,000 km^2). The total population of Alaska is 475,000, including 100,000 subsistence hunters; that of the Canadian territories and James Bay is 70,000 people, including 50,500 subsistence hunters. Canada's population within that vast region is located in 100 widely scattered settlements (Figure 1); Alaska has 600 settlements, including some fairly large cities. Within the Y–K delta alone, there are 58 villages with a population of 28,000 entitled peoples. This is equal to the number of entitled people covered by the Committee of Original Peoples Entitlement (COPE), Dené–Metis and Tungavic Federation of Nunavut (TFN) claims, i.e., the number of subsistence hunters within the 1.3 million square miles (3.37 million km^2) of the Northwest Territories. The higher density of the human population of Alaska and the population's proximity to breeding waterfowl have a far different impact on waterfowl resources than do the widely scattered Native residents of the territories and James Bay Agreement Area.

From a Canadian view, this difference is demonstrated in Table 1, documenting the number of potentially eligible participants and the distance they must travel to a concentration of breeding geese. I have restricted this presentation to various stocks of geese that breed in Canada. Compare this Canadian scene with the situation in the Y–K delta—where there are 58 villages ranging in size from 60 to 1,600 people, all living within 50 miles (80.5 km) of waterfowl concentrations, 28,000 individuals in proximity to 200,000 geese, plus ducks, a tradition of egg collecting and rounding up flightless geese, and the 50,500 native Canadians with breeding ground access to 2 million geese.

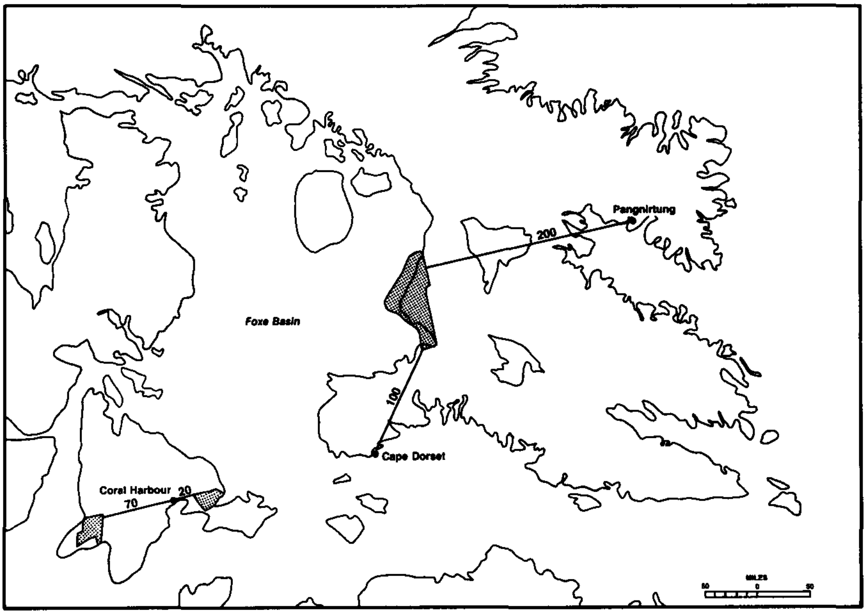

Figure 1. General geographical perspective of the proposed Protocol area (includes location of some areas identified in Table 1).

In most cases, concentrations of geese in Canada are not easily accessible. First, the geese arrive in Arctic situations in late May or early June, at spring breakup, when travel is extremely difficult. There is no evidence of any recent hunting visits to Boas River, Cape Henrietta Maria, La Perouse Bay, Bowman Bay, Egg River or Queen Maud Gulf (Figure 2). At Wolf Creek (West Hudson Bay) (Southampton Island), Anderson Delta, Jenny Lind Island and Kendall Island, limited spring shooting and egging does take place outside the sanctuary boundaries (Figure 3). The use of snowmobiles and Honda tricycles has increased, especially at Eskimo Point (West Hudson Bay) and Coral Harbour, (Southampton Island). But Canada's entitled people cannot afford the chartering of aircraft ($800 per hour) or helicopters ($1,200 per hour) to assist in "traditional" spring hunts.

In addition to hunting and egg collecting at breeding areas, there are several areas where entitled people take substantial numbers of geese on passage, in spring as well as fall.

In the case of Crees and Inuit living around the shores of Hudson Bay and James Bay in Ontario and Quebec, a considerable harvest of migrant and resident geese is known to occur—80,000 Canada geese, 60,000 snows geese and 8,000 brant). However, local populations of Canada geese (Eastern Prairie, Mississippi Valley, Tennessee Valley and Mid-Atlantic) breeding in interior string bogs and muskeg are generally inaccessible during the nesting season and are chiefly hunted in spring and fall when they come to the coast and are joined by snow geese and brant. The local fall flight of geese available to Crees and Inuit of Ontario and Quebec is in excess of 4.5 million.

Table 1. Relationship between nearest Native settlements and major breeding populations of colonial nesting geese in Canada.

Settlement	Entitled population	Distance in miles	Area	No. of breeding geese	Protected status[a]
Old Crow Yukon Territory	250	10–100	Old Crow Flats	5,000	R.S.
Aklavik	600	50	Kendall Island	5,000	MBS
Inuvik N.W.T.	1,100	150			
Sachs Harbour N.W.T.	250	10–100	Egg River	200,000	MBS
Paulatuk N.W.T.	150	150	Anderson River	50,000	MBS
Bathurst	100	300	Queen Maud Gulf	275,000	MBS
Cambridge Bay N.W.T.	500	300			
Cambridge Bay,	700	85	Jenny Lind Island	50,000	N.P.
Gjoa Haven N.W.T.	550	125			
Pond Inlet N.W.T.	500	50	Bylot Island	90,000	MBS
Coral Harbour N.W.T.	500	70	East Bay	45,000	MBS
Cape Dorset,	1,100	150	Bowman Bay	400,000	MBS
Pangnirtung N.W.T.	900	300			
Eskimo Point N.W.T.	900	5–50	West Hudson Bay	350,000	MBS
Churchill Manitoba	600	40	La Perouse Bay	25,000	None
Winisk,	160	100	Cape Henrietta Maria	100,000	P.S.
Attawapiskat Ontario	700	125			
Total	9,560				

[a]MBS = Federal Migratory Bird Sanctuary; P.S. = Provincial Sanctuary; R.S. = declared Ramsar Site (Wetland of International Importance).

One reason to implement the Protocol to the Migratory Bird Convention is to obtain a legal way of including subsistence users in the management and measurement of harvests. A number of studies carried out in conjunction with land--claim negotiations and settlements is available (Drolet et al. 1982, Boyd 1977) and, in other areas, estimates have been derived based on local knowledge.

Derived estimates of the fall flight and Native take of birds by goose population

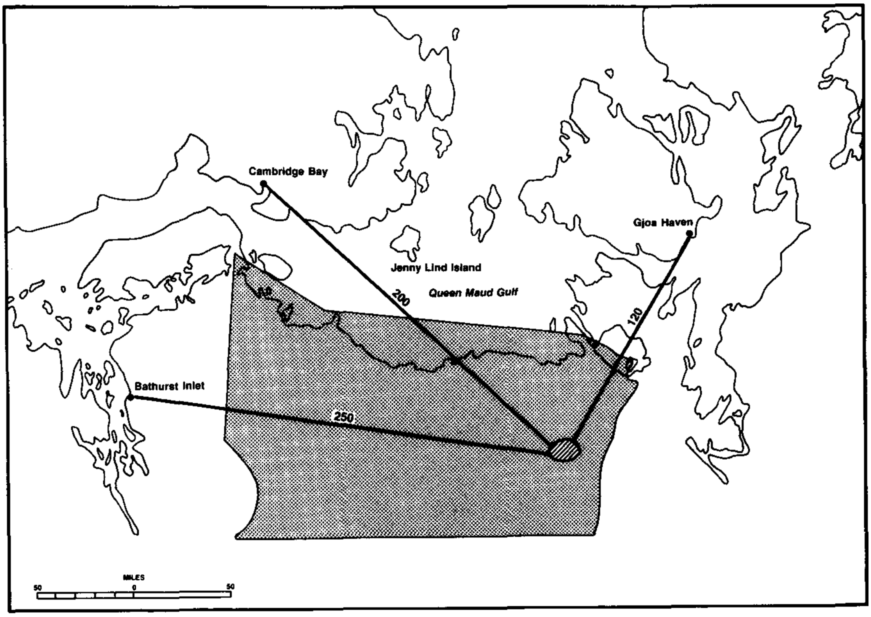

Figure 2. Proximity of major goose–breeding concentration (screened area) along Queen Maud Gulf, N.W.T., to nearest human settlements (detail from Figure 1).

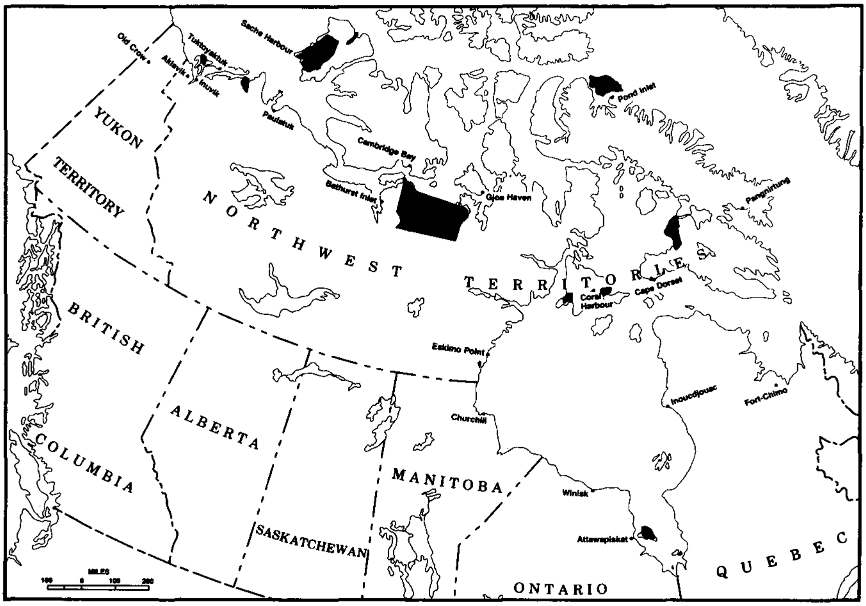

Figure 3. Proximity of major goose–breeding concentrations (screened areas) near Foxe Basin, N.W.T., to nearest human settlements (detail from Figure 1).

Table 2. Fall flights of geese from within the Protocol area.

Species	Population	Average fall flight	Kill by Natives	Population trend
Lesser snow goose	Baffin Island	600,000	40,000	Stable
	Southampton Island	400,000	20,000	Stable
	Cape Henrietta Maria	300,000	10,000	Stable
	La Perouse Bay	20,000	500	Increasing
	West Hudson Bay	550,000	10,000	Stable
	Queen Maud Gulf	200,000	1,000	Increasing
	Jenny Lind	100,000	1,000	Increasing
	Banks Island	350,000	3,000	Stable
	Kendall/Anderson	20,000	500	Stable
(Total)		(2,720,000)	(95,000)	
Great snow goose	Bylot	100,000	1,000	Stable
	Baffin	200,000	3,500	Increasing
	North	25,000	500	Decreasing
(Total)		(325,000)	(5,000)	
Atlantic brant	Southampton	40,000	500	Stable
	Foxe Basin	125,000	7,200	Increasing
	Elsewhere	30,000	300	Increasing
(Total)		(195,000)	(8,000)	
Pacific brant	Western Arctic	20,000	1,000	Stable
(Total)		(20,000)	(1,000)	
White–fronted goose	Eastern Midcontinent	100,000	200	Increasing
	Western Midcontinent	140,000	1,300	Increasing
(Total)		(240,000)	(1,500)	
Canada goose	Tallgrass Prairie	390,000	1,000	Increasing
	Shortgrass Prairie	225,000	1,000	Stable
	Mid-Altantic	1,250,000	60,000	Increasing
	North Atlantic	75,000	2,000	Increasing
	Mississippi Valley	450,000	30,000	Decreasing
	Tennessee Valley	180,000	5,000	Stable
	Eastern Prairie	280,000	1,000	Stable
(Total)		(2,850,000)	(100,000)	
Ross goose	Queen Maud	150,000	500	Increasing
	Elsewhere	25,000		Increasing
(Total)		(175,000)	(500)	

are given in Table 2. The relative kill by entitled people, and other Canadian and U.S. recreational hunters is given in Table 3. No attempt has been made here to present the recreational take by species or population, since goose populations tend to coalesce as they move southward.

The situation for the principal species of sport ducks is considerably different from that of geese in that they are largely absent from the 1 million square miles (2.6 million km^2) of tundra beyond the tree line and restricted to the Yukon, the Mackenzie River Valley and the Hudson Bay/James Bay Lowlands. Because ducks tend to disperse throughout the area, egging is not a serious problem. There is no real tradition of rounding up flightless birds, and mortality of ducks is largely due to shooting. In areas where geese are abundant, few ducks are shot, because few people

Table 3. Relative harvest of geese of Canadian origin by Native and recreational hunters.

Species	Average fall flight	Kill by hunter group: Native Canadians	Other Canadians	U.S. hunters	Total kill
Greater snow goose	325,000	5,500	50,000	40,000	95,000
(Percentage)		(5.7)	(52.4)	(41.9)	
Lesser snow goose[a]	2,720,000	95,000	120,000	423,000	638,000
(Percentage)		(14.9)	(18.8)	(66.3)	
Ross goose	175,000	500	5,000	15,000	20,500
(Percentage)		(2.4)	(24.4)	(73.2)	
Canada goose[b]	2,850,000	100,000	393,000	963,000	1,456,000
(Percentage)		(7.0)	(27.0)	(66.0)	
Atlantic brant	195,000	8,000	1,000	52,000	61,000
(Percentage)		(13.1)	(1.6)	(85.3)	
Pacific brant	40,000	1,000	500	100	1,600
(Percentage)		(62.5)	(31.3)	(6.2)	
White–fronted goose[c]	400,000	1,500	53,000	141,000	195,000
(Percentage)		(7.7)	(27.1)	(72.2)	

[a] Pacific Flyway kill prorated between geese of Siberian, Alaskan and Canadian origin.
[b] Fall flight does not include birds breeding outside protocol area.
[c] Whitefronts include at least 250,000 birds from interior Alaska.

would waste a shell on a one–pound (0.45–kg) duck if a six–pound (2.7–kg) goose was available.

Some species, notably the snow geese, are probably now at record population levels. Small colonies characteristically erupt and undergo almost exponential periods of growth, followed by a leveling off. Recent examples occurred at Cape Henrietta Maria, West Hudson Bay, Boas River, Queen Maud Gulf and, most recently, Jenny Lind Island. Why this happens is not clear. Colonies above 64 degrees north latitude, depending on spring snow cover, have production that can vary from 0–50 percent. Colonies south of that latitude, with longer windows of possible nest initiation and brood rearing have never had recorded production of young less than 30 percent. This is a mixed blessing, because sustained annual production has led to extensive habitat destruction, which eventually may destroy the ability of those areas to produce geese in any numbers. This situation appears to be unique to snow geese, which often nest in concentrations approaching 2,000 pairs per square mile (772/km^2). In years of nonbreeding, the birds farther north tend to disperse rather widely, and habitat is given an opportunity to rebound somewhat.

A second point of some concern with heavily exploited high Arctic nesting species such as lesser and greater snow geese, and small races of Canada geese, is the consistency of the kill. In years when production and replacement have dropped to zero, there has not been an attendant decrease in harvest. This is a consequence of both hunter expectation and the gregarious nature of snow geese throughout their range. A hunter in James Bay, Manitoba, or the Dakotas, California, or coastal Louisiana and Texas will not recognize the difference between a fall flight of 2.2 million and one of 1.8 million snow geese. The birds available to those hunters are concentrated, and hunters having access to the geese will generally be successful. Native people simply work a little harder to get essential subsistence. These biological factors make more difficult goose population management plans that establish spring or fall flight population goals.

In conclusion, no population of geese or breeding of geese in Canada is unduly stressed by kill of birds on the breeding grounds. Indeed, Boyd (1985) showed that the proportion but not the numbers of geese taken by Native people in Canada actually decreased between 1976 and 1983.

Acknowledgment

Hugh Boyd has provided invaluable comments and data to make this contribution possible.

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Cooperative Efforts to Halt Population Declines of Geese Nesting on Alaska's Yukon–Kuskokwim Delta

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During the past two decades, population declines have occurred in four goose species that nest on Alaska's Yukon–Kuskokwim (Y–K) Delta: cackling Canada geese (*Branta canadensis minima*); Pacific white-fronted geese (*Anser albifrons frontalis*); black brant (*Branta bernicla nigricans*); and emperor geese (*Chen canagica*). Annual surveys of cackling Canada geese and white–fronted geese, conducted in the late 1960s and throughout the 1970s, documented severe downward trends in these populations (Table 1). During this same period, brant populations fluctuated within an overall downward trend (Table 2). Significant declines in emperor geese (Table 3) were documented in the early 1980s (Petersen and Gill 1982).

Table 1. Cackling Canada and Pacific white-fronted goose population indices, 1965–85, as measured in fall and winter surveys in California.[a]

Year	Cackler population index	Whitefront population index
1965	384,000	303,200
1966	351,000	492,900
1967	322,400	495,500
1968	376,100	457,700
1969	143,000	310,600
1970	314,000	353,500
1971	289,000	383,600
1972	234,400	320,600
1973	244,800	196,200
1974	136,300	199,600
1975	217,900	165,300
1976	212,300	112,300
1977	62,000	117,700
1978	118,300	100,700
1979	64,100	114,900
1980	127,400	97,000
1981	98,700	116,500[b]
1982	54,100[c]	91,700
1983	26,200[d]	112,900
1984	25,800	100,200
1985	32,100	93,900

[a]Information from Pacific Flyway Council representative, 1985.
[b]Indices for 1981–85 include counts in Klamath Basin and Sacramento Valley.
[c]Indices for 1982–85 are derived from counts in Klamath Basin, Sacramento Valley and, in 1984–85, included Oregon.
[d]Klamath Basin only.

Table 2. Pacific black brant population indices, 1962–86, based on coordinated January surveys.[a]

Year	Pacific states	Total (including Mexico)	Three-year moving average
1962	51,591	170,236	158,114
1963	24,827	139,602	159,240
1964	44,522	187,220	165,686
1965	24,635	166,885	164,569
1966	26,257	159,871	171,325
1967	26,582	179,652	168,803
1968	18,340	154,340	164,621
1969	10,611	143,111	159,034
1970	10,086	141,681	146,377
1971	12,419	149,219	144,670
1972	5,375	124,775	138,558
1973	9,405	125,005	133,000
1974	7,351	130,651	126,810
1975	8,150	123,490	126,382
1976	9,989	122,045	125,395
1977	16,211	146,967	130,834
1978	19,770	162,887	143,966
1979	9,343	129,413	146,422
1980	8,815	146,365	146,222
1981	12,437	194,197	156,658
1982	7,642	121,044	153,869
1983	4,396	109,314	141,518
1984	8,727	133,430	121,262
1985	13,235	144,803	129,182
1986	13,845	128,570	135,601

[a]Information from Pacific Flyway Council representative, 1986.

Table 3. Emperor goose population estimates for 1964 and 1980–85[a]

Year	Spring index	Fall index
1964[b]	139,000	
1980		63,091
1981	91,267	63,156
1982	100,643	80,608
1983	79,155	82,610
1984	71,217	82,842
1985	58,833	59,792

[a]Information from U.S. Fish and Wildlife Service.
[b]No population estimates made 1965–79.

In 1983, a major cooperative program was initiated throughout the Pacific Flyway to address these serious biological problems. The Alaska Department of Fish and Game (ADFG), the California Department of Fish and Game (CDFG), the U.S. Fish and Wildlife Service (USFWS), the Pacific Flyway Council, the Association of Village Council Presidents (AVCP) and its Waterfowl Conservation Committee (WCC), the Waterfowl Habitat Owners' Alliance (California), the California Waterfowl Association, and other conservation groups worked together to develop management strategies applicable to recreational hunting throughout the Pacific Flyway and to subsistence hunting on Alaska's Y–K Delta. All parties recognized the need for support and commitment from Y–K Delta residents. Accordingly, the management approach was based on developing understanding among all parties, recognizing mutual concerns, applying intensive information and education (I&E) programs, and achieving compliance through the normal regulatory system and the established social control mechanisms in rural communities of the Y–K Delta.

In 1984, the initial management strategies were formulated into a plan referred to as the Hooper Bay Agreement (HBA), which addressed cacklers, whitefronts and brant. In 1985, the HBA was modified to include emperor geese and new provisions into the Yukon–Kuskokwim Delta Goose Management Plan (YKDGMP). Agency plans for 1986 are to re–endorse the YKDGMP with additional conservation provisions and to incorporate the concepts of this plan into comprehensive flyway management plans for all four goose species. The purposes of this paper are to: (1) provide a brief historical overview and current status of the four goose populations that nest on the Y–K Delta; (2) summarize the recent cooperative efforts to reverse the population declines, and describe the effectiveness of these actions; and (3) describe key elements that should be included in future management actions.

Goose Population Status

There are numerous populations and reports that document population declines in four species of Arctic–nesting geese (e.g., O'Neill 1979, Timm and Dau 1979, Petersen and Gill 1982, King and Conant 1983, Raveling 1984). Three of these species—cackling Canada geese, white–fronted geese, and a major portion of black brant—nest primarily in coastal areas of the Y–K Delta in Alaska and winter in southern portions of the Pacific Flyway. Emperor geese nest primarily on the Y–K Delta and winter in the Aleutian and Commander Islands and west to the Kamchatka Peninsula.

Data depicting population status of these geese have been developed with different methods and presented in various ways. The two most commonly used expressions are population indices and total population estimates. Annual counts were done in areas when and where the largest portion of a population normally gathers and are used in establishing a population index. Numerous factors, such as weather and survey timing, influence annual population indices. Population indices measure long–term trends and are usually not reliable for assessing year–to–year changes. Total population estimates were formulated by analyzing standard population indices and ancillary data, such as reproductive success and known mortality.

Cackling Canada Geese

The decline in cacklers, dropping from a population index of 384,000 birds in 1965 to 25,800 birds in 1984 (Table 1), has aroused the greatest alarm. During the winter of 1984–85, total population estimates ranged from 26,700 to 38,500. In October 1985, the USFWS made aerial photo counts near Pilot Point and Cinder River on the Alaska Peninsula and documented about 39,000 cacklers (R. E. Gill personal communication). Ground counts and aerial photography acquired in late

October in California found about 43,000 cacklers (D. G. Raveling personal communication), notably more birds than were recorded in similar intensive efforts during the 1984–85 winter. Estimates made from the ratio of collared to uncollared birds ranged from about 41,000 in December to 49,000 in March 1986.

Pacific White-fronted Geese

The annual population index of whitefronts dropped from 495,500 in 1967 to 93,900 in fall of 1985 (Table 1). Total population estimates are difficult to develop because of dispersion on wintering areas and nesting grounds, and lack of staging areas in Alaska, on which reliable counts can be made. The most recent population data come from concurrent counts on October 29, 1985, when 73,400 whitefronts were in the Klamath basin (J. Hainline personal communication) and an additional 52,500 were counted in four federal refuges in the Sacramento Valley (M. Heitmeyer, personal communication). Although approximately 4,000–5,000 of these birds may have been tule geese (*Anser albifrons gambelli*), the current population of Pacific whitefronts probably exceeds 120,000 birds.

Black Brant

Annual population estimates of brant are made from coordinated aerial surveys conducted in the Pacific coast states and Mexico in January. During the past 25 years, the brant population index has varied considerably between years (Table 2). The three-year moving average peaked at 171,325 in 1966 (1964–66) and has oscillated at lower levels to the current figure of 135,601 (1984–86).

Although there has been a modest decline in the brant population, ADFG's main concern is the dramatic decline in brant nesting on the Y–K Delta. Since 1981, the number of nesting pairs has fallen from about 68,000 to 16,000 (Garrett and Wege 1985). At Tutakoke, a major brant nesting colony at the mouth of the Tutakoke River, nesting pairs dropped from 14,000 in 1981 to 1,122 in 1985 (Sedinger et al. 1985).

Emperor Geese

Population data on emperors indicate a downward trend from the 1960s. The first spring survey, conducted in 1964, indicated a minimum population of 139,000 birds (Table 3). Petersen and Gill (1982) reported a spring population of 91,267 birds in 1981. The 1984 fall count was about 83,000, and the following spring and fall counts were about 59,000 emperors each. Although spring surveys for emperors are normally considered more reliable than fall estimtes, the 1985 results for both spring and fall are suspect, presumably because of unusual weather conditions that affected emperor distribution in southwestern Alaska. With a minimum estimate of 83,000 in the fall of 1984, it is improbable that nearly 24,000 birds were lost while dispersed widely over their primary wintering grounds in the Aleutian Islands.

Factors Affecting Population Declines

There are numerous factors (e.g., habitat, weather, predation, disease, harvest rates) that can contribute to waterfowl population declines. A combination of factors, if working simultaneously on a population, can accelerate declines and have long-lasting effects. The extent to which factors such as quantity and quality of wintering habitat, environmental contaminants or disease have contributed to the population declines in the four goose species of concern is not fully understood.

Goose nesting success on the Y–K Delta can be affected by spring phenology, spring and fall storms, predation, disturbance, and a variety of other natural conditions. During the past five years, the four goose species, especially brant and cacklers, have experienced low nesting success and productivity (Stehn 1986). Cacklers had only 42 percent nesting success in 1984 and 44 percent in 1985; brant had 14 percent success in 1984 and 37 percent success in 1985. In 1985, whitefronts had the lowest nesting success (60 percent) ever recorded on the Y–K Delta. Harsh weather and high nest predation by Arctic foxes (*Alopex lagopus*), gulls and other predators seem to be the major causes of low nesting success in all species. Stehn (1986) reported that Arctic fox predation was the most important cause of nest loss in 1984 and 1985. Brant and cacklers are the most prone to nesting failures because they nest near the coast, where flooding and habitat loss to storms are severe in some years, and neither species presents an effective nest defense against foxes.

Goose Harvests

Although the quality of goose harvest data varies, there is little doubt that hunting has been the most–significant source of mortality for Y–K Delta geese over the last 20 years. Continued harvest and nest predation have suppressed population recoveries in recent years.

Recreational harvest. Fall recreational hunting in the Pacific Flyway has comprised the bulk of the reported harvest of all four species. Because Canada goose harvests are not determined by subspecies, the total fall harvest of cacklers is unknown. However, between 4,000 and 6,000 cacklers were harvested annually in California public hunting areas from 1962–75, decreasing to an annual take of about 1,000 birds in 1982 (Table 4). Although past cackler harvests on California private lands are unknown, they likely equaled or exceeded harvests on public hunting areas. There were no open cackler seasons in Alaska, Washington, Oregon or California in 1984–85 and 1985–86.

Annual harvests of whitefronts in the Pacific Flyway ranged from about 36,000 to 76,000 from 1962 to 1978 (Table 5). About 92 percent of this harvest occurred in California. In recent years, due principally to reductions of seasons and bag limits in California, the reported Pacific Flyway recreational harvest has decreased from about 24,000 whitefronts in 1979 to 8,000 birds in 1984.

Since the early 1960s, the number of brant wintering north of Mexico has decreased substantially, thus influencing the size and distribution of harvests and increasing the difficulty in obtaining complete harvest information. Prior to 1980, the total recreational harvest of brant in Pacific coast states, British Columbia and Mexico averaged 7,000–10,000 birds annually (J. C. Bartonek personal communication). From 1980 to present, annual brant harvests have been reduced, by season and bag limit adjustments in Pacific coast states and Mexico, to an estimated 5,000 or fewer birds (J. C. Bartonek personal communication). Brant take in Mexico has increased slightly and now comprises a greater proportion of the total Flyway harvest (Kramer et al. 1979, Eldridge and Kramer 1985).

The reported fall harvest of emperor geese in Alaska has averaged about 2,100

Table 4. Cackling Canada goose harvests by sport hunters in Alaska and California, 1962–1984.

Hunting season	Alaska[a]	California[b]
1962–63		4,352
1963–64		5,599
1964–65		4,258
1965–66		5,411
1966–67		5,465
1967–68		4,105
1968–69		5,723
1969–70		5,482
1970–71		4,414
1971–72		
1972–73		6,336
1973–74	4,500	3,966
1974–75	1,500	4,084
1975–76	1,700	3,728
1976–77	1,200	2,290
1977–78	2,250	4,842
1978–79[c]	1,800	2,057
1979–80	2,400	1,593[d]
1980–81	1,800	1,226
1981–82	1,700	2,300
1982–83	750[e]	1,109
1983–84	630	940
1984–85	60[f]	0[g]

[a]Reported fall harvests of Canada geese at Pilot Point and Cinder River taken from state mail questionnaire surveys; major portions of these harvests were cackling Canada geese; no harvest estimates made 1962–72.
[b]Based on check station data; does not include harvests from private hunting areas in California.
[c]Restrictions placed on Canada goose harvest to protect the Aleutian Canada goose in 1978.
[d]Additional harvest restrictions implemented in California.
[e]Harvest restrictions instituted on fall staging areas in Alaska.
[f]Reported harvest of all goose species.
[g]No cacklers were recorded at check stations, but ADFG estimated that 600–1,000 cacklers were killed. This estimate is based on 244 known and reported kills and cripples, an estimate of 1,022 downed cacklers extrapolated from 14 collared birds reported shot when 1 in 73 were collared, and that monitoring efforts were not focused on private lands where most of the goose harvest normally occurs (only 12 percent of reported downed cacklers were from private lands).

birds from 1970 through 1980 (Table 6), and has been reduced about 40 percent since. The extent of emperor goose harvest along the eastern Siberian coastline is unknown.

Subsistence harvest. In addition to recreational harvests, all four goose species are taken by hunters from Y–K Delta communities. Systematic and long–term harvest surveys have not been made of the spring and summer take of waterfowl on the Y–K Delta. In 1964, the estimated spring take was 20,000 Canada geese (all subspecies), 13,500 whitefronts, 2,500 brant and 6,500 emperor geese (Klein 1966). Klein also estimated a total fall harvest of 34,500 geese. In 1980, the estimated spring harvest was about 6,100 cacklers, 7,300 other Canadas, 5,900 whitefronts, 3,600

Table 5. Pacific white-fronted goose harvests in the Pacific Flyway states, excluding Mexico, 1962–1984, based on USFWS and ADFG mail questionnaire surveys.

Hunting season	Alaska[a]	California	Other Pacific states[b]	Total
1962–63		50,088	1,567	51,655
1963–64		56,694	6,351	63,045
1964–65		51,735	5,832	57,567
1965–66		42,211	4,179	46,390
1966–67		65,321	6,603	71,999
1967–68		62,819	5,225	68,743
1968–69		47,345	4,273	52,474
1969–70		68,443	3,544	73,191
1970–71		70,639	4,434	76,340
1971–72		34,216	834	37,865
1972–73	240	51,813	1,796	54,325
1973–74	558	44,615	2,729	48,098
1974–75	397	40,682	572	41,592
1975–76	535	30,193	7,075	38,485
1976–77	516	44,044	678	46,010
1977–78		33,572	803	35,566
1978–79		344,719	2,132	38,021
1979–80		21,399	2,397	24,395
1980–81		18,693	1,888	20,874
1981–82		21,781	925	22,851
1982–83	621	14,734	1,236	16,453
1983–84	378	16,809	553	17,849
1984–85	745	6,606	974	8,325

[a]Reported fall harvests only, excluding harvest of midcontinent whitefronts.
[b]Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming, excluding harvest of midcontinent whitefronts.

Table 6. Reported fall harvests of emperor geese in Alaska, 1970–1984.

Hunting season	Harvest[a]	Hunting season (continued)	Harvest[a] (continued)
1970	1,400	1978	2,968
1971	715	1979	2,055
1972	1,840	1980	2,306
1973	2,373	1981	700
1974	2,067	1982	1,770
1975	2,891	1983	1,674
1976	2,592	1984	1,118
1977	2,198		

[a]Information based on ADFG mail questionnaire surveys (1970–76 and 1982–84) and USFWS harvest surveys (1977–81).

brant and 8,300 emperor geese (Copp and Smith 1981). In 1985, after implementing the first stratified sampling survey of waterfowl harvests on the Y–K Delta, Copp and Roy (1986) reported harvests of about 1,500 cacklers, 3,800 whitefronts, 2,200 brant and 4,000 emperors.

Efforts to Reverse Declining Goose Populations

Although downward trends in three goose populations were apparent prior to 1979, there were few substantive actions taken by managing agencies to reverse the declines (Raveling 1984). Season restrictions on Canada goose hunting in portions of California were first enacted in the mid–1970s, to protect the endangered Aleutian Canada goose (*Branta canadensis leucopareia*). Reductions in bag limits and season lengths were first made in 1979 in certain areas of California to reduce harvests of cacklers and whitefronts. Although the USFWS and Pacific Flyway states initiated a comprehensive management planning process for geese and other waterfowl in the late 1970s, final management plans for cacklers, whitefronts and emperors have not been completed and officially adopted by the Pacific Flyway Council.

In June 1983, the ADFG approached the USFWS and representatives of Y–K Delta communities about initiating concerted efforts and obtaining long–term commitments to reverse downward trends in the four goose species of concern. The ADFG suggested that management actions be taken to significantly lower hunter–induced mortality, while building support for more–comprehensive research on the four species and improving harvest information throughout the Pacific Flyway.

The idea of reducing harvest was not new, but the 1983 approach was to initiate a *cooperative flyway–wide program* consisting of a major information exchange, intensive educational efforts, establishment of specific population objectives, and substantial harvest reductions. The ADFG wanted to involve representatives from appropriate resource managing agencies, subsistence hunters from the Y–K Delta, recreational hunters from Pacific coast states (especially California), and other interested parties in a comprehensive management process. The concept was to open lines of communication, stop placing blame, develop trust and initiate positive actions having a high potential for success. In essence, the proposal was for *long–term cooperation, rather than confrontation*. This approach was based on several considerations: (1) the biological seriousness of the situation; (2) lack of consistent, positive and effective actions by managing agencies for more than two decades; (3) recognition of the high value of geese to all users throughout the Pacific Flyway; and (4) a belief that the only means to achieve lasting success in reversing the goose population declines was if all major interest groups understood the significance of the problem and were involved in and committed to resolving it.

Although the taking of waterfowl in spring and summer was believed contrary to federal and state law, the full application of conventional conservation law enforcement on the Y–K Delta was believed unlikely to yield a satisfactory result. First, the Y–K Delta area is about the size of Indiana, and its human population is widely dispersed in 46 relatively small, remote villages and seasonal fishing and hunting camps. The region has few roads and travel between communities is by small aircraft, boat or snowmachine. Therefore, intensive enforcement would be difficult from a logistical standpoint alone. Second, enforcement is most likely to be successful only if local residents acknowledge it as a legitimate use of authority and support or assist enforcement. Third, the cost of a large enforcement effort would be substantial and probably require major reallocations of funding by the USFWS, ADFG and Alaska Department of Public Safety. Unless additional funds could be obtained, other important wildlife–related duties would receive less support. Fourth, given the past history of sporadic and unsuccessful enforcement efforts, the collision between long–established community practices and an aggressive enforcement program could be expected to produce immediate adverse reactions with serious long–term social and political ramifications, and little improvement in the affected goose populations.

Hunter check stations and certain other harvest monitoring tools characteristic of more–developed areas were considered infeasible. Agencies decided that harvest data must be compiled primarily from voluntary reports, accompanied by monitoring and verification mechanisms, similar to the nationwide waterfowl harvest surveys conducted by the USFWS. The cooperation of local residents also was needed for other resource–related programs, ranging from refuge planning and wildlife studies by the USFWS to resident species management (e.g., muskoxen, moose, salmon) by the ADFG.

The ADFG believed that cooperation could be achieved because Y–K Delta residents have a long history of waterfowl use and have been among the most consistent and assertive defenders of coastal wildlife habitats in Alaska. For example, Y–K Delta residents pushed hard for environmental safeguards in outer continental shelf lease tracts for oil and gas exploration, and they also supported creation of the Yukon Delta National Wildlife Refuge.

Signals from elsewhere in the Flyway were also positive. Pacific Flyway states and their recreational hunters supported additional season and bag limit restrictions. The CDFG was particularly active in communicating with Alaskans on these issues and in developing a cooperative approach for solving problems in a fair and effective manner.

The Hooper Bay Agreement

In 1983, an interagency migratory waterfowl task force was formed by the USFWS, ADFG and representatives of Y–K Delta communities. The USFWS agreed to coordinate this effort. Numerous preliminary meetings followed between the ADFG, USFWS, AVCP and AVCP's environmental arm—Nunam Kitlutsisti (NK). They set the stage for a major meeting in Bethel, Alaska, in August 1983, including representatives from 30 villages, NK, the AVCP, USFWS, California waterfowl hunting groups (Waterfowl Habitat Owners' Alliance and California Waterfowl Association), CDFG, and the ADFG. The agencies summarized biological information on the four goose species and made a formal request for voluntary harvest reductions. At that meeting, the AVCP representatives agreed to participate in the interagency task force and formed their WCC, made up of community leaders from numerous Delta villages.

Representatives of the same groups and others met in November 1983 at Chevak, Alaska, and during January 1984 at Sacramento, California, to develop the provisions of a cooperative program to reduce the take of cacklers, whitefronts, and brant. Tentative consensus was reached at Sacramento and, later that month, the HBA was approved formally by representatives of the affected villages during a special AVCP convention at Hooper Bay, Alaska. In July 1984, the Pacific Flyway Council adopted a resolution that expressed support for the efforts and commitments in the 1984 plan.

On California's initiative, the HBA included an emergency closure of cackling Canada goose hunting in California for the end of the 1983–84 season and for complete closure in 1984–85. Comparably, there was to be no hunting of cacklers anywhere in Alaska in 1984. Recreational harvests of black brant were to be reduced by 50 percent in California and Alaska (recreational hunting seasons were closed in Washington and Oregon) and recreational harvests of white–fronted geese were to be reduced by 50 percent throughout the Flyway. Hunting of white–fronted geese and black brant was not to occur on the Y–K Delta during nesting, rearing or molting periods, and there was to be no egg gathering from nests of cacklers, whitefronts and brant.

The 1984 plan also included the following commitments: (1) involvement of the WCC in future discussions of goose biology and population data, regulations and management; (2) efforts by the USFWS and California organizations to reduce the take of black brant and white–fronted geese in Mexico; (3) joint monitoring, verification and enforcement of the program by the agencies, AVCP and respective tribal councils, with annual harvest reports to the agencies and the councils; (4) designation and acquisition of additional wintering habitat areas for the protection of the geese in the Pacific Flyway; (5) provision by the ADFG and the USFWS of funds (seasonal staff salaries and travel expenses) for local Y–K Delta organizations to fulfill the requirements of the HBA; (6) development of a joint letter to be signed by the USFWS, ADFG and AVCP concerning the causes of the population declines; and (7) avoidance by the USFWS of unnecessary disturbance of geese while conducting field studies and surveys during nesting, rearing and molting.

Information about the plan was disseminated over radio and television channels and by mail to all Delta villages. Representatives of the USFWS, ADFG, AVCP and NK traveled to many delta villages to inform residents about the HBA and the monitoring measures to be used. By early April, the USFWS was prepared to begin a limited harvest survey program.

Shortly after the plan was finalized, a legal challenge was brought by the Alaska Fish and Wildlife Federation and Outdoor Council, Inc. and the Alaska Fish and Wildlife Conservation Fund. Among other things, the lawsuit sought preliminary injunction barring implementation of the HBA. A U.S. District Court judge denied the plaintiffs' motion in May 1984 and the plan was implemented as scheduled.

The 1985 Yukon–Kuskokwim Delta Goose Management Plan

In 1985, the HBA was expanded into the YKDGMP. Provisions were included in the YKDGMP for increasing protection of emperor geese. Eggs of all four species were not to be gathered, the harvest of cacklers was still prohibited, and there was to be no hunting of whitefronts, brant and emperor geese during nesting, rearing and molting periods. Bag limits for emperor geese and brant in Alaska were to be reduced to two birds per day and Pacific Flyway harvests of brant and whitefronts were to remain at the reduced levels established in 1984.

Population objectives were established for all four species and minimum population levels were identified, with the stipulation that no hunting would occur if populations fall below the minimum levels. Threshold levels were established whereby hunting could possibly resume when populations recover to acceptable levels (Table 7).

The 1985 plan contained other provisions on a variety of topics, including: contin-

Table 7. Population objectives for four species of geese nesting on the Yukon–Kuskokwim Delta.[a]

Species	Population objectives[b]	Minimum population levels[c]	Population threshold levels[d]
Cackling Canada geese	250,000	80,000	110,000
White–fronted geese	300,000	95,000	120,000
Black brant	185,000	120,000	140,000
Emperor geese	150,000	60,000	80,000

[a]From the 1985 YKDGMP; all population levels are based on three-year moving averages.
[b]Represents desired population levels.
[c]No hunting allowed when populations fall below minimum levels.
[d]Hunting again possible when populations rise above threshold levels.

uation of efforts to reduce brant harvests in Mexico; preparation of comprehensive research and management plans; avoidance of unnecessary disturbance to the four goose species during certain periods; acquisition and protective designation of wintering habitats; and a commitment to pursue with Canada ratification of the protocol amending the Migratory Bird Treaty. The plan also called for an expanded I&E program to be applied flyway–wide, with emphasis on Y–K Delta villages located near important goose nesting areas.

A monitoring, verification and enforcement plan was developed to ensure compliance with the YKDGMP. Monitoring was to be conducted jointly by the USFWS, ADFG, AVCP, WCC and local village governments. Any suspected violations would be documented on incident report forms and submitted to the USFWS and AVCP. Reported incidents or observations of noncompliance were to be checked by participating parties; field responses, findings and actions were to be recorded and appended to the original incident reports. Periodic visits to villages wuld be made to evaluate the effectiveness of the I&E program, provide additional support for the YKDGMP and evaluate compliance with the plan. Harvest surveys would also be expanded.

Enforcement provisions were included to deal with serious violations. Citations were to be issued and geese or goose eggs confiscated if recurring noncompliance or blatant violations were found, charter or private aircraft were used to assist in hunting, or local village governments requested special enforcement action.

Results of Plan Implementation

The development and implementation of the HBA in 1983–84 and the YKDGMP in 1985 led to direct management actions being taken to reduce hunting mortality of the four goose species of concern. Furthermore, the plans resulted in increased goose research efforts, expanded I&E programs, heightened awareness for habitat protection, better communication between managing agencies and users, and greatly improved cooperation.

Recreational Harvest Reductions

Cackling Canada geese. California emergency action closed Canada goose hunting during the last two weeks of the 1983–84 season, and California, Oregon and Washington enacted statewide closures on cacklers for the 1984–85 season. Alaska closed the fall hunting season on Canada geese in areas where cacklers normally occur. For the 1985–86 seasons, the taking of cacklers remained prohibited in all Pacific Flyway states.

Harvest data indicated a take of 61 geese (all species) in 1984 on the central Alaska Peninsula—the traditional fall staging area for cacklers. This represented a 90–percent reduction from the 1983 estimated fall harvest of 630 Canada geese, which were mostly cacklers (Table 4).

In Washington, where cacklers occur briefly on migration, 10 were confiscated from hunters in 1984; 7 cacklers were reported taken in cited violations in Oregon where approximately 2,500 wintered in the Willamette Valley (J. C. Bartonek personal communication). Historically, few cacklers have been harvested in either of these states.

In the 1983–84 season, the reported cackler harvest on California public hunting grounds was 940 birds (Table 4). During the 1984–85 season, with a statewide closure on cacklers, the known take was 244 birds (USFWS unpublished data). Citations were issued to known violators. These documented kills represent birds found dead, observed killed or confiscated from hunters, primarily on public lands in the Central Valley. Among these mortalities were 14 collared birds (USFWS unpublished data) when the collared to uncollared ratio was about 1:73 (T. Aldridge personal communication). From 1979 through 1982, an average of 8 percent of the total Canada goose harvest was recorded on public lands; 52 percent of this harvest was cacklers (USFWS and CDFG unpublished data). Based on these data, ADFG estimated that 600–1,000 cacklers were killed in California during the 1984–85 season.

The primary reason for this harvest was probably mistaken identification of cacklers as other Canada geese that could be taken legally. Most of the killed cacklers were found after December 16, when the season in the Sacramento Valley opened for other Canada goose subspecies. To protect cacklers further, California's 1985–86 regulations closed an important cackler wintering area in the Sacramento Valley to the taking of all Canada geese, in addition to the zones closed to protect Aleutian Canadas.

White-fronted geese. The HBA called for an additional 50–percent reduction in the Pacific Flyway recreational harvest of whitefronts. Because California had accounted for over 90 percent of the reported whitefront harvest in previous years (Table 5), regulatory restrictions there included a substantial cut in season length and a one–bird daily bag limit. The 1984–85 reported whitefront harvest was 8,325—a reduction of about 53 percent in the Pacific Flyway harvest from 1983–84 (Table 5). The 1985–86 hunting regulations remained unchanged from 1984–85.

Black brant. Brant are currently harvested in Alaska, British Columbia, California and Mexico. Washington and Oregon have had closed seasons since 1983. Regulatory changes to affect a 50–percent reduction in brant harvests were less effective than restrictions placed on the other goose species. In Alaska, state harvest data indicate that a reduction of the daily brant bag limit from four to two in 1984 resulted in a reported fall harvest of 1,544 brant—down 20 percent from 1983. California's reported brant harvest was 487—a reduction of 13 percent. Based on a harvest survey in Mexico, the USFWS estimated that between 1,749 and 2,374 brant were taken in the 1984–85 season (Eldridge and Kramer 1985). The 1985–86 hunting regulations were unchanged from 1984.

Emperor geese. In 1984, Alaska reduced the daily bag limit for emperors from six to two. State harvest–survey data indicate that 1,188 emperors were killed—a 29 percent reduction from 1983 (Table 6). These restrictions remained in place for the 1985 season.

Reductions in Spring and Summer Harvests

Although the methods used to assess waterfowl harvests on the Y–K Delta have been inconsistent, harvest data and field observations indicate that there have been significant reductions in harvests of all four goose species. As specified in the YKDGMP, the USFWS conducted, via an independent contractor, an expanded waterfowl harvest survey in 1985. The survey was designed to sample 25 percent of the Y–K Delta human population in randomly selected villages within six ecological strata (Copp and Roy 1986). Sixteen villages and the larger community of Bethel were surveyed. Copp and Roy (1986) projected a total 1985 spring–through–fall harvest of 1,485 cacklers, 3,803 whitefronts, 2,168 brant and 4,031 emperors. Compared to the 1980 spring harvest estimates of Copp and Smith (1981), the 1985 spring and summer harvests were reduced 78 percent for cacklers, 42 percent for whitefronts, 43 percent for brant and 57 percent for emperors (Table 8). The total harvest of all four species in 1985 was 56 percent less than in 1980.

The 1985 survey also documented substantial reductions in egg take. Copp and Smith (1981) reported an estimated 15,241 goose eggs harvested on the Y–K Delta in 1980. In 1985, the total projected egg take for cacklers, whitefronts, brant and emperors combined was 151 (Copp and Roy 1986). The estimated egg take for all goose species that nest on the Y–K Delta was 335. Although some incidents of egg take were not detected in the harvest survey, the present level of goose egg harvest has been reduced substantially and is inconsequential compared to egg predation.

Information and Education

Both the HBA and the YKDGMP called for expanded I&E programs flyway-wide. In 1984, an I&E task force was established in Alaska, with representatives from the USFWS, ADFG, AVCP and NK. The group was responsible for developing I&E programs for the Y–K Delta to inform residents of the seriousness of the goose population declines and efforts underway to reverse them. The task force developed

Table 8. Spring goose harvest estimates for the Yukon–Kuskokwim Delta, 1964, 1980 and 1985.

Species	1964[a]	1980[b]	1985[c]
Cackling Canada geese	20,000[d]	6,050	1,339
White–fronted geese	13,500	5,876	3,410
Black brant	2,500	3,555	2,017
Emperor geese	6,500	8,316	3,592

[a]Spring harvest estimates from Klein (1966).
[b]Spring harvest estimates from Copp and Smith (1981).
[c]Spring through midsummer harvest estimates from Copp and Roy (1986).
[d]Reported as Canada geese; most were probably cacklers.

written materials and visual aids depicting population declines and compliance provisions, produced information for television, radio, newspapers and magazines, and arranged for meetings in villages and visits to schools. Initially, village meetings were held prior to the spring return of geese; additional visits were made when resources and time permitted.

In 1985, a new I&E objective was to encourage local communities to form their own educational programs by establishing "goose conservation committees." In April, an environmental education workshop, with emphasis on the four goose species, was held for Y–K Delta teachers. A poster contest for school children, grades 1–12, was sponsored by members of the I&E task force and the National Audubon Society.

The I&E programs have been highly successful in distributing information, increasing public awareness and understanding of the shared nature of the goose resources and cooperative plans, and obtaining support from local residents to comply with the conservation measures. Most Y–K Delta residents had the opportunity to learn of the YKDGMP and, prior to arrival of geese in the spring of 1985, 34 village councils had passed resolutions supporting the YKDGMP.

Information disseminated in other parts of Alaska and to other states has been related mostly to regulatory changes in Pacific coast states. In addition, a few articles and editorials have appeared in the news media and national magazines.

Monitoring, Verification and Enforcement

Both the HBA and YKDGMP emphasized voluntary compliance by hunters on the Y–K Delta. However, the parties to the plan upgraded the monitoring, verification and enforcement programs in 1985. The expanded program called for joint efforts by the USFWS, ADFG, AVCP, WCC and local governments to increase compliance, document incidents of noncompliance and conduct enforcement actions if necessary.

In 1985, a network of persons across the Y–K Delta monitored hunting activity and reported incidents of noncompliance. Nine refuge information technicians, covering two to six villages each, assisted in this effort, as well as serving an I&E role and participating in the village goose–harvest surveys. Biologists working at USFWS field research camps and local community leaders provided additional monitoring assistance.

A team, composed of representatives from the USFWS, ADFG, AVCP and the WCC, was established to visit villages in response to reported noncompliance incidents. There were 17 reported incidents, and each was investigated by the verification team. Eight of the incidents were reported by the hunters who committed them.

Cooperation and assistance from village governments was exceptional for the most part. During each investigation, community leaders worked with the joint team and, in many cases, issued to local residents notices that reiterated the importance of the YKDGMP.

There were three reported incidents of serious consequence: (1) the taking of brant and emperor geese during the nesting period near Kokechik Bay; (2) egging reported at a brant colony on Kikigak Island; and (3) the taking of seven cacklers near the village of Mekoryuk. In the Kokechik Bay and Kikigak Island incidents, the joint team was unable to obtain positive identification of the violators. The Mekoryuk incident was reported by a local resident and the team found three individuals responsible. These persons received citations by the USFWS after consultation with village leaders and the chairman of the WCC. The Mekoryuk village council provided unanimous endorsement of this action. These citations were the first issued by the USFWS for spring waterfowl hunting on the Y–K Delta in nearly 25 years (L. Hood personal communication).

Biological Research

Research studies on the four goose species have been proposed, expanded and supported because of the YKDGMP. A broad range of research needs were identified, including goose habitat requirements, productivity, predation, disease and contaminants, and improved methods for determining annual population estimates.

Efforts by state and federal management agencies and support from several national conservation organizations resulted in the USFWS receiving an additional $750,000 for Arctic goose research in fiscal year 1985. In spring 1985, the USFWS initiated and expanded projects on the Y–K Delta, including: effects of Arctic fox and avian predation on all four goose species; goose mortality during nesting and post–hatching through fledging; and identification and evaluation of important brood–rearing habitats. Aerial surveys of cacklers on the fall staging areas near Ugashik Bay were initiated by the USFWS to develop an improved population index. The USFWS joined the ADFG to expand monitoring and assessment work on spring migration staging areas in Upper Cook Inlet. The USFWS also continued a contract study with the University of California–Davis, directed at segregating cackler mortality between geographic areas and seasons of the year, and to provide another method for estimating cackler population size and distribution on the wintering grounds.

Habitat Protection and Restoration

Cooperative efforts and increased awareness at local, state and national levels have enhanced support for increased protection of goose habitats throughout the flyway. The State of California, in recognition of wetland losses and deterioratng goose winter habitat, passed a $40 million bond program in 1985, to acquire and enhance high quality wetlands, and is actively securing important waterfowl wintering areas. Recent litigation brought by California and the U.S. Army Corps of Engineers to stop wetland drainage on an important cackler winter staging area was joined by the National Audobon Society and National Wildlife Federation, clearing the way for CDFG to acquire the 10,000–acre (4,047 ha) Ash Creek Wildlife Area in Big Valley. Negotiations also are underway to acquire 5,600 acres (2,266 ha) in the San Joaquin Valley.

The ADFG, several national conservation and hunting organizations, and local organizations on the Y–K Delta recently cooperated to modify the U.S. Bureau of Land Management's plans to allow petroleum exploration and development in coastal wetlands near Teshekpuk Lake on Alaska's North Slope. Resolutions for protecting this important wildlife area—where up to 22 percent of the black brant population gathers to molt—were adopted by the Pacific Flyway Council, Western Association of Fish and Wildlife Agencies, and the International Association of Fish and Wildlife Agencies. In addition, the State of Alaska, several fishing and environmental groups, and some Native organizations brought suit against the Department of the Interior over oil and gas leasing plans for the Bristol Bay area in southwestern Alaska.

Improved Cooperation and Communication

The HBA and YKDGMP are products of active cooperation, improved communication and a commonly shared goal to rebuild declining goose populations. Sincere cooperation by all parties resulted in resolution of many misunderstandings and increased trust among the groups. Jointly shared tasks with agency representatives have helped to strengthen working relationships, provide positive feedback for all participants and improve public understanding of wildlife management concepts and practices.

Interagency coordination and communication in Alaska and among Pacific Flyway states have improved considerably as a result of the recent cooperative efforts. Several national conservation groups have joined in the cooperative management planning process and their efforts are making significant contributions to the objectives of the YKDGMP. Overall, the increased cooperation among interested parties may be the most important benefit of the YKDGMP process. From a policy perspective, this approach has been highly successful and provides a sound example by which other serious resource problems and conservation issues involving different groups can be addressed.

Current Actions

The parties to the YKDGMP are presently reviewing the results of the 1985 YKDGMP with the intent of further improving goose conservation efforts in 1986. Additional provisions being considered include: designating several key areas on the Y–K Delta as "special goose management areas"; establishing check stations near selected villages to obtain additional biological information; clarifying procedures for the monitoring, verification and enforcement programs; and revising the village goose–harvest survey design used in 1985. On some of the special goose management areas, human disturbance to nesting geese would be minimized, while on other areas, experimental fox–control projects would be continued and expanded. The latter projects will involve studies designed to understand better the ecological relationships and interactions of foxes and nesting geese.

A primary strategy during the formulation of the HBA and YKDGMP was to obtain comprehensive management plans for the four goose species, which would be used and supported flyway–wide. At that time, draft Pacific Flyway management plans had identified many research and management needs, along with management recommendations. The parties to the YKDGMP have agreed that comprehensive goose management plans should be publicly reviewed and finalized in 1986, with the plans to be adopted by the Pacific Flyway Council in 1987. Special attention will be given to continuing goose harvest reductions, improving nest success, increasing habitat protection and enhancement, minimizing adverse human impacts on nesting and wintering grounds, and expanding I&E efforts throughout the Pacific Flyway.

In January 1986, the U.S. District Court issued its final judgment in the lawsuit brought against the USFWS and ADFG. The court's decision granted the intervenors' (the Alaska Federation of Natives and others) motion for summary judgment on their cross-claim and ruled that plaintiffs' claims, therefore, were moot. The court found that although Congress had intended the Migratory Bird Treaty Act to apply to subsistence hunting in Alaska, an exception had been created in the Alaska Game

Act of 1925 (as amended) for Alaska Natives' hunting birds for food. However, the court explicitly left open the possibility that other authorities may be used to regulate the harvest. The court ruled, in part: "Until such time as the Secretary of the Interior adopts regulations pursuant to section 3(h)(2) of the Fish and Wildlife Improvement Act, the Congress has authorized Alaska Natives to harvest migratory waterfowl under the Alaska Game Act of 1925 (as amended) during any season of the year, including but not limited to the spring and summer months, when they or members of their family are in need of food and other sufficient food is not available" (*Alaska Fish and Wildlife Federation and Outdoor Council v. Jantzen,* No. 784–013Civ., Final Judgement at 2. D. Alaska January 24, 1986). Plaintiffs have filed a notice of appeal in the case.

As of March 1986, the USFWS and ADFG are considering how to proceed in light of the court's decision. Current plans are not to issue emergency regulations in 1986, but to use the normal federal and state regulatory processes to establish regulations for 1987. The YKDGMP will provide the basis for monitoring compliance with harvest restrictions in 1986. Both agencies also believe it is important to obtain U.S. ratification of the Protocol amending the Migratory Bird Treaty with Canada. This action is necessary to establish sound management of migratory birds and provide a consistent regulatory basis with Canada.

Recommendations

It is extremely important that the established cooperative programs be continued. By being involved in the planning and decision–making processes, all participants improve their understanding of the situation, develop mutual trust and contribute essential suggestions, thus helping to sustain strong commitments to rebuilding the affected goose populations.

Until goose populations are restored to acceptable levels, Pacific Flyway management agencies, especially the USFWS, should consider this effort as a top priority for their respective waterfowl programs. Adequate financial and personnel resources must be dedicated to management and research projects that will improve biological knowledge while maintaining cooperative efforts.

Goose research on the Y–K Delta should continue to focus on population dynamics and reproductive ecology of the four goose species. More attention should be given to evaluation of poor nesting success and the effects of predation, particularly by Arctic foxes. Fox–control programs in high density nesting areas should be seriously considered. Important fall staging areas for geese on the Y–K Delta should be identified.

Work should continue on the breeding pair survey for geese on the Y–K Delta. Fall counts of cackling Canada geese staging in the Ugashik Bay area should become an annual management activity conducted by the USFWS. Spring and fall emperor goose surveys along the Alaska Peninsula should be improved and additional work undertaken to identify major factors affecting the species' decline. Coordination and timing of fall surveys of white–fronted geese should be improved to provide more–reliable population indices. The USFWS should ensure the continuation of the cackler inventory and mortality study using neck–collared birds.

The USFWS should continue the stratified, village goose–harvest survey on the Y–K Delta, and Pacific coast states should work closely with the USFWS to improve harvest information on cacklers and brant. The USFWS should expand cooperative actions with Canada and Mexico to collect better information on annual brant harvests. More–reliable information is needed on cackler harvest on private lands in California.

Resource management agencies, conservation organizations and other concerned parties should broaden efforts to protect, maintain and enhance important goose habitats throughout the Pacific Flyway. In Alaska, consideration should be given to expanding the state–designated Critical Habitat Areas near Pilot Point and Cinder River used by cacklers for fall staging. Spring staging areas for cacklers and other species in the Redoubt Bay area of Upper Cook Inlet should be considered for special land–use designation that recognizes important wildlife values. Suitable locations in western Alaska where new goose nesting populations could be established should be identified. In the Pacific coast states, wintering grounds for these species should be protected from further wetland losses and environmental contamination.

Comprehensive goose management plans for all four species should be finalized in 1986 and adopted no later than 1987. Conservation measures in management strategies (e.g., population objectives) in the YKDGMP should be incorporated in comprehensive Flyway plans. These plans should address goose conservation issues throughout the Pacific Flyway and establish responsibilities, priorities and schedules for implementation of tasks by appropriate agencies and organizations. The plans should receive full endorsement of the Pacific Flyway Council.

The I&E programs, as expanded in 1985 on the Y–K Delta, should be continued by the parties to the YKDGMP. Information and educations programs applicable to Pacific coast states should be expanded to provide current information on the status of the four goose species and maintain public awareness of and support for conservation measures being taken throughout the Pacific Flyway to rebuild these populations.

Summary

A major cooperative effort was initiated in 1983 to address the long–standing declines of four goose populations that nest on Alaska's Y–K Delta. The most difficult aspect was the first step, which required from all participants a commitment to cooperation, mutual understanding and trust. Through this process emerged a common goal—to re–establish healthy goose populations. By maintaining open communication, reaching consensus on virtually all aspects of the cooperative plans and implementing conservation measures jointly, all participants shared responsibility for the plans' success.

Despite the complexities of implementing the plans, preliminary results indicate that populations of cacklers and whitefronts appear to have stabilized or increased slightly. Given poor goose production on the Y–K Delta in recent years, flyway–wide harvest reductions have been the key to halting the critical declines in these two species and setting the stage for recovery when natural production improves.

Although the future legal framework for managing migratory birds is unclear, the HBA and the YKDGMP have laid a sound foundation from which restoration of declining goose populations can occur. Preliminary results are encouraging, but it will take years of cooperation, patience and dedication to assure the future of the affected goose populations. By maintaining habitats, increasing biological knowledge, improving the reliability of harvest data and continuing to restrict harvest, there can be a brighter future. From ADFG's perspective, the policies embodied in this management strategy reflect a commitment to sound conservation principles and will result in increased populations of Y–K Delta geese.

Acknowledgements

Although I have summarized the important events and results associated with the development and implementation of the HBA and the YKDGMP, the significance of the cooperative attitude, dedication and hard work of many individuals and organizations throughout the Pacific Flyway cannot be overemphasized. Without the willingness of all parties involved to negotiate honestly and compromise, the outlook for the four affected goose species would be much different than it is today. I express my deep appreciation to all those individuals, from Chevak, Alaska to Sacramento, California, who have assisted in this unprecedented cooperative effort.

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The Role of Native People in Waterfowl Management in Canada

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That the waterfowl resource in Canada is of particular importance and concern to native people should come as no surprise. The Northwest Territories alone produces 50 percent of the continental goose and swan populations, 23 percent of the continental diving ducks, and 56 percent of the sea ducks (calculated from Bellrose 1980). Northern Quebec, northern Ontario, northern Manitoba and the Yukon also contribute significant numbers. Over the past millennia, native people have learned to take advantage of this food resource and, in many cases, to depend on it. Although native cultures are evolving and adjusting to modern times, reliance on waterfowl for food continues in most of northern Canada.

Examples of use of waterfowl by Natives abound. The well–documented situation in James Bay will be familiar to many—20–30 percent of the food harvested from the land by Cree Indians is comprised of waterfowl and their eggs (James Bay and Northern Quebec Native Harvesting Research Committee 1982). The new honesty of government and users alike in acknowledging legitimate use of waterfowl by Natives in spring and summer is beginning to help clarify present levels of use in other regions. Snow geese (*Chen caerulescens*) and Canada geese (*Branta canadensis*) and their eggs are taken annually by Inuit along the shores of Hudson Bay and Baffin Island, particularly in June (Donaldson 1983, 1984, Gamble 1984, McEachern 1978). Eiders (*Somateria* spp.) are also important in the harvest of eastern Northwest Territories, where they are taken throughout the spring and summer (Baffin Island) and in late fall/early winter (Belcher Islands). People in the Kitikmeot or Central Arctic Region primarily take ducks and geese in June (Northwest Territories Department of Renewable Resources and Kitikmeot Hunters' and Trappers' Association 1985). Ducks (mainly eiders and scoters [*Melanitta* spp.]), geese and tundra swans (*Cygnus columbianus*) are harvested each spring and autumn by Inuit and Dene in the Mackenzie Delta region (Barry in prep.) of the Northwest Territories.

Overlap in species between harvest by recreational or sport hunters and subsistence hunters is greatest for geese and relatively low for ducks. This is related to the availability of waterfowl, with species such as eiders, scoters and oldsquaws (*Clangula hyemalis*) generally more available to native subsistence hunters than are traditional "game ducks." In addition, the nongame species are typically larger than many of the game ducks, providing more meat per shot or unit of effort (cf. Macauley and Boag 1979). Similarly, use of the larger–bodied geese—a group of waterfowl widely available to native hunters in Canada—makes good sense.

Given this dependence on the waterfowl resource, it is important that Native people in Canada participate in research and management of the resource. Waterfowl are an important source of food, often in areas where alternative foods cost $5.00 to $8.00 per pound ($2.27–$3.63/kg) to replace (Gamble 1984). Thus, they are valuable in economic terms. Second, Native users account for essentially all of the consumptive use sustained by sea ducks and, therefore, they have the most to lose by not conserving the resource.

The take of geese and their eggs by Native people, particularly in spring, constitutes a substantial addition to the annual harvest of geese on the North American continent. It is critical, as has become apparent from the Yukon–Kuskokwim Delta situation in Alaska (Raveling 1983), that the harvest by Natives be accurately measured and accounted for when establishing annual continental harvest guidelines among our three nations. To accomplish this, Native cooperation and participation are essential.

Native participation can contribute substantially to both waterfowl research and management. To date, almost all waterfowl research on the impact of harvest on wild populations has been directed towards defining the impact of fall harvests. Such characteristics as compensatory and additive mortality, threshold levels, and survival rates have been studied and debated for decades, and justifiably so (see Anderson [1975] and Anderson and Burnham [1976] for reviews). However, along with the recent recognition of the need to measure spring and summer mortality and survival characteristics (e.g., causes of nesting failure, effects of predation, disease and other factors on post–"season" survival—see Johnson and Sargeant [1977] and Cowardin et al. [1985]), must come recognition of the need for objectively studying the impacts of spring and summer harvest of waterfowl on populations and production. Research on this question must be assigned high priority, as Native populations, their access to resources and technical capabilities to harvest the resource continue to increase dramatically.

The most–effective means of participation in research is through consultation during research design, direct involvement in field research and cooperation in providing researchers with reliable information pertinent to the studies conducted. Native people can provide valuable advice on research design by recommending where and when studies should take place, based on local knowledge of reproductive chronology, travel logistics, nesting densities and costs of operation. Potential conflicts with resource harvesting or other traditional uses of areas that are readily accessible to communities can be avoided through consultation. Employment of Natives as guides, agents of resupply, field assistants and biologists (when trained as professionals) to assist with or conduct research will serve to involve people directly in the research programs that can ultimately affect them. We are certain that scientists of the Canadian Wildlife Service and numerous biologists with territorial and provincial agencies can provide evidence of the considerable benefits already derived through projects in which Natives have been specifically employed.

To be effective, research on the impact of spring harvests will require accurate accounts of where, when, how and how much harvest occurs and of which species. Methods of take, sex and age composition of the kill, and egg–collection practices—whether some, most or all eggs are taken from nests—will all be important data necessary from Natives for reliable interpretation of research results. Monitoring of productivity and nesting populations on established study areas can become routine, providing employment opportunities for trained Native people residing near waterfowl production areas. Input into any management recommendations flowing from research is desireable. Thus, it is immediately obvious that Natives' role in research is a highly responsible one. A proper environment for such cooperation to occur will be necessary beforehand, and this is the responsibility of government and Native leaders alike. The North American Waterfowl Management Plan clearly recognizes the importance of this.

Native involvement in day–to–day management activities is valuable. Initially, simply promoting and contributing to harvest studies will be important. Cooperation in the form of accurate kill reports, reports of band recoveries, and learning and understanding waterfowl conservation practices are needed.

Development of regulations that provide mechanisms to control spring and summer harvests will occur in the near future. To be meaningful and effective, drafting of regulations must involve full participation by those Native people who will be affected. Typically, subsistence harvests occur in areas where traditional law enforcement is difficult at best. For this reason and others, regulations must be sensitive to cultural characteristics of hunters, in order to satisfy management needs of the resource as well as receive the voluntary support of Native people.

Regulatory needs go beyond voluntary support, however. It will be the responsibility of Native elders and resource management professionals not only to promote conservation practices, but also to ensure some form of community–based control for cases where regulations are ignored. This will not only be important locally, but will also be a message to other users of the resource that Native participation in waterfowl management is responsible.

Recognition by Natives of the international nature of the waterfowl resource is essential, as is some level of understanding of the management attention awarded these species in other provinces and states. In the recent past, Native people have been provided with tours of wintering waterfowl refuges where ducks and geese concentrate. Such tours continue to pay dividends in remote communities, where participants are still discussing with residents their observations and experiences gleaned while on the tours.

Similarly, Natives must interact with management agencies and the full spectrum of waterfowl users to promote recognition and understanding of their use of waterfowl. Management will be most effective once all uses of waterfowl have been acknowledged.

Only one year ago, the Inuvialuit of the western Canadian Arctic and the Government of Canada came to a final agreement on land claims in the region. In this settlement, the Inuvialuit received exclusive right to harvest all migratory gamebirds on Inuvialuit lands and preferential rights to harvest these species throughout the region. Other land–claim agreements presently being negotiated with the Government of Canada are those of the Dene/Metis and eastern Arctic Inuit. Conservation of wildlife resources is and will be the key aim of any wildlife agreements formalized in Canada, but such agreements also call on responsible participation of Native peoples in ensuring that conservation is maintained.

During this year, we anticipate the signing of the North American Waterfowl Management Plan. In that document, the two countries will proclaim that the "managed subsistence . . . harvest of the renewable waterfowl resource" is "desireable and consistent with its conservation." This brief statement is significant in that it opens the field of waterfowl management to Native participation and paves the way toward a mechanism to legitimize and regulate spring harvest of waterfowl by Native people. When that has been accomplished, hopefully in the near future, Native participation will begin to realize its full potential.

These are controversial issues—issues that require sensitivity and understanding from all parties involved. To achieve understanding, communication must be improved. The role of Native people in improving communication and ensuring that their perspective on the waterfowl resource is understood will possibly be the most-challenging role of all. As a northern politician and a wildlife biologist with roots in the natural heritage of northern Canada, we look forward to a future in which there are new partnerships in the management of our waterfowl resource.

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Land Claim Settlements and the Management of Migratory Birds, A Case History: The James Bay and Northern Quebec Agreement

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Introduction

In 1975, the Government of Quebec decided to proceed with the construction of a hydro-electric development project on the Rivière La Grande, a river flowing into James Bay in northwestern Quebec. This decision was to have important ecological impacts in the area, diverting and drying up major rivers and flooding hundreds of square kilometers of forested land. It also was to cause significant socio-economic impacts.

Cree Indians, who have lived on that land on a continuing basis for generations, were directly affected by the project and fought a legal battle to have their rights recognized. This conflict ended in 1976 in a negotiated settlement—the James Bay and Northern Quebec Agreement (JBNQA)—to which the Governments of Canada and Quebec, the Provincial Crown corporations, (Hydro–Quebec, Société d'Énergie de la baie James, Société de Développement de la baie James) the Cree Indians, and the other Native groups living in Northern Quebec, the Inuit and the Naskapi, were all parties. The total affected Native population was about 14,000 individuals, living in 22 northern communities. The Agreement considers a territory of 410,000 square miles (1,061,900 km^2).

What are the main terms of that land–claim settlement? How does it affect the management of wildlife and particularly migratory birds in the area? What new obligations and new opportunities has it created? How did it impact on the resource and its use? Seeking some answers to these questions will help us grasp the significance of Native land–claim settlements in general and the new situations they create for the management of the wildlife resources of the North, particularly migratory birds.

The JBNQA: Objective and Content

The JBNQA set forward, identified and protected in a legal framework an array of rights and privileges granted in exchange for the extinguishment of the undefined rights that the Native people claimed to have on the territory. It offered the opportunity for the governments to integrate the native communities fully into the administrative, legal, medical and social–benefit system prevailing in southern Quebec.

The JBNQA applies to a vast territory—approximately two–thirds of northern Quebec—renowned for its large populations of caribou and fish, but also very important as a production and staging area for numerous species of waterfowl. More than 400,000 pairs of Canada geese nest throughout the territory, 60,000 pairs each of black ducks, mergansers, scoters and eiders have also been surveyed. About 300,000 lesser snow geese migrate along the coasts of Hudson Bay and James Bay.

And there is increasing evidence of a very important utilization of the interior as a migration stop for the greater snow goose, whose population numbers more than 300,000 in the fall.

The Hunting, Fishing and Trapping Regime of the JBNQA—the aspect of the JBNQA that will be the focus of our discussion—puts emphasis on priority of Native harvesting of the wildlife resource by the beneficiaries. It grants and defines the right to exploit all species, everywhere in the territory and at all times of the year, subject to the principle of conservation and to the Migratory Birds Convention (MBC) and the acts and regulations putting it into force in Canada. The incompatibility of these two sets of legal entities, the JBNQA and MBC Act and regulations relative to the forementioned rights, remains unsolved. Canada recognized in the JBNQA its obligation to endeavor to solve that problem. We will see later how this situation has evolved.

The priority of Native harvesting is particularly illustrated by the concept of guaranteed level of harvesting. This guarantee protects hunting levels, equal to those prevailing at the signing of the JBNQA, in case of a conflicting use of the resource by non-Native users operating within the James Bay territory. The guarantee acts as a minimum threshold, based on the biological capacity of wildlife populations to support the guaranteed harvest levels. If wildlife populations were unable to sustain a harvest larger than the guaranteed level, all harvest inside the territory would be allocated to the beneficiaries. The opposite situation makes possible a recreational harvest, with the surplus being then divided between subsistence and recreational hunters, taking into consideration the need of Native subsistence. In the case of migratory birds, the guarantee consists of a fixed percentage allocation of the kill of each migratory bird population of the flyway. This guarantee in itself shall not operate to prohibit or reduce hunting of migratory birds elsewhere in the flyway or in Canada.

Negotiations of the guarantees were to be based principally on the results of research to establish present levels of Native harvesting—a five–year, $1 million data–gathering study conducted through interviews with the Native hunters (James Bay and Northern Quebec Native Harvesting Research Committee 1982).

Opportunities and Obligations

The results of the Native harvesting research indicate sizable harvests of migratory birds. Mean annual kills of 88,700 Canada geese, 34,200 lesser snow geese, 8,850 brant and 65,500 ducks have been established.

These results illustrate one important consequence of the JBNQA—it offered the wildlife manager an opportunity to obtain estimates of the harvest of migratory birds by an important group of users. Before this study, ". . . waterfowl managers had largely ignored Native kill in their rough equations which attempt to balance production versus mortality" (Finney 1979). This is a step toward a full integration of Native harvest statistics in the national harvest survey in Canada. Data now also exist for the Native kill of Baffin Island and the west coasts of James Bay and Hudson Bay, which, along with like data from northern Quebec, are only part of the complete picture, because Native users elsewhere are not yet represented in the statistics.

The JBNQA did not create, but rather brought to light, certain legal problems associated with this hunt. The studies established that important spring harvests of migratory birds are occurring in the James Bay claim area and that species not identified as game species by the MBC are taken.

The JBNQA also imposes an obligation never before encountered in the management of migratory birds in North America, namely, the identification and allocation of a fixed proportion of the kill to a distinct group of users. This new obligation will necessitate a much closer look at the status of populations and the seeking of improved kill statistics. Difficulties with this intricate process will really start surfacing in time of scarcity.

A second set of opportunities offered by the JBNQA originates with the spirit in which it was negotiated. The Native people were given opportunity to play a greater role in the management of the wildlife resource of the territory, mainly through their participation in the Hunting, Fishing and Trapping Coordinating Committee—a committee composed of representatives of the signatories of the JBNQA—and mandated to implement the Hunting, Fishing and Trapping Regime.

Certainly this concern regarding wildlife management is not new to Native people. There is some evidence that subsistence hunters have practiced and continue to practice some form of wildlife management in order to maximize or optimize harvest of wildlife. The Crees differentiate game that responds to management and other game that does not. Feit (1985a) has shown how the Crees use available indicators in trends in moose populations to guide their hunting decisions. Feit also described interesting parallels between Native knowledge and practice and those of wildlife managers.

Goose hunting is another traditionally controlled activity. A strict set of rules is applied by "goose bosses," or coastal trapline tallymen, regarding the conduct of the hunt. For example, no hunting is allowed on calm days or on Sundays, the hunt alternates between sites, some areas are left undisturbed for periods of time, and the main flocks are not harassed. Some management of the coastal marsh is traditionally made to create small impoundments attractive to geese. The objective being to maximize and, in the opinion of some anthropologists, to optimize harvest by groups of hunters, usually family units.

The JBNQA has encouraged more–formal involvement of Native people into the migratory bird management scheme. An example of this is the eider project in 1983, conducted by Makivik Corporation—a corporation established by the Inuit beneficiaries to manage the JBNQA fund. This project, supervised by the Canadian Wildlife Service, yielded information on the status of a poorly known population of eiders in Ungava. It included collecting ecological information from the Inuit hunters, followed by a census of the nesting duck population (Chapdelaine et al. in press, Reed, 1983, Nakashima in press). Banding programs are to follow, and the drafting of a management plan to reestablish eider colonies that have been decimated by over-exploitation is encouraged. The Inuit are interested by the development of an eider down industry in the area, but also in using eiders and their eggs for food.

Other projects include an ambitious survey of Inuit knowledge and land–use, in which the special knowledge that subsistence hunters have of the land and of the resource that they use was to be collected and organized in order to progress in the management of wildlife and the protection of essential habitat of the north. On the Cree side, surveys of the James Bay coastal marshes are contemplated in order to monitor the impact of the hydro–electric development on those marshes and the geese that stage there. This concern is certainly not unfounded, given the unexpected array of impacts that this development has had on wildlife, including the drowning of

9,000 caribou while trying to cross a river swelled by water–regime manipulation (SAGMAI 1985), the recent discovery of high levels of mercury in the fish caught in the impoundments, and the possible reduction of Zostera marina beds in James Bay—a species important to brant (Hydro–Québec and SEBJ 1985).

These projects demonstrate that the Native hunters are ready and eager to collaborate toward better resource management, and that land–claim settlements can create the circumstances to allow such collaboration.

I have briefly mentioned the principle of conservation on which the whole Hunting, Fishing and Trapping Regime is based. It is a principle that considers the protection of the territory's ecosystems for the purpose of perpetuating traditional Native activities and, secondarily, the satisfaction of the non–Native hunting and fishing needs. This principle, which was found acceptable by both parties, provides for legal control over excessive exploitation. As signatories of the JBNQA, the Native people accept the scope and consequences of this principle of conservation, and the need to restrict their harvest of declining species if sufficient supporting evidence is presented, in order to meet quotas that may be imposed in the interest of conservation.

First, however, the problems of spring harvest and illegal harvest of nongame species have to be resolved. The Native people resent the illegality in which the MBC has put them without prior consultation. A protocol to amend the MBC was signed between Canada and the U.S. in 1979, contemplating the possibility of a regulated spring harvest of migratory birds for subsistence purposes. The fear was raised that this protocol would create an uncontrolled situation and an increase of the kill, but it is considered unfounded. If its area of application is carefully circumscribed, the protocol will, in fact, recognize and control an existing situation for most of northern Canada. Various programs associated with the JBNQA have, over the years, successfully reversed the downward trend that the subsistence activities were experiencing before the JBNQA. In a review of the situation, Feit (1985b) noted a one–third increase of these activities. However, no increase of migratory bird harvest was noted and no migratory bird population has become endangered as a result of the JBNQA signing. The JBNQA contemplates legalization of a spring harvest that has been practiced for many generations. The implementation of the protocol will only recognize a reality that the negotiators of the new 1916 Convention had overlooked.

Conclusion

Land–claim settlements, if properly and fully implemented in the spirit they were negotiated, can create inviting new opportunities for wildlife managers.

More than ever, financially stressed wildlife agencies must seek additional support and cooperation from the public. The beneficiaries of such land–claim settlements, because of their needs to ensure sustained yields of wildlife, can become strong allies. Their support and collaboration can be made possible through the process of land–claim settlements. We must learn to work within the legal complexities that usually emerge from that process, otherwise we will miss out on this opportunity to gain the valuable input of this special group of users.

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Alaska Waterfowl Management and the Law

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Introduction

Biologists have extensively documented the crisis facing four depleted populations of migratory geese that nest and breed in the deltas of the Yukon and Kuskokwim (Y–K) Rivers of western Alaska.[1] The failing species of geese are the cackling Canada goose, white–fronted goose, emperor goose and Pacific black brant. Overhunting on the Alaskan nesting grounds and in the "Lower 48," loss of wintering habitat outside Alaska, pesticides, natural predation, ineffective management, and other factors have combined to deplete these four species of geese.

The ensemble of decimating factors, particularly the hunting that occurs each year on the birds' nesting grounds in the Yukon delta has been described as "near catastrophic."[2] In the absence of significant improvements in conservation of these birds, the prognosis is clear: "one has no trouble predicting disaster for the geese."[3]

In Alaska, aboriginal harvest of migratory geese, eggs and other waterfowl species has occurred in the Y–K delta since prehistoric time. The harvest occurs each spring, when millions of birds return to the Arctic to breed and nest.[4]

A recent decision handed down by the U.S. District Court for Alaska declares that the 1925 Alaska Game Act partially repealed the 1918 Migratory Bird Treaty Act.[5] Under the result–oriented decision, Alaska Indians, Eskimos, travelers, prospectors and explorers may take or possess migratory birds without regard to closed seasons, bag limits or other regulatory restrictions, provided the taking is for nutritional needs.

It is difficult to see how this ruling will aid the four failing species of geese or the biological integrity of any other migratory birds that nest in Alaska.

Past Actions Taken to Reduce Spring Waterfowl Harvests

The History of Protective Legislation

The idea of protection of migratory birds "dawned slowly" in the U.S.[6] The first federal statute protecting migratory birds—known as the Migratory Bird Law, was

[1] e.g., Raveling "Geese and Hunters of Alaska's Yukon Delta: Management Problems and Political Dilemmas" (1985).

[2] Raveling, *supra*, p. 564.

[3] *Id.*, p. 11; *see also* U.S. Fish and Wildlife Service *Pacific Flyaway Reports*, November, 1983, pp. 5–6, in which a computer regression analysis forecasts "termination" of the goose colonies of the Y–K delta by 1994.

[4] S. Rep. No. 96–1300, 95th Cong., 2d Sess., October 9, 1978, p. 158; Fitzhugh and Kaplan, *Inua, Spirit World of the Bering Sea Eskimo* (1982).

[5] Memorandum and Order, January 24, 1986, *Alaska Fish and Wildlife Conservation Fund v. Jantzen*, (D. Alaska) Civ. # J–84–013, *mandamus docketed*, #86–7036 (9th Cir. January 22, 1986).

[6] Phillips, "Migratory Bird Protection in North America" (1934); Matthiessen *Wildlife in America* (1959); Lund *American Wildlife Law* (1980) pp. 86–88.

passed in 1913.[7] This law was promptly attacked in the courts as lacking a sound constitutional basis.[8]

In 1916, the U.S. concluded a treaty with Great Britain (acting on behalf of Canada) that prohibited most spring waterfowl hunting.[9] An exception to the 1916 Convention's rule of no spring harvest of waterfowl was created for Eskimos and Indians: "The close [sic] season on migratory nongame birds shall continue throughout the year, except that Eskimos and Indians may take at any season auks, auklets, guillemots, murres, puffins, and their eggs, for food and their skins for clothing, but the eggs and birds so taken shall not be sold or offered for sale."[10]

To implement the treaty, Congress passed the Migratory Bird Treaty Act (MBTA) in 1918.[11] Based on the sound constitutional footing of the Executive branch's treaty power, the 1918 MBTA quickly passed Constitutional review.[12] Ever since 1920—at least until the radical court decision of 1986 in the Alaska waterfowl litigation—the MBTA has been at the bedrock of federal wildlife law.[13]

The 1918 MBTA makes the 1916 Convention with Canada more than a mere international agreement; it "executes" the treaty and makes it a valid, enforceable law.[14] MBTA makes all hunting of migratory birds listed in the treaty and the Act illegal, except as permitted by regulation.[15] The 1916 treaty, MBTA and its implementing regulations state that it is illegal to hunt most migratory birds from March 10 to September 1, annually.[16]

In 1925, Congress passed the Alaska Game Law.[17] It includes general prohibitions on taking or possession of game animals, furbearers and birds, unless permitted by that Act.[18] The 1925 law includes an emergency exception. It provides that regulations adopted pursuant to the Game Law shall not: ". . . prohibit any Indian or Eskimo, prospector or traveler to take animals or birds during the close season when he is in absolute need of food and other food is not available. . . ."[19] It also provides that no regulations may ". . . contravene any of the provisions of the migratory bird treaty [sic] Act and regulations."[20]

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[7] 37 Stat. 847 (1913); *see also* Fox *John Muir and His Legacy: The American Conservation Movement* (1981).

[8] *United States v. Shauver,* 214 F. 2d 154 (E.D. Ark. 1914), appeal dismissed, 248 U.S. 594 (1919).

[9] U.S.–Great Britain (on behalf of Canada) Convention for Protection of Migratory Birds, August 16, 1916, 39 Stat. 1702, T. S. No. 628.

[10] *Id.,* Article II; *see also* 50 CFR 20.132.

[11] Migratory Bird Treaty Act (MBTA), 16 USC 703 et seq.

[12] *Missouri v. Holland,* 252 U.S. 416 (1920).

[13] Comment, "Treaty–Making Power as Support for Federal Legislation," 29 Yale L.J. 445 (1920); Coggins, Patti. "The Resurrection and Expansion of the Migratory Bird Treaty Act," 50 Colo. L. Rev. 165 (1979); Coggins, Wilkinson. "The Law of Wildlife Management on the Federal Public Lands," 60 Oregon L. Rev. 59 (1981): ANILCA, sec. 815 (4), 16 USC 3125.

[14] The rule regarding when a treaty requires an Act of Congress to become binding law in the United States is stated in *Foster v. Neilson,* 27 U.S. (2 Pet.) 253, 314 (1829).

[15] 16 USC 703; *Bailey v. Holland,* 126 F. 2d 317, 321, 324 (4th Cir. 1942); *Landsden v. Hart,* 168 F. 2d 409 (5th Cir. 1948), *cert. den.,* 335 U.S. 858 (1949).

[16] *Id.,* 50 CFR 20.

[17] 1925 Alaska Game Law, 43 Stat. 743.

[18] *Id.,* sec. 8.

[19] *Id.,* sec. 10, 43 Stat. 744.

[20] *Id.*

Finally, it should be noted that the 1925 Alaska Game Law contains broad language of repeal, although the language is vague on its face: ". . . the provisions of existing laws relating to the protection of game and fur-bearing animals, birds, and nests and eggs of birds in the Territory shall remain in full force and effect until expiration of ninety days. . . ."[21]

Regulations promulgated by the U.S. Department of Agriculture after passage of the 1925 Alaska Game Law clearly indicate the continued applicability of MBTA in Alaska, stating that the closed season for migratory birds in Alaska runs from March 10 to September 1, annually.[22]

In 1978, MBTA was amended.[23] The amendment was passed in anticipation that the 1916 U.S.–Canada Convention would soon be amended to allow a substantial expansion of spring waterfowl harvesting by indigenous peoples. Indeed, a Protocol amending the 1916 Convention was signed by representatives of Canada and the U.S. in January 1979. The 1979 Protocol has never been ratified by the U.S. Senate; consequently, it is of no legal effect in the United States.[24]

Two other U.S. treaties dealing with migratory birds contain more liberal provisions for spring harvesting by indigenous people than does the 1916 U.S.–Canada Convention. However, MBTA requires that harvest regulations must comply with *all* international commitments. Thus, the stricter terms of the U.S.–Canada Convention are controlling.[25]

Enforcement of Waterfowl Conservation Laws in Alaska

Throughout the history of Alaska, from territorial days to the present, government has dealt inconsistently with the Native population of Alaska in its enforcement of conservation laws: "An extremely difficult problem is faced in the question of how far natives shall be allowed the use of game in and out of season. . . . With the government doing almost nothing for the support of the Alaskan native, if the privilege of obtaining food is taken from him his plight will be pitiful, and yet some steps must be taken to curb his unthinking killing of game of both sexes, and in all seasons."[26]

Early efforts to enforce migratory waterfowl conservation laws were made difficult by the remoteness of Alaska, a lack of manpower, and sympathy for the impover-

[21] *Id.*, sec. 16, 43 Stat. 747.

[22] Alaska Game Law and Regulations and Federal Laws Relating to Game and Birds in the Territory 1, 12 (May, 1925); Regulations Relating to Game, Land Fur Animals, and Birds in Alaska, 12, (May, 1935); 50 CFR 91.28 (1938); Proclamation of August 28, 1950, 64 Stat. A421, A425; 50 CFR 91.3 (1944); 50 CFR 46.31 (1949); 50 CFR 46.11 (1957); 50 CFR 20.132.

[23] Fish and Wildlife Improvement Act of 1978, codified as 16 USC 712.

[24] U. S. Constitution, Art. 2, sec. 2, cl. 2; *H. V. Holcomb v. Confederated Tribes of the Umatilla Indian Reservation*, 382 F. 2d 1013, 1014 (9th Circ. 1967).

[25] Convention Between the Government of the United States of America and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction, and Their Environment, 25 U.S.T. 3329, T.I.A.S. No. 7790 (March 4, 1972); Convention Between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment, 29 U.S.T. 4647, T.I.A.S. No. 9073 (November 19, 1976); 50 CFR 20.132; 1978 U.S. Code Cong. & Adm. News, 7641, 7645, 7655; 16 USC 3125 (4). The Convention Between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Mammals, 50 Stat. 1311, T. S. No. 913 (Feb. 7, 1936) does not address the issue of indigenous hunting.

[26] 1918 Annual Report of the Governor of Alaska on the Alaska Game Law, pp. 10–11.

ished Native populace.[27] Although professional concern was expressed periodically, a laissez–faire attitude prevailed.[28]

In 1961, near the Arctic Ocean village of Barrow, enforcement of the closed season on waterfowl by U.S. Fish and Wildlife Service (USFWS) agents resulted in acts of civil disobedience by approximately 127 Eskimos who formally admitted illegally harvesting eider ducks (a species whose populations were high). After considerable publicity and vigorous political intervention by Alaska's Governor and U.S. Senators, all charges were dropped.

After the 1961 Barrow "duck-in" and accompanying brouhaha, USFWS ceased all law enforcement efforts directed at protecting migratory birds in the Yukon delta, and most of the rest of rural Alaska, as well.[29]

In 1975, U.S. postal officials in the Yukon delta apprehended a rising young Eskimo political leader who tried to mail freshly killed ducks during the spring, when, under MBTA, hunting is illegal. Caught in an apparent quandary between political expediency and the demands of the MBTA and federal regulations, USFWS did not wish to provoke a repeat of the 1961 Barrow episode. Instead, it promulgated a formal statement of its intent to abstain from enforcing the conservation laws and regulations that protect migratory birds in Alaska—the Watson nonenforcement policy.[30]

USFWS gave the nonenforcement policy a more expansive interpretation than the literal terms of the document would indicate. As a result of the Watson policy, taking geese (and all other species of migratory birds) on the nesting grounds has been allowed by USFWS for any person, regardless of need.[31]

The rule of nonenforcement did not set well with prosecutors, such as the U.S. Attorney for Alaska: "There can be no doubt that the Fish and Wildlife Service's policy of non–enforcement under these circumstances would have the force and effect of law. . . . Moreover, even in instances of obvious sport hunting, where no conceivable claim of subsistence hunting could be made, I would tend to have serious reservations about the viability of prosecution in light of the fact that the Fish and Wildlife Service has, through formalized and openly acknowledged policy making, apparently placed into effect without any statutory, regulatory, or other legal authorization, a pattern of selective enforcement primarily based upon racial categories."[32]

Administrative Measures to Protect Waterfowl

In 1984, USFWS entered into the Hooper Bay Agreement.[33] The other signatories were the Alaska Department of Fish and Game (ADF&G) the California Department of Fish and Game, and the Association of Village Council Presidents (AVCP), a

[27] e.g., Matthiessen, *op cit.*, pp. 242–249.

[28] e.g., Scott "Wildlife in the Economy of the Alaska Native" (1951); Klein "Waterfowl in the Economy of the Eskimos on the Yukon–Kuskokwim Delta, Alaska" (1966).

[29] *See* generally, USFWS Memorandum, from Acting Area Director for Alaska to USFWS Associate Director, Washington, D. C., July 27, 1978.

[30] USFWS, Watson nonenforcement policy, December 4, 1975.

[31] USFWS Memorandum, Ladd, "Alaska Migratory Bird Subsistence Hunting," March 12, 1979; *c.f.* Memorandum, Associate Solicitor, Dept. of Interior, January 15, 1973.

[32] Letter from U.S. Attorney A. Bryner to USFWS Special Agent L. Hood, June 30, 1978.

[33] USFWS, Hooper Bay Agreement, February 22, 1984.

quasi-governmental "umbrella" organization for the 56 villages of the Y–K delta.

The goal of the agreement was to reduce the spring harvest of three depleted species of geese. In return for a pledge from AVCP to refrain from hunting the three species from the onset of nesting until the birds were again on the wing, USFWS and other agencies agreed to allow harvesting on the nesting grounds during all other times. No bag or total harvest limits were set, and no restrictions were made on harvest methods or means.[34]

Preliminary data indicate that the Hooper Bay Agreement did not appear to benefit the most seriously depleted of the three species—cackling Canada geese.[35] They also indicate that the Agreement caused a shift in hunting pressure to a species that was omitted from the agreement—emperor geese.[36]

In 1985, USFWS entered into a second cooperative agreement, more grandly titled the Yukon–Kuskokwim Delta Goose Management Plan (YKDGMP).[37] The parties were the same as the previous year, but the emperor goose, left out in 1984 at the insistence of AVCP despite its depleted status, was included. As in 1984, USFWS granted broad harvest rights during part of the closed season in exchange for a pledge from AVCP that local hunters would limit the portion of the closed season during which they hunted.[38]

Another similar agreement is planned by USFWS for 1986.[39]

Current Alaska Goose Litigation

Genesis of the Lawsuit

On May 18, 1984, the Alaska Fish and Wildlife Conservation Fund filed suit in federal court for the District of Alaska seeking injunctive and declaratory relief to protect the geese of the Y–K delta.[40] The suit was filed after USFWS and ADF&G each failed to make any response to two, separate administrative petitions filed by the Conservation Fund, seeking emergency action to protect four depleted species of geese.[41]

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[34] *Id.*

[35] USFWS Memorandum, August 6, 1985, from USFWS Alaska Regional Director Gilmore to Director, USFWS, Washington, D.C.

[36] USFWS, May 24, 1984 Memorandum from Refuge Manager, Yukon Delta NWR to Assistant Regional Director, Wildlife; Dau and King, "Spring Survey of Emperor Geese in Southwestern Alaska, 12–16 May, 1985."

[37] 1985 YKDGMP, USFWS document, March 1985.

[38] *Id.*

[39] USFWS Region 7 AWR Briefing Statement, September 3, 1985.

[40] *Alaska Fish and Wildlife Conservation Fund v. Jantzen,* No. J–84–013, Civil. On May 24, 1984, a motion to intervene was filed by the Alaska Federation of Natives (AFN), AVCP and (former) State Representative Tony Vaska. The motion was granted the same day.

[41] APA Petition to USFWS Regional Director Putz, April 28, 1984, filed pursuant to 5 USC 553 (e); APA petition to ADF&G Commissioner Collinsworth, April 28, 1984, filed pursuant to A S 44.62.220. The petitions each sought protection for the three species of geese included in the Hooper Bay Agreement, as well as for emperor geese, since petitioners stated that a shift in hunting effort to emperor geese could be expected if emperors were not protected, and the depleted status of emperor goose populations made increased hunting effort extremely ill–advised; *c.f.* USFWS Memorandum, C. Dau to USFWS Refuge Manager, November 30, 1978, and USFWS Memorandum from C. Dau to J. Bartonek, November 24, 1978.

The remedy sought from the court by the Alaska Conservation Fund includes:

1. an injunction forbidding USFWS and ADF&G from agreeing to allow taking geese during the closed season;
2. requiring USFWS and ADF&G to prepare plans immediately to curtail or eliminate the legal hunting season throughout the range of these four species of geese;
3. a declaratory judgment that the Hooper Bay Agreement and Watson nonenforcement policy violate MBTA and the APA (Administrative Procedure Act);
4. immediate preparation by USFWS of an environmental impact statement (EIS), discussing in detail the cumulative impacts of the annual spring harvest of geese, and alternative law enforcement approaches, including a "worst-case" analysis; and
5. establishment of an oversight committee composed of scientists from universities and federal and state agencies.

Legal Issues Raised in the Alaska Goose Litigation

Violation of MBTA. Simply put, the Alaska Fish and Wildlife Conservation Fund claims that USFWS has acted in violation of MBTA by formally agreeing to allow harvest of geese during the season closed to hunting by the 1916 U.S.–Canada Convention, MBTA and implementing regulations. The Fund argues that, although the 1984 Hooper Bay Agreement and 1985 YKDGMP each seek to reduce spring harvest of geese, the *quid pro quo* selected by USFWS involves express permission to harvest during the closed season—a violation of the clear terms of MBTA.[42]

Violation of the Administrative Procedure Act. The federal APA requires that all "substantive rules" be preceded by an opportunity for public notice and comment.[43] The Conservation Fund claims that the Hooper Bay Agreement and YKDGMP are each a substantive rule, since they set waterfowl harvest rules exactly like any other regulation.[44] Since neither agreement was preceded by public notice, and the general public had no opportunity to comment on USFWS' decision to allow spring hunting until after the agreements were signed, the Fund claims the APA was violated.

Violation of the National Environmental Policy Act (NEPA). NEPA includes a set of action–forcing alternatives designed to assure consideration of the environmental impact of major agency actions affecting the human environment:[45] "NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken."[46]

USFWS did not prepare an EIS, an EA (Environmental Assessment) or a FONSI (Finding of No Significant Impact) for the Hooper Bay Agreement, the 1985

[42] MBTA, 16 USC 703.

[43] APA, 5 USC 553.

[44] *See Lewis–Mota v. Secretary Cohen,* 469 F. 2d 478 (2d Cir. 1972); *American Bus Assn. v. United States,* 627 F. 2d 525 (D.C. Cir. 1980); *Kenai Peninsula Fishermen's Cooperative Assn. v. State,* 628 P. 2d 897, 905 (Alaska, 1981); Davis *Administrative Law Treatise* (1979 ed.) Vol. 2, Sec. 7:5, and Davis *1982 Supplement to Administrative Law Treatise,* sec. 7:5.

[45] 42 USC 4321; *Calvert Cliffs' Coordinating Committee v. Atomic Energy Commission,* 449 F. 2d 1109, 1123 (D.C. Cir. 1971); *Kleppe v. Sierra Club,* 427 U.S. 390, 409 (1976).

[46] 40 CFR 1500.1 (b); *see also* 42 USC 4332; 40 CFR 1508.

YKDGMP or the Watson nonenforcement policy. Nor has USFWS prepared a comprehensive EIS on its management of Y–K delta waterfowl.[47]

The gist of the Fund's NEPA claim is that USFWS has not made a reasoned choice among alternative management approaches for the dangerously depleted geese of the Y–K delta. Although at least one other alternative has been put forth by a waterfowl biologist with over two decades of Alaska experience, there is no indication that USFWS has formally considered it.[48]

The Alaska Fish and Wildlife Conservation Fund also claims that NEPA requires USFWS to do a worst-case analysis.[49] The Fund cites USFWS' inability to gather scientifically reliable harvest data regarding either the historic or current levels of spring waterfowl take.[50]

Law Enforcement. The Conservation Fund claims that USFWS cannot legally adopt a formal policy renouncing its intent to enforce the law. The Fund claims that the Watson nonenforcement policy not only violates the APA, it also violates USFWS' statutory duties.[51] The Fund recognizes that USFWS has broad discretion to decide how and when to enforce the law, but argues that an absolute rule against law enforcement exceeds the agency's authority.[52]

ANILCA. The last claim made by the Conservation Fund is that USFWS has violated the statutory purposes set forth in ANILCA, which created the Yukon Delta National Wildlife Refuge. Since ANILCA requires fulfillment of the international treaty obligations of the United States, and the 1984 and 1985 USFWS agreements allow harvesting during the time the 1916 U.S.–Canada treaty requires the season to be closed, the Fund argues that each agreement violates ANILCA.[53]

Conclusion

The January 24, 1986 decision of the federal court dismissed as "moot" all of the claims made by the Alaska Fish and Wildlife Conservation Fund. Instead, the court ruled that the 1925 Alaska Game Law partially repealed the 1918 MBTA, and that Alaska Indians, Eskimos, travelers, prospectors and explorers can take or possess all species of migratory birds at any time of year, without regard to bag limits or other restrictions, provided the birds are taken for nutritional needs.[54]

The federal court's ruling may not stand. The Alaska Conservation Fund has already carried the case to the Ninth Circuit Court of Appeals. Although it may be

[47] *See National Wildlife Federation v. United States Forest Service*, 592 F. Supp. 931, 940, fn. 17 (D. Or. 1984).

[48] J. King, "A Strategy for Managing Alaskan Goose Colonies," February 19, 1985, presented at the ADF&G Alaskan Bird Conference and Workshop, Anchorage.

[49] *See* 40 CFR 1502.22; *Save our EcoSystems v. Clark*, 747 F. 2d 1240 (9th Cir. 1984).

[50] e.g., Copp, Smith "A Preliminary Analysis of the Spring Take of Migratory Waterfowl by Yupik Eskimos on the Yukon–Kuskokwim Delta, Alaska, October 13, 1981; Copp, Garrett, "Results of the 1982 Survey of Spring Waterfowl Hunting by Eskimos on the Yukon–Kuskokwim Delta, Alaska," USFWS, undated.

[51] *c.f.* 16 USC 706; 16 USC 707; 16 USC 460k–3; 16 USC 668dd (c); 16 USC 742a.

[52] *See* generally: Davis *Administrative Law Treatise* (1979 ed.) Sec. 9:1, pp. 217–225.

[53] ANILCA, sec. 303 (7) (B); 16 USC 668dd, note; ANILCA sec. 815 (4), 16 USC 3125.

[54] *supra*, note 5.

many months before the Alaska goose litigation is finally closed, some preliminary thoughts may nonetheless be offered.

First, the present situation is biologically untenable. Unlimited harvesting of any species runs counter to the essence of sustained–yield wildlife management. Immediate action should be taken to protect these birds from overharvest.

Second, it is naive not to admit that the great majority of hunters taking geese in the spring are Yu'pik Eskimos, some of whom have a nutritional need for some form of fresh meat (although not necessarily a need for depleted geese).[55] The practice of spring waterfowl hunting will not end, no matter how the instant litigation ends.

Congress should therefore act promptly to reconsider the 1979 Protocol Amendment to the 1916 U.S.–Canada Convention. The Protocol should either be rewritten to accommodate the many concerns of conservationists and wildlife managers, or it should be adopted as now written, so that implementing regulations can be put into place as soon as possible.[56]

Third, social, economic, aesthetic and political considerations properly enter into decisions as to how to allocate a wildlife harvest among competing user groups. However, the fundamental question of whether or not a harvestable surplus exists should be made solely on biological grounds.

Fourth, USFWS' continued avoidance of its law enforcement duties will nullify any diplomatic or congressional efforts to create a new legal framework for management of migratory birds in Alaska. The sensible approach would appear to be for USFWS to concentrate its efforts and manpower in the narrow coastal strip within which the vast majority of the affected geese attempt to nest each year. Critical habitat zones should be set aside as absolutely closed to hunting, and especially closed to charter aircraft now used by some hunters.

USFWS needs to be aggressive, yet diplomatic in its enforcement effort, balancing the interests of the wildlife against the social realities of the Y–K delta. ". . . we have to be realistic and remember that periodically in conservation we have a pill to swallow, and that regardless of how much molasses you put on it, it will be bitter to some people."[57]

Fifth, for close to two decades, the field biologists of USFWS and ADF&G have warned of the crisis we now face in Arctic goose management. Yet their reports have been ignored or edited into homilies, and management has been effete. One must conclude that top–level managers in USFWS have been "asleep at the wheel," and have failed to discharge their duties properly. Congressional oversight hearings on USFWS should be held regarding migratory waterfowl management and how to rectify this problem.

Sixth, USFWS' 1984 and 1985 cooperative agreements have avoided, if not deliberately violated, two important procedural laws—NEPA and the APA. These laws let the public and the agency know the parameters of the environmental and social

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[55] D. Kelso "Subsistence Use of Fish and Game Resources in Alaska: Considerations in Formulating Effective Management Policies" (1982).

[56] Regarding problems in the 1979 Protocol as now written, *see* Memorandum to International Association of Fish and Wildlife Agencies from P. Lenzini, February 11, 1985; regarding the "almost unanimous opposition to the present Protocol by conservation groups in the United States and Canada..," *see* Letter to Asst. Secy., Dept. Interior, R. Arnett from ADF&G Deputy Commr. Collinsworth, October 12, 1981.

[57] Hawkins, Hanson, Nelson, Reeves, eds. *Flyways*, p. 377 (1984).

problems they face. They help delineate the known and unknown factors that should be considered *before* decisions are made. Nonetheless, there are surely some positive benefits that have accrued from the Hooper Bay Agreement and 1985 YKDGMP.

Finally, whether one applies the label of "subsistence" or "recreational" to spring goose hunting is irrelevant to the biological impact spring hunting has on the resource. Whatever adjective one uses to describe the hunter, there is only one way to describe his prey: "dead."

Harvests of geese on the Yukon delta are excessive, and when combined with harvest in the rest of the Pacific Flyway, the allowed level of harvest is even more egregious. ". . . it is naive and destructive to ignore the impacts of expanding human populations and technology. . . . 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."[58]

Clearly, mutual trust and cooperation between resource users and managers are essential to formulating a new, realistic, legal framework for Arctic waterfowl management. Just as clearly, there must be a commitment to enlightened and consistent enforcement of the law, for without enforcement, the law is nothing but a meaningless shibboleth.

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Native Subsistence Hunting of Migratory Waterfowl in Alaska: A Case Study Demonstrating Why Politics and Wildlife Management Don't Mix

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With increasing regularity at meetings such as the North American Wildlife and Natural Resources Conference biologists working in Alaska can be heard lamenting the demise of professional wildlife management on the "last frontier." Politicians and lawyers, so the argument goes, are increasingly obstructing the biologists' ability to "manage" fish and wildlife in a nonpolitical and scientific fashion. And looking at the situation from the biologists' point of view, the complaint appears to have considerable merit.

In the past fifteen years, the number of federal and state laws dealing with fish and wildlife management has substantially increased. Such laws as the Marine Mammal Protection Act, Title VIII of the Alaska National Interest Lands Conservation Act, and the 1978 Alaska state subsistence statute establish regulatory standards of one kind or another that, prior to their enactment, were matters of administrative discretion rather than federal or state law. The number of lawsuits in Alaska challenging administrative decisions made in the name of "biology" by federal and state resource managers has similarly increased.

Why are politicans and lawyers intruding into the wildlife management decision–making process with such increasing frequency in Alaska? I would suggest that their participation is directly related to the failure of the wildlife management profession to acknowledge two increasingly omnipresent realities.

The first is that the constituency which supports wildlife conservation in the United States has expanded far beyond the group of white sportsmen and ammunition companies that established the wildlife conservation movement during the first decades of the twentieth century. Whatever the original contributions of organizations such as the Boone and Crockett Club, the Izaak Walton League, the American Game Protective Association and its successor, the Wildlife Management Institute, the era when members of those and similar organizations formed the core wildlife management constituency both nationally and in Alaska is over. Today, millions of men and women who do not hunt, and tens of thousands of Native Americans who do, are as interested in wildlife conservation as white male sportsmen. Yet representatives of these important constituencies are woefully underrepresented on the staffs of the U.S. Fish and Wildlife Service (FWS) and the Alaska Department of Fish and Game's Division of Game. They are similarly underrepresented at this conference. Until such time as FWS and the Alaska Department of Fish and Game staffs more accurately reflect the attitudes about wildlife management that are becoming increasingly prevalent in America, conflicts between wildlife managers and members of excluded constituencies (and their political and legal representatives) can be expected to increase.

The second reality that the wildlife management profession has been hesitant to acknowledge is the fact that decisions as to who is to be provided an opportunity to take the harvestable surplus of a game population and under what terms and conditions frequently have little, if anything, to do with biology. In Alaska, however, such decisions can have profound social and economic consequences. And since decisions regulating harvest opportunities affect human beings, such decisions are by their very nature "political." When professional wildlife managers in Alaska intrude into political disputes over the division of the harvestable surplus of a game population to argue for a result favorable to the constituency of which they are members (i.e., the white–male–sportsman constituency) on the ground that the result is mandated by biological, rather than political, considerations, the public's confidence in the intellectual integrity of the wildlife management profession is significantly eroded. Even more importantly, such behavior can have profound and adverse biological consequences for the game population that is the subject of the dispute.

No incident in recent memory better demonstrates the risks that wildlife managers run when they allow their political opinions and agendas to compromise the discharge of their professional responsibilities than the controversy that has surrounded the effort to reverse the statistical decline of four species of geese that nest on the Yukon–Kuskokwim River delta in western Alaska.

The taking of ducks, geese and other migratory waterfowl during the spring months is an important part of subsistence harvest cycle for Alaska Natives, particularly the Yup'ik Eskimo people who live on the Yukon–Kuskokwim River delta. Because they arrive a month prior to the end of the long northern winter, migratory birds are the first source of fresh meat of the new year for families in many Native villages. As the U.S. Dept. of the Interior noted in 1973: "Throughout the [Yukon–Kuskokwim River] Delta, migratory birds are an important source of food in the spring, early summer, and fall. Hunting is most intensive in the early spring, immediately after the birds first start arriving on the tundra. At this time birds are more available than at other seasons, supplies of dried fish are usually depleted or exhausted, and other game (except in the coastal villages where there are seals) is harder to come by. In some coastal and tundra villages, bird eggs, mostly geese, are harvested and eaten, the birds and bird eggs providing variety to the fish and sea mammal diet."[1]

Because of the importance of migratory waterfowl to the subsistence cycle, whenever Congress has enacted wildlife conservation laws applicable to Alaska, it has consistently recognized and made adequate accommodation for the Native subsistence migratory waterfowl hunt. The first Alaska Game Act, enacted in 1902,[2] for example, prohibited the taking of migratory waterfowl in Alaska during spring and summer months, but exempted Native subsistence hunting from the prohibition. As the report on the legislation submitted by the House Committee on Terrorities explained: "[T]he Indians and Eskimo may *at all times* kill game animals or *birds* for their food or clothing."[3] (Emphasis added.) The Alaska Game Act was substantially

[1] U.S. Dept. of the Interior, *Final Environmental Statement: Proposed Yukon Delta National Wildlife Refuge—Alaska* 40 (1973).

[2] 32 Stat. 327 (1902).

[3] House Rept. No. 951, 57th Cong., 1st Sess. 2 (1902).

amended in 1908, but the Native subsistence hunting exemption in the 1902 Act was retained unaltered.[4]

Between 1913 and 1918, the staff of the U.S. Bureau of Biological Survey (BBS) and the leadership of the new wildlife conservation movement expended considerable effort to secure federal legislation to extend the prohibition on spring and summer hunting of migratory waterfowl in the Alaska Game Act throughout the United States. In 1913, this effort resulted in the attachment of a prohibition on spring and summer hunting as an amendment to a U.S. Department of Agriculture appropriation bill.[5] Three years later, the Senate ratified a migratory bird treaty with Canada, which committed each nation to prohibiting spring and summer hunting.[6] In 1918 the Congress implemented the treaty by enacting the Migratory Bird Treaty Act (MBTA).[7] The MBTA requires federal regulations governing the taking of migratory waterfowl to be consistent with the substantive provisions of the Canadian treaty. Since the treaty prohibits hunting during spring and summer months, MBTA regulations must do the same.

The history of the negotiations that resulted in the Canadian treaty and the legislative history of the MBTA reflect considerable confusion as to whether the Congress intended Native subsistence hunting of migratory waterfowl in Alaska to be subject to MBTA regulations or to remain exempt from regulation pursuant to the 1908 Alaska Game Act.[8]

In 1925, Congress clarified the situation when it enacted the third Alaska Game Act. The purpose of the 1925 Act was two–fold: (1) to consolidate regulatory and enforcement responsibilities for both game and fur–bearing animals in one agency (the BBS); and (2) to provide an opportunity for greater local participation in the adoption of hunting and trapping regulations, through the establishment of a five–member Alaska Game Commission.

Section 2 of the 1925 Act defines "game birds" to include "migratory waterfowl, commonly known as ducks, geese, brant and swans . . ." Section 10 of the Act states: "[T]he Secretary of Agriculture . . . is hereby authorized and directed from time to time to determine when, to what extent, if at all, and by what means . . . game birds . . . may be taken . . . and to adopt suitable regulations permitting and governing the same . . . but *no such regulation shall . . . except as herein provided . . . prohibit any Indian or Eskimo . . . to take . . . birds during the close season when he is in absolute need of food and other food is not available;* . . . nor shall any such regulation contravene any of the provisions of the migratory bird treaty Act and regulations." (Emphasis added.)

In other words, the taking of migratory waterfowl in Alaska was subject to regulations adopted pursuant to the 1925 Alaska Game Act rather than the MBTA. With one exception, this was a meaningless technical distinction, since the same agency

4 35 Stat. 102 (1908).

5 37 Stat. 847 (1913).

6 39 Stat. 1702 (1916).

7 40 Stat. 755 (1918).

8 In his recent opinion in *Alaska Fish and Wildlife Federation and Outdoor Council v. Jantzen* (January 24, 1986), United States District Court Judge James von der Heydt concluded that the Congress did intend Native subsistence hunting to be subject to MBTA regulations between 1918 and 1925.

(the BBS) adopted both sets of regulations and regulations adopted pursuant to the 1925 Act were required to be consistent with regulations adopted pursuant to the MBTA. However, unlike the MBTA, the 1925 Act exempted from regulation Native subsistence hunting in situations in which a Native hunter or his family was in "absolute need" of food and other food was not available.

Three months after enactment of the 1925 Act, the BBS adopted regulations implementing it. In pertinent part, Regulation No. 8 provided: "An Indian, Eskimo, or half–breed who has not severed his tribal relations by adopting a civilized mode of living or by exercising the right of franchise . . . may take . . . *birds* in any part of the Territory *at any time* for food when in absolute need of food and other food is not available. . . ."[9] (Emphasis added.) Regulation No. 8 was republished periodically for the next 19 years.

In 1944, however, the BBS published a version of Regulation No. 8 which unilaterally wrote the taking of migratory waterfowl out of the Native subsistence hunting exemption in the 1925 Act. The 1944 regulation provided that: "An Indian or Eskimo . . . may take animals, birds (*except migratory birds*) . . . in any part of the Territory at any time for food when in need thereof and other sufficient food is not available. . . ."[10] (Emphasis added.) The regulation was published because officials at the BBS opposed legislation enacted by Congress in 1940 that expanded the scope to the Native subsistence hunting exemption. Throughout the 1930s, the BBS and the Tlingits and Haidas were at constant odds over the application of the "in absolute need of food" exemption to the taking of deer in southeastern Alaska. At the request of the Alaska Native Brotherhood, Alaska Delegate Anthony Dimond introduced legislation enacted in 1940 which replaced the "in absolute need of food" standard with a subsistence exemption that authorized Native hunters to take game and birds whenever they or their families were in need of food and "other sufficient food is not available."

The U.S. Constitution vests the Congress—not the BBS or FWS—with authority to manage America's natural resources, including migratory waterfowl. If officials at the BBS believed that the 1940 Act's expansion of the Native subsistence exemption was going to have an adverse effect on migratory waterfowl populations in Alaska, they could have informed Congress of their concern and requested that the exemption be amended to eliminate the taking of migratory waterfowl from its purview. Instead, BBS officials used their rule–making authority under the 1925 Act to usurp unlawfully the authority of Congress by substituting their judgment for the Congress'. However, after adopting the 1944 regulation, for the next 16 years, the BBS and later the FWS did not attempt to enforce it against Native subsistence hunters.

The quiet was shattered in May 1961, when FWS enforcement agents arrested an Inupiat hunter at Point Barrow for taking ducks during spring. In response, 100 Inupiat hunters gathered at a mass meeting to protest the arrest, after which they each presented enforcement officers with an eider duck and demanded to be arrested. A short time later, 300 Inupiat petitioned President Kennedy to adopt emergency

[9] U.S. Dept. of Agriculture, Bureau of Biological Survey, *Service and Regulatory Announcements: Alaska Game Commission—Alaska Game Law and Regulations and Federal Laws Relating to Game and Birds in the Territory* (May 1925).

[10] 9 Fed. Reg. 5270 (May 15, 1944).

regulations authorizing subsistence hunting of migratory waterfowl or, if such regulations were prohibited by the Canadian treaty, to amend the treaty to authorize spring and summer subsistence hunting.[11] In response to protests lodged by Alaska's congressional delegation, then–Assistant Secretary of the Interior Frank B. Briggs wrote Senator Ernest Gruening that, while the Department of the Interior was "much concerned by the welfare of the Eskimos . . . treaty provisions give the Department no recourse but to carry out a progressive program of enforcement."[12] Secretary of the Interior Stewart L. Udall similarly lectured Senator Gruening that "U.S. game management agents are expected to see good judgment in the enforcement of these treaties and the Treaty Act regulations, but they cannot in good conscience overlook violations of these agreements and the regulations adopted pursuant to them."[13]

At no time during this period did the Office of the Solicitor write for either Secretary Udall or Assistant Secretary Briggs a formal memorandum that demonstrated that Native subsistence hunting was intended by Congress to be subject to regulations adopted pursuant to the MBTA. Had the Solicitor done so, for the reasons previously discussed, he would have determined that the 1925 Alaska Game Act exempted Native subsistence hunting from regulation under the MBTA. Instead, the Department of the Interior's policy was based exclusively upon FWS representations that the subsistence hunt was subject to MBTA regulations, hence, illegal.

Alaska Natives, relying on FWS representations to the same extent as did Secretary Udall, began work to try to persuade Congress to amend the Canadian treaty to authorize the Native subsistence hunt. No action was taken as a result of the 1961 petition to President Kennedy from the Barrow Inupiat. However, after a decade and a half of trying (during which Native hunters were periodically arrested for hunting migratory waterfowl out of season), Alaska Senator Mike Gravel succeeded, in 1978, in persuading the Senate to ratify a migratory bird treaty with the Soviet Union, which authorized spring and summer subsistence hunting in Alaska,[14] and to amend the MBTA to authorize FWS to adopt regulations regulating the hunt.[15]

Although it represented to the Congress that it wanted authority to regulate the Native subsistence hunt, FWS successfully persuaded the Senate Committee on Environment and Public Works to attach language to the 1978 amendment to the MBTA that FWS interprets as preventing it from adopting regulations regulating the hunt until such time as the Senate ratifies an amendment to the Canadian treaty, which authorizes subsistence hunting during spring and summer months.

An amendment to the Canadian treaty was negotiated by the the Department of State in 1979 and delivered to the Senate Committee on Foreign Relations in late 1980. And there it has languished for over half a decade. Immediately upon taking office in January 1981, then–Secretary of the Interior James Watt wrote then–chairman of the Senate Committee on Foreign Relations Charles H. Percy to request that the Committee take no action on the amendment because of objections from "the National Wildlife Federation, the Canadian Wildlife Federation, the Wildlife Man-

[11] *See generally* 107 Cong. Rec. 18416–18425 (September 6, 1961)(remarks of Ernest Gruening).

[12] *Id.* 18419.

[13] *Id.* 18421.

[14] Convention Concerning the Conservation of Migratory Birds and Their Environment, Nov. 19, 1976, United States—U.S.S.R., 29 U.S.T. 4647, T.I.A.S. No. 9073.

[15] Fish and Wildlife Improvement Act of 1978, Sec. 3(h)(2), 92 Stat. 3110 (1978).

agement Institute, the International Association of Fish and Wildlife Agencies, the Wildlife Legislative Fund of America, Ducks Unlimited [and] the Waterfowl Habitat Owners Alliance. . . ."[16]

Secretary Watt sent the letter at the behest of then–Assistant Secretary of Fish and Wildlife and Parks Ray Arnett. Because sportsmen's organizations, such as those listed above, have been perceived by FWS as the core of its constituency since the establishment of the BBS (and native Americans, such as the Alaska Natives, have not), Secretaries Watt and Arnett compromised their commitment to professional wildlife management in order to placate political constituencies whose support they valued.

For the first few years, the delay continued to disadvantage Native hunters, who continued to think of themselves as criminals for hunting migratory waterfowl during spring and summer months to obtain fresh meat to feed their families. However, in 1983, the danger of playing politics with wildlife management became starkly apparent.

Available data indicated that four species of geese which nest on the Yukon–Kuskokwim River delta—cackling Canada geese, white–fronted geese, black brant and emperor geese—were experiencing a dramatic population decline. Sportsmen who hunted the geese in Washington, Oregon, California and Mexico blamed Native subsistence hunters. Native hunters blamed sportsmen. In fact, a number of factors, most notably loss of habitat[17] and natural predation,[18] contributed to the decline as much as hunting.[19] However, unlike construction of housing tracts in wetlands of the Central Valley of California or the behavior of arctic foxes on the nesting grounds at Kokechik Bay, hunting by human beings is one of the few factors affecting population status which FWS has at least the theoretical capacity to "manage."

However, since FWS and the sportsmen's organizations whose politics it supported had done everything possible to prevent the Native subsistence hunt from being legalized, so that the activity could be regulated in a manner consistent with the attainment of recognized conservation goals (as the Native community had been asking be done for almost a quarter of a century), FWS found itself in the embarrassing position of not having the regulatory authority it needed to respond to the

[16] Letter from James Watt to Hon. Charles H. Percy (January 28, 1981).

[17] Although the summer nesting grounds on the Yukon–Kuskokwim River delta remain largely intact, winter habitat for the cackling Canada goose in the Central Valley of California has almost disappeared: "In the span of little more than a century, native wetland areas in the Central Valley have declined so drastically that they may now be described as small islands in a sea of agricultural and urban development. Before settlement, the state [of California] contained an estimated 5 million acres of wetlands. About 4 million of this total were in the Central Valley. Closely associated with these wetlands were extensive riparian forests that covered about 900,000 acres. Recent estimates [by FWS] indicate that only about 6 percent of the original wetland area and 11 percent of the riparian forest now remains in the Central Valley. Gilmer, Miller, Bauer and LeDonne *California's Central Valley Wintering Waterfowl: Concerns and Challenges* (1982), Trans. N. Amer. Wildl. Nat. Res. Conf. 47:441–452.

[18] In 1985, for example, Mimi Hogan, FWS' acting migratory waterfowl coordinator, reported that "we are very concerned about nest predation by mammals and gulls and poor weather during the brood–rearing period, which could further reduce total population [of Canada, white–fronted and emperor geese and black Brant]." *See* U.S. Fish and Wildlife Service, Office of Alaska Public Affairs, *Migrating Geese Face Harsh Spring* (June 18, 1985).

[19] After reviewing the evidence, Judge James von der Heydt attributed the decline to loss of habitat, natural predation and hunting by *both* sportsmen and Native subsistence hunters. von der Heydt Opinion 2.

unexpected biological crisis. The danger of playing politics with wildlife management had come home to roost with a vengeance.

Fortunately, the Yup'ik Eskimo people of the Yukon–Kuskokwim River delta were equally concerned about the declining status of the four species of geese and committed to doing what they could to improve the situation. The result was a remarkable series of negotiations between FWS, the Alaska and California departments of fish and game, and the Association of Village Council Presidents (AVCP).[20] On January 27, 1984, the negotiations culminated in the so-called "Hooper Bay agreement."[21]

As a result of the agreement, Native hunters voluntarily agreed to curtail the subsistence harvest of cackling Canada geese, to curtail egging of white–fronted geese and black brant, and to refrain from hunting the latter two species during the nesting, rearing and molting seasons. In exchange, FWS and the Alaska and California departments of fish and game committed themselves to seeking reductions in recreational harvest throughout the southern part of the flyway.

By any standard of measurement, the Hooper Bay agreement[22] has been a success. According to the Alaska Department of Fish and Game, the agreement resulted in a reduction during 1985 of egging of all species to an "inconsequential" level, a 78–90 percent reduction in the subsistence take of cackling Canada geese, a 45-percent reduction in the subsistence take of white–fronted geese and black brant, and a 58–percent reduction in the subsistence take of emperor geese.[23]

Unfortunately, the possibility that the agreement might benefit the geese populations whose status was the primary concern of all the parties to the Hooper Bay agreement did not impress two newly organized sportsmen's organizations in Alaska, and whose leadership has long opposed state and federal laws that recognize and protect subsistence hunting and fishing in rural Alaska. On May 18, 1984, the Alaska Fish and Wildlife Federation and Outdoor Council (AFWFOC) and the Alaska Fish and Wildlife Conservation Fund filed a lawsuit in the United States District Court in Juneau challenging the Hooper Bay agreement. More importantly, the plaintiffs requested the court to issue a preliminary injunction ordering FWS to send enforcement agents into AVCP villages to arrest village hunters caught harvesting geese for subsistence purposes during the spring and summer months.

The Alaska Federation of Natives (AFN) and AVCP intervened in the litigation to represent the interests of the Native hunters AFWOC was attempting to have arrested. In addition to defending Native hunters against the AFWOC suit, AFN–AVCP filed a cross–claim against FWS, which requested declaratory relief that the 1925 Alaska Game Act (which has never been repealed) specifically exempts Native subsistence hunting from regulations adopted pursuant to the MBTA.

[20] AVCP is the regional Native organization that represents the 56 Yup'ik Eskimo villages on the Yukon–Kuskokwim River delta, including the coastal villages, whose residents traditionally harvest the four species of geese for subsistence purposes.

[21] Hooper Bay, a Yup'ik Eskimo village on the coast of the Bering Sea near the summer nesting grounds, was the site of the January 27, 1984, meeting between the parties which resulted in the agreement.

[22] The agreement was renewed by the parties prior to the 1985 subsistence hunting season. The 1985 agreement was renamed the Yukon-Kuskokwim Delta Goose Management Plan.

[23] Alaska Dept. of Fish and Game, *Implementation of the Yukon–Kuskokwim Delta Goose Management Plan in 1985*. 8–13 (November 1985). Emperor geese were included in the agreement prior to the beginning of the 1985 season.

Judge James von der Heydt denied AFWOC's request for a preliminary injunction and, on January 24, 1986, dismissed AFWOC's lawsuit and granted AFN–AVCP's motion for summary judgment on their cross–claim. In a detailed opinion, the court held that AFN–AVCP's legal theory was correct. That although the Congress specifically exempted Native subsistence hunting from regulation in 1925, the BBS in 1944 unlawfully usurped Congress' authority and unilaterally attempted to subject Native subsistence hunting to the MBTA. Like Native subsistence hunting of marine mammals, Native subsistence hunting of migratory waterfowl, as a result of the court's decision, is now exempt from regulation. The court did, however, specifically reserve the question of whether FWS presently has authority under the Fish and Wildlife Improvement Act of 1978 to adopt regulations regulating the subsistence hunt.[24]

For Alaska Natives, Judge von der Heydt's decision is social justice long overdue. However, for FWS and the sportsmen's organizations whose political interests it has attempted to advance over the years at the Native community's expense, the decision and the events which preceded it are and should be a source of considerable embarrassment. If FWS had initially dealt with the Alaska Native people fairly and in a manner consistent with the discharge of its responsibilities (rather than its leadership's political proclivities) when the biological emergency arose on the Yukon–Kuskokwim River delta, FWS would have been equipped to respond in a timely and professional fashion. Instead, as a result of a quarter century of playing politics with wildlife management, by the time the problems on the delta became apparent, FWS had a poor working relationship with the Native community, and its authority to regulate the subsistence hunt was nonexistent.

Hopefully, however, the development of the Hooper Bay agreement represents the beginning of a new era of cooperation between FWS and Alaska Natives. Both AVCP and FWS have profited greatly from working to achieve a common goal. The commitment that village hunters have displayed to conforming their harvest activities to the terms of the Hooper Bay agreement demonstrate that, when treated with dignity and respect, Alaska Natives are as committed to wildlife conservation goals as any other group of Americans. FWS' good faith effort to negotiate a workable solution to a difficult problem and to work closely with AVCP to implement the Hooper Bay agreement in a fair and reasonable fashion has been recognized by village hunters as the beginning of a long–term relationship of cooperation and mutual concern for the protection of wildlife resources of importance to the continuation of village life. Of all the organizations that have been involved in the controversy surrounding the development and implementation of the Hooper Bay agreement, however, only time will tell whether AFWFOC has similarly profited from the experience. If it has not, the management of migratory waterfowl in Alaska can be expected to remain mired in the political controversy from which four important species of arctic–nesting geese have only narrowly escaped.

[24] AFN–AVCP argued to the court that FWS presently has regulatory authority. However, FWS argued that it cannot exercise its authority until the Senate ratifies the pending amendment to the Canadian migratory bird treaty.

Status of Legal Issues Involving Goose Populations: Canadian Issues

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The present status of legal issues involving goose populations in Canada is, on the surface, relatively simple—geese are being taken mainly by northern Native people in spring and summer during closed season. Courts in Canada have consistently found that the Migratory Bird Convention Act applies to Native harvest of migratory birds, thus, Native harvest of geese between March 10 and August 31 is illegal throughout Canada.

Detailed information on the take of geese by northern Natives in Canada is scanty, but as explained Dr. Cooch, we know that, with the possible exception of a few local areas, Native take of geese is not having a serious effect on species or populations. The take is largely unregulated. Essentially, therefore, the situation in Canada is this: (1) a traditional subsistence harvest of geese is occurring in northern Canada; (2) that harvest is unregulated and takes place during the closed season; (3) in most instances, the number of birds or eggs taken is unknown; (4) but since northern goose populations are stable or increasing, the Native spring and summer harvests of geese are not thought to be creating a serious problem.

It is likely, however, that problems will soon arise. Increasing Native populations will probably result in increased demands on the migratory bird resource, and improved transportation may enable Natives, to exploit waterfowl populations that are not now accessible because of distance from Native communities. Also, Native groups are becoming increasingly frustrated that their traditional spring subsistence harvest continues to be illegal, and are demanding a strong role in the management of the wildlife on which continuation of their traditional lifestyle depends.

The Canadian Wildlife Service believes that the key to improved waterfowl management in northern Canada is the increased involvement of northern native peoples in the management of the resource. There are three initiatives presently underway which, we believe, will accomplish this goal. They are (1) amendments to the Migratory Bird Convention; (2) negotiation and implementation of Comprehensive Native Land Claims; and (3) the Waterfowl Management Plan.

Other speakers have referred to proposed changes to the Migratory Bird Convention, which would permit Canada and the United States to amend the Migratory Bird Convention Act and Migratory Bird Treaty Act in order to legalize and regulate the subsistence take of waterfowl in both countries. The Canadian Wildlife Service views an amended Migratory Bird Convention Act as one essential component of the goal of bringing subsistence users of geese—and, indeed, all migratory gamebirds—into the continental management equation.

In 1973, the Government of Canada decided to settle what are still undefined Native rights, through a process of negotiation. Native people whose aboriginal interest has not been settled by treaty or superseded by law are negotiating settlements with government. Comprehensive land claims are being negotiated or implemented in some provinces and with all northern Native groups in the Yukon and Northwest

Territories. Some claims, most notably the James Bay and Northern Quebec Claim in Quebec and the Committee for Original Peoples' Entitlement Claim with the Inuvialuit of the western Arctic, have been settled and legislated—the Quebec claim in 1975, and the Inuvialuit or COPE claim in 1984. Other claims are in progress with the Council for Yukon Indians, the Dene/Métis people of the Mackenzie Valley, and the Tungavik Federation of Nunavut, or Inuit of the eastern Arctic.

Many issues—such as land and subsurface ownership by claimant groups, cash payments, environmental protection regimes and social programs—are dealt with in negotiation. Most important, though, from a waterfowl management agency's point of view, is the definition of Native harvesting rights and the role of Native people in wildlife management. Claim agreements have or will specify that Native subsistence use of wildlife (and, therefore, waterfowl) will, in claim areas, be recognized as the first priority demand on wildlife populations, but that Native harvesting, as well as harvesting by non-Natives in claim areas, will be subject to conservation limits. Further, although not all Native claimant groups necessarily agree, it is government's position, supported by the Supreme Court of Canada, that Native harvest of all migratory birds is subject to the provisions of the Migratory Bird Convention Act.

Provisions that ensure that the continental nature of migratory bird harvest and management are recognized are or will be negotiated in all claim settlements. What this means is that, while Native rights to harvest migratory birds are recognized and confirmed in claim settlements, such confirmation must not result in undue constraints on migratory bird harvest by other users of the same bird populations in other parts of the flyways.

In addition to defining and confirming rights to harvest, claim settlements will also define a role for Native peoples in wildlife (and waterfowl) management in each claim area. The same general approach will be followed throughout northern Canada.

In each of the claims, Wildlife Management Boards will be established, composed of equal members of Native representatives and government appointees representing the wildlife management agencies. These boards will consider all aspects of wildlife and habitat management, propose wildlife management measures and forward these proposals to the management agency with jurisdiction. By the same token, the management agency, when proposing new regulations or other wildlife management measures, will consult with the boards and take board decisions and opinions into account before enacting regulations for the claim areas. The Government of Canada retains the ultimate authority for wildlife management in all claim areas.

The negotiating process has been underway for more than 10 years, and progress toward resolution of claims is slow. The process is not an easy one, but government officials, wildlife managers and Native groups are developing better understandings of each other's points of view. The Canadian Wildlife Service is optimistic that the establishment and workings of the Wildlife Management Boards will result in improved and more-cooperative systems of wildlife management in claim areas, particularly regarding waterfowl.

The third initiative—the Waterfowl Management Plan—ties it all together. The Plan recognizes the importance of harvest by subsistence users, supports amendments to the Migratory Bird Convention to permit a regulated spring harvest by subsistence users, and proposes an increased involvement of subsistence users in continental waterfowl management.

A Proactive Strategy for Funding Fish and Wildlife Research in Universities and Colleges

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Opening Remarks

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The thrust of this special session will be to identify a potential pathway for procuring a base of funding to support fish and wildlife research at this nation's colleges and universities. Success in this endeavor is imperative if universities, with their standing crop of scientific expertise, are to continue to be major contributors—along with federal, state and private agencies—in solving the complexity of fish and wildlife problems confronting this nation. One might question the advisibility of undertaking such an initiative at a time when a reduction of the federal budget deficit has become the battle cry. I would counter that the tide has always been going out when appropriations for fish and wildlife have been on the federal docket. So, in short, let's go for it. We have little to lose, but much to gain.

The funding initiative designed to enhance the university support of fish and wildlife research that will be presented today is a product of the National Fish and Wildlife Resources Research Council and the National Association of State Universities and Land-Grant Colleges. The purpose is to propose the mechanism and to provide selected "case studies" as potential disciplinary pathways for implementation. As this session unfolds, I ask you to harken back to Aldo Leopold, who, in his preface to *Game Management* published in 1933—53 years ago—challenged the fish and wildlife profession by simply asking if we, as professionals, were "too poor in purse and spirit" to be the stewards of our fish and wildlife resources.

Fish and Wildlife: The Forgotten Resource in National Policy

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Assessment

Point 1. The *1980 National Survey of Fishing, Hunting and Wildlife-Associated Recreation* (USDI/USDC 1982) revealed a strong and expanding clientele for fish and wildlife resources. Of the 170 million Americans 16 years of age or older, 99 million (58 percent) engaged in some type of wildlife-related activity. The resource had two groups of users: 47 million people (27 percent) were "consumptive" users—they hunted or fished, or both; 83 million (49 percent) were "nonconsumptive" users—they observed, photographed or otherwise enjoyed fish and wildlife resources. Nonconsumptive use of the fish and wildlife resource outweighed consumptive use by nearly 2 to 1. Collectively, such users spent $40 billion in 1980. Thus, there is a high public demand for this nation's fish and wildlife resources, and that demand is accompanied by a substantive economic force.

Point 2. The intelligent and rational conservation and management of our fish and wildlife recources in the years ahead will be crucial and difficult. Loveless et al. (1979:194) stated that ". . . demands between now and 2,000 will call for the duplication of everything that has ever been built in this country. At stake are the nation's irreplaceable estuaries, wetlands, beaches, flood plains, rivers and lakes, farms and forests, and the habitats of fish and wildlife." Conflict resolution wrought by the impacts of agriculture, forestry, industry and urban development on fish and wildlife, and their habitats, will accelerate precipitously in the years ahead. However, the research base needed to underpin the development of critical fish and wildlife policies is lacking. Moreover, the scope of problems and challenges in fish and wildlife research on which decision making and, thus, management is dependent, far exceeds the capabilities of resource agencies and institutions. The priority need, therefore, is not only to ensure the effective application of existing resources but also to supplement the current pool of available research funds. We cannot continue to discharge our growing management responsibilities effectively with status quo funding.

The Policy Arena

The irony of the dilemma of fish and wildlife is reflected in two conflicting truths. First, we have a fish and wildlife resource that is in high public demand and, thus, has high social and economic values. Second, we cannot meet our stewardship commitment to this resource because of an insufficient funding base. What has precipitated this incongruity? The funding plight of the fish and wildlife profession can be traced to the fact that fish and wildlife is a neglected if not forgotten resource in national policy. In this light, we, as professionals, have been notably inept at identifying the worth of our fish and wildlife programs to our nation's policy makers. In fact, we have not demonstrated effectively our professional worth to the users of the fish and wildlife resources, which is reflected by our low profile with the public. These points go hand–in–hand. The political process is stimulated by public demands. In the absence of those public demands, we will continue to garner only bureaucratic lip service and welfare handouts. The bottom line is that we have an important product to sell, but we don't have an organized or innovative sales department!

A brief perusal of just where fish and wildlife does stand in the national political agenda is warranted. Some fish and wildlife issues—particularly those associated directly with hunting and sport fishing—have a respectable amount of political visibility. However, the issue of fish and wildlife research elicits low political visibility even though it is the foundational basis for resource decision making. And low political visibility means limited support in the manner that counts—*dollars!*

The problem associated with low federal funding for the support of fish and wildlife research is not the lack of federal authority. We have been the recipients of lip service authority in research and education repeatedly. Generic authority is provided for in the U.S. Department of the Interior, and specific authority within Interior is provided for in the Fish and Wildlife Service. Similarly, generic authority is provided for in the U.S. Department of Agriculture, and specific authority within Agriculture is provided for in the Forest Service, Agricultural Research Service, and Cooperative State Research Service. Targeted authority also is provided for in such federal enactments as the Fish and Wildlife Conservation Act of 1980, which has never been funded by Congress. Even universities have been given federal authority in fish and wildlife as per the Cooperative Research and Training Program (PL 86–686) of 1960. Adequate authority? Generally, yes! Adequate appropriations? Emphatically, no!

The University Situation

Although the research thrusts of all fish and wildlife governmental and private entities suffer mightily due to insufficient funding, those of academic institutions are in a particularly precarious position. The plight of academic institutions in the arena of fish and wildlife research was fully documented in a series of papers presented in a special session, entitled "Wildlife and Fisheries Research Needs" at the 44th North American Wildlife and Natural Resources Conference in Toronto, Canada in 1979 (Cringan et al. 1979, Edwards et al. 1979, Grant et al. 1979, Labisky et al. 1979, Loveless et al. 1979, Moyle et al. 1979, Sanderson et al. 1979, Smith et al. 1979, Weller et al. 1979) Conclusions reached were: "Academic institutions . . . are the only major public–service institutions with a mandated research mission that do not have a sustained funding base that can be directed to fish– and wildlife–related research. This really means that we have a large pool of scientific talent and facilities in our nation's universities that is not being deployed to solve critical current and emerging problems impacting our fish and wildlife resources" (Labisky et al. 1979:220). The upshot of this major funding initiative was the drafting of enabling legislation, titled "The Fish and Wildlife Resources Research Act," that was designed as a federal formula–funding mechanism to support fish and wildlife at all the nation's academic institutions (Labisky et al. 1979). Polished and poised in readiness, the draft bill was not introduced because the political climate appeared unfavorable. Considering the storm clouds generated by the Gramm–Rudman–Hollings budget deficit legislation of 1985, the climate of the early 1980s was salubrious! Nonetheless, the fact remains that our colleges and universities are in a weaker position to contribute on the research front today than ever before because they are dependent principally on external support dollars from federal, state and private sources—and those dollars are certainly "threatened," if not "endangered."

The plight of the universities striving to continue as a viable component of the nation's fish and wildlife research network is further exacerbated by the issue of competing and conflicting interests lodged within the program authorities of federal agencies. Cases in point: the missions of federal resource agencies (and state resource agencies as well) differ in operational and political philosophy from those of academic institutions; the economically driven management practices of agriculture, range and forestry are often in conflict with fish and wildlife interests; and there is often not a meeting of minds between agricultural (including forestry) and wildlife interests on the topic of animal damage.

A Potential Way Out

Enhancement of the university position in fish and wildlife research is needed critically. In order to address the full spectrum of conservation and management of this nation's fish and wildlife resources, the pool of expertise available within the university community must be utilized fully. However, at a time when the reduction of our federal budget deficit is a benchmark issue, the prospect of obtaining an independent funding initiative to support university fish and wildlife research should be viewed with guarded optimism. Nonetheless, this option must be pursued vigorously and persistently.

There is an initiative, however, that does offer promise for enhancing the funding base for university fish and wildlife research with respect to both near–term and long–term time frames. This initiative, for simplicity, could be called a "hitchhiking" or "piggybacking" approach. It is founded in the fact that fish and wildlife issues are a major component of other highly visible and politically supported national issues, such as clean water, acid rain, toxic waste, soil erosion, cropland conservation, "sodbuster" and "swampbuster" programs, range rehabilitation, and reforestation. In short, we must strive to make fish and wildlife an issue *in other issues*, rather than making it an independent issue. Efforts to build cooperative coalitions with agricultural, forestry, range and water interests hold the promise of incorporating fish and wildlife issues into the broader programs of the Departments of Agriculture, Commerce and the Interior, and the Environmental Protection Agency. Our mode must be to seek concessions, not conflicts. The targeting of our efforts toward making the existing federal authorities more effective and responsive to public needs would certainly seem to have a greater opportunity for success with the Congress than trying to establish yet another authority.

This funding initiative will require the interfacing of fish and wildlife research needs into existing federal authorities. In this effort, we must be selective in approach, identifying those high-profile needs that will mesh with such authorities. Only in this way will we be able to convince our nation's lawmakers that the end product will be enhanced by the incorporation of available but underutilized university talent. To this end, we have identified five priority areas that show promise for "hitchhiking" on existing authorities, including: aquatic ecology; environmental toxicology; endangered species; urban wildlife management; and land-use management. Hopefully, this funding initiative of "hitchhiking" on existing federal programs will be a step toward strengthening of the position of fish and wildlife in the national policy arena.

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Aquatic and Wetland Ecosystems: Multifaceted Challenges

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Introduction

Lakes, ponds, wetlands and streams are known for their high productivity of fish and wildlife, and often have been focal points of system–level research because they tend to be discrete entities. Data based on such natural units have played major roles in the evolution of our understanding of ecological systems and processes (Lindemann 1942, Odum 1957, Pomeroy and Wiegert 1981). However, the fish and wildlife resources dependent on these habitats generally are distributed widely, both in geographic area and in habitat within each system. The new classification system for "wetlands and other deepwater aquatic habitats" by Cowardin et al. (1979) demonstrates that we often deal with a continuum from near–terrestrial to truly aquatic. Hence, our first steps in meeting the research challenges of these diverse habitats must be to break down the artificial barriers of scientific disciplines, and develop integrated teams to conduct long–term research on aquatic resource problems that affect a diversity of fish and wildlife species over wide geographic areas.

Universities are strategic sites for such multidisciplinary efforts and can play a major role in resolving some of the major challenges that agencies often face but have difficulty meeting. The proposed funding sources for such research efforts have been addressed by Labisky et al. (1986). Moreover, our purpose is not to list and prioritize all research needs on these aquatic systems, but rather to identify some examples of major areas of national concern that we feel might be addressed innovatively by cooperative effort among university researchers. Broadly speaking, these include problems of habitat loss and degradation, pollution, water regimes, nutrient and salinity balance, exotics, aquaculture, and competitive uses of resources.

Wetlands

The crisis in the loss, conversion and degradation of wetlands has been well-documented by the recent National Wetlands Inventory (Frayer et al. 1983, Tiner 1984), but the solution to stopping these losses is not at hand. Additional interdisciplinary research efforts on wetland processes and functions will add to our understanding of the mechanics of these complex systems, elucidate their economic values and document their importance to society, thereby enhancing opportunities to save these vital habitats.

Hydrologic, salinity and nutrient relationships can only be determined by costly interdisciplinary studies crucial to the understanding of wetland functions and values. Although the role of stream nutrients in estuarine production has been much studied, there are still many unanswered questions (Nixon 1984, Odum 1984). Due to the continuing development of upstream reservoirs in some areas, salinity gradients and the timing and volumes of freshwater inflow have been altered, thus impacting conditions for finfish and shellfish in coastal waters (Armstrong 1984). Similarly, in the Great Lakes freshwater systems, volumes and quality of water entering those water bodies are impacted by impoundments (Harris and Sager 1984). Effects of such water quality changes on reproduction, distribution and harvest have tremendous economic importance, but have not been investigated satisfactorily. In both freshwater and salt water systems, the loss of filtering wetlands and the increase in nutrient loading create potential problems that are neither completely understood nor within our ability to control (Spencer et al. 1984, Nixon 1984).

Experimental work involving interdisciplinary teams testing ecosystem-level models in the field must become a more prominent part of our working strategy. Such studies now are being conducted in the freshwater wetlands program of the Delta Waterfowl and Wetlands Research Station in southern Manitoba (Murkin et al. 1984) and in estuaries of North Carolina (Gilliam et al. 1985), but these approaches are rare in coastal systems (Nixon 1984).

Mitigation now is being used more regularly in lieu of damage avoidance, because short-term economic rewards are used to justify development in wetlands. Efforts toward enhancement, restoration and creation of wetlands will increase still further if mitigation banking (Zagata 1985) becomes accepted. Currently, evaluations are too crude to measure the functional success of wetland creation and enhancement, and their permanence and functioning are rarely incorporated into mitigation agreements. Development of more-precise evaluation methods that measure the effectiveness of these actions is a major challenge for scientists.

Cumulative impacts of many separate, permitted actions on wetlands are of great concern. And although some models are being developed to assess the problem in terrestrial systems (Salwasser and Sampson 1985), the assessment of such actions, especially in coastal wetlands, is an ominous and costly task that must be addressed. The functions of wetlands, especially along the coast, are extremely complex. Research there must involve scientists examining physical and chemical aspects of coastal systems as well as microbial, plant, vertebrate and invertebrate components. These studies will yield data useful in a variety of basic and applied modes. It is essential, however, that they also be organized to produce evaluation systems. Without these precise measures of success or failure, we will continue to lose precious bits of wetland and may find—all too late—that wetlands are much more expensive to recreate than preserve.

Reservoirs

Many small and moderate–sized reservoirs and a few large ones, such as the Garrison Diversion system, are under construction or planned. These are either in arid regions where they are desired for water development and irrigation or in areas where hydroelectric power is needed—especially in Canada. This reservoir development provides new lacustrine habitats, but in the process, often destroys wetland or terrestrial habitats and modifies sections of stream and reduces downstream inflow.

The implications of these construction activities are great for fisheries, with opportunities being created for commercial as well as sport fishing. Reservoirs have been expected to meet increased demands for water and water–based recreation, but because reservoir construction has slowed, increased demand must be met through improved utilization. Utilization can be increased by management designed to improve production of desired species.

Reservoir fisheries management has been largely trial–and–error, characterized by attempts to apply management procedures developed for natural systems (Noble 1986). Research is needed to develop principles of reservoir community ecology (Hall 1985), as has been done for natural glacial lakes and streams. For many years, there was progress in this area through the National Reservoir Program of the U.S. Fish and Wildlife Service. This program was just being redirected from an emphasis on fish to an emphasis on functions of reservoir biological systems (Ploskey and Jenkins 1982) when the program was abolished in 1983. A comprehensive program—multidisciplinary and multi–institutional—is needed to address the ecology and management of reservoirs, and universities offer a logical organization to complete such a task.

Exotic and Transplanted Fish and Plants

Another area of research requiring increased activity in the future involves the role of exotic and translocated fishes in aquaculture and fishery management. There are heated controversies concerning the exotic walking catfish (*Clarias batrachus*), grass carp (*Ctenopharyngodon idella*), tilapia (*Tilapia* spp.), and such translocated native fishes as walleye (*Stizostedion vitreum*), alewife (*Alosa pseudoharengus*) and Florida largemouth bass (*Micropterus s. salmoides*). Interestingly, few have questioned the introduction of exotic invertebrates such as penaeid shrimp in Texas. The introduction of disease organisms with exotic fishes and invertebrates is but another area of concern. Research on exotics is essential, and it interfaces nicely with the biotechnology of polyploid induction to prevent reproduction.

Introduction of Atlantic salmon (*Salmo salar*) into commercial net–pen culture in the state of Washington has occurred. Questions concerning the possible impacts of such culture on the traditional commercial fishery for native salmon, the potential for the introduction of diseases, the possible consequences of the establishment of wild runs of these "exotic" fishes, and potential pollution from net pens will require answers. Similar questions can be asked relative to exotic shrimp farming in Hawaii, Texas and other states.

Exotic plants such as hydrilla (*Hydrilla verticillata*), Eurasian water milfoil (*Myriophyllum spicatum*) and water hyacinth (*Eichornia crassipes*) have increased in distribution and abundance in the United States. Even fisheries biologists cannot agree on how much aquatic vegetation is optimal (Durocher et al. 1984, Hoyer et al.

1985). Meeting the needs of water/vegetation ratios for waterfowl, fish, and municipal or industrial uses of water must be done by compromise and optimization. Perhaps exotic plant research needs to shift from problematic situations to the study of patterns and processes that will produce a sound ecological foundation for management. Botanists, zoologists and limnologists collaboratively could conduct well–designed field and laboratory experiments in an attempt to interpret these complex interactions between exotic plants and native flora and fauna. Although this collaboration has not happened at the federal level, the potential for effective collaboration in universities is great.

Pollution Issues

The quantity and quality of water required to provide desirable habitat for fish and wildlife must be assessed thoroughly. This issue is important for all aquatic habitats but is especially critical for coastal wetlands, which serve as nursery areas for fish and wintering grounds for waterbirds. We need: (a) better definition of the habitat requirements and tolerances for many species; (b) more–complete assessment of impacts from watershed practices that reduce instream flow or produce sedimentation (e.g., agriculture, logging, mining and grazing); and (c) measurements of the impacts of industrial and agricultural chemicals. Instream flow studies are an example of progress in this area, but those efforts are only a start. Because of geographical as well as subject matter breadth of such problems, few agencies have been involved in such research. Within a single state, numerous agencies with regulatory as well as management interests may be involved, and cooperation on research projects is difficult to achieve.

Research programs directed at rehabilitation of aquatic systems that have been heavily abused in the past are critically needed. Efforts on Lake Erie and the Chesapeake Bay are examples of collaborative restoration efforts that were founded on extensive research bases. In the western U.S., increasing or maintaining the quality of water for coldwater salmonids is the initial step to restoring or enhancing runs of salmon by improving spawning and rearing habitat.

Fish Genetics

The age of genetic engineering and biotechnology (Abelson 1983) is offering new opportunities for fisheries scientists. Fish have great potential as experimental animals in biotechnology research, due to their large numbers of embryos, ease of spawning and suitability for cryopreservation. Two facets of genetics need to be studied in a comprehensive framework—genetic inventory and genetic management. Although extensive biological inventories are no longer popular in modern fisheries and wildlife research, inventories of genetic variation using modern techniques of assessment and data analysis are essential, especially for game species and endangered species. It is important to know the basic genetic resources, what genetic contamination has resulted from stocking programs, and what reductions in genetic diversity may have occurred due to habitat degradation. Furthermore, artificial aquatic habitats (e.g., reservoirs and ponds) may best be managed using species modified through genetic manipulation (Noble 1986). Gene splicing, hormone manipulations and other techniques are being employed in attempts to "manufacture" aquatic organisms with improved performance, delayed or accelerated maturity, and better body composition. The potentials and dangers inherent in such activities are fairly clear, yet it is not clear that research efforts are coordinated. The development of a national fish genetics program administered through universities has been explored, and the concept has a broad base of support in the states. But the initiative has stalled at the federal level.

Aquaculture

Aquaculture will become limited and may already be limited by the supply of water in some regions. Water resources in Texas, for example, will be depleted in less than 20 years at current rates of use expansion. Areas such as the Thousand Springs region in the Snake River Canyon in Idaho are unique for their high production of cultured trout. Yet, even there, production may not increase significantly. Similarly, the delta region of Mississippi, where channel catfish (*Ictalurus punctatus*) culture is centered, is beginning to feel the strain of water availability.

The integration of aquaculture with other land–use practices holds a good deal of promise. There has been some use of aquaculture effluents that provide some nutrients as sources of irrigation water. There is also the concept of rotating an aquaculture crop with other crops, such as rice and crayfish. Integration of aquaculture into agriculture can also extend to small levels of production from farm ponds where 892 pounds per acre per year (1,000 kg/ha/yr) is easily attainable with catfish.

Specific research is needed on the impact of aquaculture on wetlands in general, and on how much aquaculture pollutes natural environments. Aquaculturists must maintain the best–possible water quality for the animals or plants being reared. Yet, water from a culture facility released into a receiving water body may be viewed as a pollutant. In instances where effluents from aquaculture pose a threat to natural communities of aquatic organisms, new methods of waste treatment must be developed. Sanitary engineers, working with biologists, should address this problem in a methodical fashion.

In the Northwest, there is conflict between landowners and aquaculturists interested in the further development of salmon net–pen culture in Puget Sound. There is also growing interest in evaluation and mitigation of the perceived pollution problem in Puget Sound and in other embayments and estuaries around the country. Continued water and fish sampling to identify a problem that has already been found would seem to be a waste of effort. As in other system–level problems, an interdisciplinary research effort is needed to model such systems and predict the impacts of continued pollution inputs. Such models will point out the researchable gaps in our knowledge and provide insight on studies that should be implemented. Many of these studies may be most appropriate for university researchers, whereas others should be done by governmental agencies or qualified consulting firms.

Meeting Research Needs

In aquatic areas, as in other resource areas, university researchers have at hand a great body of human and technological resources. This potential is not fully realized because of the lack of funding dedicated to broad resource management goals, and failure to obtain multiagency agreement of targets that serve all. Multidisciplinary research is the key to successful resolution of these broad–based problems, and university scientists are perhaps best geared administratively and conceptually to work in this framework. Often, within a single university, there is a large cluster of faculty members with a wide range of interests and who are available to address multidisciplinary research studies. Where this "cluster" does not exist, cooperative programs are developed as consortia among several universities. At hand are facilities for the development of computer–based simulation models of ecosystems useful in generating lists of research needs. Research aimed at addressing those needs will provide positive feedback to the models, leading to the development of new research areas. This ongoing process, by which models generate questions and researchers feed information back, will perhaps be the best mechanism for addressing the difficult problems facing aquatic resources.

University programs often are best designed for long–term research. Turnover of principal investigators is slower in universities than in agencies, because advancement of individual careers is based on continuing and programmatic research results. Moreover, students in many institutions can produce published or publishable papers in lieu of a traditional thesis.

Generally speaking, research in universities is cost–effective, leading many industries to depend entirely on such programs for their applied as well as basic research. Universities provide more results per dollar invested because of available facilities, modest salary scales and fewer restrictions on overtime. Also, graduate students can be put into the field at minimal costs while gaining vital experience to enhance their careers. Although different agencies often differ in goals and approaches, university faculty can be expected to maintain objectivity in their research. With continuing budget cutbacks by federal agencies, better and quicker results can be obtained by such agencies by funding university projects than by adding professional staff. These multidisciplinary projects can be funded through existing legislation, but they will require agency cooperation and mutual agreement on research goals.

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Contaminants: Neglected and Forgotten Challenges

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We are hearing much concern recently as to where the fish and wildlife profession is going, how a declining atmosphere of research might relate to the status of this profession, whether scientific research is actually a problem–solving process or if problem solving is a separate process that should use research as a tool, and how research and profession are related to conservation and management. Gill (1985:580) called wildlife research (after Leopold's 1937 term "intellectual endocrine") the "intellectual enzyme" of the wildlife profession, and stated: "Deterioration and dismantling of wildlife research institutions have alarming implications for the entire wildlife profession." This implies, then, that they also have potentially alarming implications for the conservation and management of fish and wildlife resources.

We are not here to speak for a profession or clientele and, as McCabe (1985:343) stated, ". . . the basic responsibility [we have] as professionals is to the resources. . . ." The concept of "wise use"—usually an integral element of the idea of conservation—still has as its ultimate responsibility the resource itself. It takes a viable profession as a tool to accomplish that, however, and it is thus legitimate to relate the three—profession, conservation and scientific research.

Our society is traditionally committed to research: an American commitment to professional scientific research in the natural sciences goes back to at least 1838 (see Miller 1985). This tradition continues, and it applies equally to fish and wildlife research (FWR), a relative newcomer. And within FWR, and more specifically here to our discussion, this commitment can apply equally to a newcomer within the older but still young field of FWR—fish and wildlife–pollution research (FWPR).

FWPR is one FWR field (although by no means the only one) in which immediate applied uses of data are almost always evident, and this is true of much FWR. But it leads many people (especially policy makers and administrators) to believe that all FWPR must have evident, clear, immediate and practical justifications. (Demonstration of the eggshell–thinning phenomenon, for example, had an influence on banning DDT.) Yet, to mature scientifically and to increase its ability to solve and prevent environmental problems, FWPR must continue to move from a descriptive science to one with sound predictive capabilities based on mechanistic and theoretical insight (see Digiulio 1985). The complete effects on physiological mechanisms underlying how DDT/DDE thins eggshells (i.e., effects on the parathyroid), for example, are still unknown. Yet, FWPR is not a scientific discipline in itself; it is a specialty area within the wildlife management professional subculture (see Kennedy 1985) based on well–founded sciences (as chemistry, toxicology, pharmacology, ecology, ethology, physiology, etc.). (Incidentally, Doull [1985] suggested that toxicology itself has developed a "credibility problem.") The major goals in simple and specific terms are to increase our general understanding and appreciation of how natural biological systems work, by understanding *unnatural* and *natural* phenomena in these systems—as well as helping to solve environmental problems. The science part teaches us not what to think but how to think. Weiss (1977) defined an "enlightenment function" of research in that it gradually changes the general views of policy makers or managers rather than influences their immediate decisions. And this is probably the major role of research. Yet, much FWPR can and does answer specific questions of interest to the resource manager.

The two areas, basic research and management, represent extremes in a continuum overlapped by applied research. More than 15 years ago, Keith (1969:90) challenged ". . . resource policy makers to . . . recognize the futility of [inadequate levels] of side–effects research, and either greatly expand [that] research and formally integrate its results at the appropriate time into resource planning, or admit that short term goals [were] their only interest and that rational planning [was] beyond them." Gill (1985:585) also stated essentially the same idea more recently: ". . . research today on today's questions is too late." We think these same challenges still exist.

More specifically, FWPR can be a valid, specifically named *program* of endeavor within the agencies or universities—as a tool. And that is one thing we advocate here, upgrading a *still–needed* national program. This is the condition where most FWR is, but it must be realized that FWPR and other specialty activities within FWR can and do contribute significantly in empirical and theoretical insight to the more basic sciences, as well as being important and interesting scientific research that actually helps solve important environmental problems.

Like much FWR, FWPR is on the decline, both in interest and in urgency. The FWPR situation is, however, only symptomatic of a general decline in FWR, evidenced *on the surface* mostly by lack of funding (see the symposium in 1979 *Trans. No. Amer. Wildl. Nat. Res. Conf.* 44:141–223). But the causes may be in large part related to lack of interest or understanding as to just what research really is or is supposed to be (see Gill 1985).

Although we believe there will be sufficient basic and applied challenges for fish and wildlife contaminant researchers for some time to come, we do not have the time or space to point out in detail the many areas with potential research needs in FWPR, but we do have some examples and suggestions. There are new problems with new contaminants, old and neglected problems, and new problems with old contaminants. Some needed research is being forgotten "before its time" and other areas are being neglected, perhaps because much funding is directed toward immediate problem–solving applications. The research in these areas must be designed to provide predictions, be based on testable hypotheses and provide generalizations more than specific evaluations of specific contaminants released into specific habitats. The urgencies or significances of some of these might be argued; other needs might be (and should be) added.

Nonpoint Source Pollution

"Pollution," representing both natural and unnatural processes in ecological systems, is a matter of degree. The effects of siltation due to certain land–use practices, such as overplowing, poor erosion control and overgrazing, and of nutrients from sewage plants and agricultural runoff may represent profound stresses to aquatic systems (Eckenfelder 1980). Urbanization around our waterways and efforts to boost crop yields by increasing the uses of fertilizers have also contributed to nutrient enrichments of both letic and lotic systems that, in extreme cases, may even cause direct mortality of wildlife, such as fish kills (Farnworth et al. 1979).

Siltation and nutrients frequently are considered "nonpoint sources" of pollution without easily identified sources, and they may vary quantitatively and qualitatively with time and space. Unlike point sources, which are relatively easily measured, regulated and understood, nonpoint sources are difficult to address. Linkages of responsibility for nonpoint source pollution are unclear, and individual contributors appear insignificant until viewed as part of the whole problem. These problems provide both basic and applied challenges and many opportunities for cross–disciplinary research. These problems apply to contaminants (such as toxicants) as well as such events as acid rain (much research is needed, especially in the wildlife area [see Johnson 1982, Newman 1980, Fischer 1982]), sediments and nutrients.

Contaminants as Catastrophic Ecological Events and Stressors

Contaminants as catastrophies to small, rare or endangered local populations of fish and wildlife are problems that may be increasing in the future. The seriousness of single contaminant events—for example, individual lead poisonings from individual carcasses involving the California condor (*Gymnogyps californicus*) (Scott and Jurek 1985)—should be approached from individual as well as population viewpoints, where parameters such as LD_{50} may not be very useful. Another interesting example is the very limited use of the veterinary insecticide, famphur, still causing population declines of black–billed magpies (*Pica pica*) in Oregon and other ranching areas (Henny et al. 1985). These studies illucidated perhaps one of the most–interesting, recent FWPR phenomena in recent years with a wildlife species because they represent a situation that could never have been predicted from traditional laboratory studies alone!

Continued Study of Familiar Contaminants and Familiar Habitats

Continued work with familiar and "old" contaminants, despite the decline in popularity of such work, and especially in ecosystems and areas where little work has been done, may yield more insight on chemical and ecological behavior of contaminants under different environmental circumstances. This kind of comparative work is necessary to establish predictions and models on chemical behavior and its impact in natural ecosystems. For example, comparing temperate and arctic ecosystems, the behaviors of various toxicants may be completely different (Brown and Brown 1970). Such studies also have important ramifications in establishing patterns of acquisition and behaviors of contaminants in migratory wildlife, a problem with both basic and applied challenges. Contaminants are still a very real problem in some populations of migratory birds. Very good reasons to continue to study more–familiar contaminants are the well–developed analytical chemistries for most of these materials and the lack of methods for some of the more recently used xenobiotics. No work on ecosystem or physiological processes can be done with contaminants and their metabolites that cannot be readily and accurately identified at very low residue levels (ppb, ppt) by the research team. Studies of various classes of contaminants can help establish basic principles governing the movement and fate of contaminants in natural systems. Pollutants as tracers may even help us understand natural ecological processes better. For example, an innocuous, yet traceable, extraneous contaminant might be used in some cases to study the cycling of some elements or other contaminants through normal ecological pathways. Sediments (generally believed to be an environmental compartment where many pollutants are inactivated) may actually prove to be a continuing source to biota of such materials. Recent studies suggesting this have been done on the "old" pollutants, PCBs, as tracer materials (see Larsen 1985).

Recent findings of continued hazard assocated with the insecticide dicofol (resulting mainly from the continued persistence of an "old" contaminant, DDE) (Clark and Krynitsky 1983, Risebrough et al 1986, Hunt et al. 1986) have stimulated new research and new ideas about how hazardous chemicals might originate. Research like this represents the attitudes of a group of researchers that has persistently studied an "old" problem (often despite the lack of adequate funding) from a new viewpoint. Fry and Toone (1981) described the phenomenon of DDT–inducted feminization in gulls (*Larus* sp.) long after DDT was perceived as an acute environmental problem; they stated (p. 924): "Abnormal development induced by DDT in birds could be more persistent than the pollutant itself." The continuing problems with nutrients, siltation and contaminants in San Francisco Bay (Nichols et al. 1986) well–illustrate the need for continued, intensive research on many problems.

Studies such as the ones represented in this section are warranted from two important aspects: (1) understanding and predicting the dynamics and hazards of various types of chemicals and their metabolites; and (2) understanding and predicting the dynamics and hazards of chemicals in different types of ecosystems and organisms over time. These approaches sometimes yield surprises if research continues beyond the stage of faddism or purely applied purposes.

Side–effects Research

Fifteen years ago, side–effects research was the greatest priority in FWPR. The field has proven so complex and diverse, that one wonders if FWPR researchers have not become discouraged by this seemingly "endless tunnel" of newly emerging problems and complications with contaminants. Rattner et al. (1984:688) understated the challenge of side–effects research for today by saying: "Further research on the effects and mechanism of action of environmental contaminants on avian endocrine function is warranted." However, they went on to mention many specific research challenges in the field of endocrinology that could apply in principle to the many possible physiological systems potentially affected by low levels of contaminants. The study of physiological responses is an essential element in the study of environmental contaminants (Widdows 1985), and this challenge seems even greater today than it was in the past. There is a continuing need to understand side–effects and the physiological and behavioral mechanisms of contaminants and various classes of toxicants and other stressors, even though no practical applications are immediately evident. Studies like this contribute to our general knowledge and the eventual predictability of various classes of additive stressors on biological systems and to the empirical base of the fields of toxicology and pharmacology.

Studies of Interactive Effects

Because contaminants in nature are always mixtures, side–effects research must include studies of mixtures of stressors, toxicants plus toxicants and toxicants plus other biological stressors, such as disease, adverse environmental conditions, poor body condition, etc. (see recent examples by Rattner and Camardese 1985, Keith 1978), as well as reproductive, behavioral, population and habitat–modification effects. The dynamics of stress on natural ecosystems as well as individual organisms, as related to contaminants, seems to have much need for further work (see Barrett and Rosenberg 1981, for example). And it is highly possible that some contaminants may even be acting as innocuous or stimulating materials in some situations (for example, see LaMarche et al. 1984 and Paerl 1985)—we need to know this.

Better Hazard Predictability, Use of Indicator Species and Model Systems

Predictability has been a goal of FWPR since contaminants became a problem in fish and wildlife. Yet, the need continues as new insights are developed on old chemicals and new insights are needed on thousands of new materials. Although it is ecologically naive to think that one or two species can be used to predict ecosystem responses, there is need for some kind of model test species (Kendall 1982), system (such as the microcosm), or procedure (Cairns 1980), especially for wildlife (here, the aquatic toxicologists seem far ahead of wildlife toxicologists). The idea of indicator species in contaminant research, although still somewhat open to question (Morrison 1986), needs further development and exploration. The use of the mallard (*Anas platyrhynchos*), bobwhite (*Colinus virginianus*) and ring–necked pheasant (*Phasianus colchicus*) as standard laboratory test species may be inappropriate in many instances.

Hazard evaluation requires intensive research in both the laboratory and field situations. It will probably always require a great deal of intuition, but properly designed studies will yield results that greatly enhance our capabilities. Much of this kind of work will probably end up in the hands of the regulatory agencies (EPA, FDA) or their contractors, where it really belongs. It is important to approach these activities, in addition to toxicity evaluations, from the following viewpoints: (1) relating physical/chemical properties of contaminants to their expected transport, fate and effects; (2) developing pharmacodynamic models; and (3) developing ecosystem models. This area of research needs to move philosophically from toxicity evaluation to hazard evaluation (see Rudd 1975), or ecosystem risk evaluation.

Research designed to increase predictability also requires monitoring. Creative monitoring, testing hypotheses and careful planning and executing of monitoring studies can provide very interesting scientific results. Monitoring for monitoring's sake is not a creative process, and is almost solely for regulatory purposes. Yet, if approached from a viewpoint of trying to learn something about the system being studied, such monitoring might just contribute some important generalities. Creative monitoring requires creative chemistry, although the costs are constantly rising. We still do not have residue or possible impact data for pesticides (for example) that have been registered and used for years.

One recent trend in monitoring has been to decrease levels of analytical sensitivity for "efficiency reasons." This certainly allows a laboratory to process more specimens in shorter time (and, incidentally, then to keep busy and supported on outside contract work). But this does nothing but answer specific questions on specific contaminants—again making potentially valuable research merely a regulatory question on a very specific problem. We think analytical laboratories in research institutions should remain constantly in the "research mode," by keeping ever–alert for previously undetected and/or low–level contaminants. The specialty of FWPR needs good analytical chemists just as any other specialties within environmental toxicology, but it also needs chemists who work with and are familiar with fish and wildlife.

Study Philosophy: Field Research and Long-term Studies

Referring to technological developments, McCabe (1985:344) stated: "Fortunately, none has totally eliminated the need for field work." When the field of FWPR was much younger, Hickey (1970:208) applauded the "new" integration of field and laboratory studies in helping to understand the interactions between contaminants and peregrine falcons (*Falco peregrinus*). He stated what still is sound advice about where FWPR should be: "It is a place for comprehensive hypotheses, critical analysis of field data that inevitably are incomplete, and sound testing wherever possible in the laboratory by the proven methods of science. Naturalists shouldering some of the difficult and still–needed field work will continue to make an important contribution."

Gill (1985) suggested using long–term studies to test many hypotheses in FWR, even in strictly applied work, and the approach is no less important in FWPR. Time–series analyses that allow testable hypotheses in contaminant research are needed to help understand the long–term expectations of various contaminants and long–term perturbations in natural ecological systems. Persistent follow–up studies have often yielded new facts about a situation, after we thought we knew all the answers (previous examples). For example, we now know that some botanical and organophosphate insecticides are really not so non–persistent after all (Rawn et al. 1982).

Studies of Specific Industrial or Agricultural Activities

This list is potentially a long one, so we provide only a few general suggestions. There is a continuing need in contaminant research for study of developing industrial or agricultural activities for possible contaminant problems. These studies, too, must be approached from the scientific rather than regulatory viewpoint, with the intent of learning how these activities and their resultant contaminants might interact with natural biological systems. These studies should also be approached from the viewpoint that some generalizations and syntheses will result from the research rather than mere regulatory statements (which may be critically important, as well). Who is better able to comment on the biological ramifications of a situation than the researcher who studies that system? So FWP researchers, be prepared to get involved in the regulatory process—it seems to be a fact of life for the field of FWPR. Some examples of specific types of activities that require scientific study are: water development projects; evaporation ponds (Zahm 1986, Ohlendorf et al. 1986, Nichols et al. 1986), stormwater drainage for urban wildlife, urban pesticide use in landscaped areas, offshore oil development, energy development and other development projects.

Discussion

The intent of this essay is not to provide a comprehensive list of where scientific research is needed in FWPR. Instead, we wish to stimulate more interest. To us, the research needs are real and apparent. Perhaps, challenges have not changed much in 40 or so years of research (see Pearce 1986) regarding the needs and ideas of FWPR. Science requires long, patient observation and follow-up. The process is nothing new, although some of the problems may be. The beauty of science and discovery is finding out how much we really do not know about something and then developing the understanding—but this is not very satisfying to regulators and administrators. There are plenty of challenges in the future for the fish and wildlife pollution researcher, but how do we convince society to support the needs?

Could public perceptions of FWPR have anything to do with its problems? First, people outside the fish and wildlife field must recognize the value of FWPR beyond the field of wildlife and fisheries biology, or more than how it has been applied strictly to fish and wildlife conservation problems. Philosophically, we can logically define two viewpoints for study and action in the FWPR field as justification to convince the public to allocate more support for such research. First is the *resource approach,* which means that contaminants in fish and wildlife are studied as they relate to resources that are managed or protected as economic or aesthetic entities in themselves. These resources can also be regarded from another viewpoint, which might increase their value to the public at large. Second is the "*canary*" or *indicator species approach,* which means that fish and wildlife are used as monitors of environmental contaminants to predict effects in other areas (domestic animals, other species or ecosystems, or human health aspects). In FWPR, there is no other area where scientific study can be and has been effective in helping to alleviate or understand more general environmental problems (but that must not be its major justification). The obvious applied aspects of FWPR may have been a "double-edged sword," for it has led "outsiders" to expect a practical application for every bit of research (after all, one of our major points here is that the FWPR process, as a mode of discovery, needs to be understood and accepted).

Could our view of FWPR from "inside" the wildlife profession have anything to do with its problems? Gill (1985), citing Mayer (1984), believed that managers and educators are to blame for the deterioration of FWR in general, in that an "arrogance of ignorance" or "we already know it all" attitude can develop. Some universities may not be teaching students how to "differentiate between a scientific observation and a . . . belief." This could be a very serious problem because it takes us farther away from the need for scientific insight and research, and eventually leads, then, to uninformed decision making. Thus, research is far from being a luxury—it is a necessity.

We believe the agencies have also contributed strongly to the decline in the FWPR because they have major control of research funds. McCabe (1985:344) stated: "The wildlife profession is not buttressed by, nor does it cater to, any aspect of commerce, and rarely is it voluntarily funded directly by an industry. Most financial support comes from governmental sources." Just as wildlife programs at some (but by no means all) educational institutions allow "semi–educated" professionals to graduate without adequate science backgrounds, agencies have limited their ability to ensure the highest caliber FWPR by allowing noncompetitive expenditures of research funding. In FWR and FWPR, by failing to enlist outside research performances, especially on controversial issues, the agencies, therefore, have also contributed to this decline. The self–appointed "rights of first refusal" (giving internal researchers unchallenged first option on stated research needs) operating in many agencies, for example, only tends to provincialize FWPR (and FWR in general). Even within the U.S. Fish and Wildlife Service (USFWS), for one example, solicitation frequently goes only as far as the Cooperative Fish and Wildlife Research Units. This leaves untapped a large body of potential expertise at non–unit schools and elsewhere. It is interesting, that in a recent review of federal sources of funding for unsolicited ecological research proposals, the USFWS and the U.S. Bureau of Land Management were two federal agencies among the 10 listed that do not even regularly issue RFPs (Requests for Proposals), let alone accept unsolicited proposals (Matthews 1986). Press (1986) shows that of the 11 federal departments, Interior has the greatest percentage (95 percent) of intramural expenditures. Research should seek out the best talent available, and nobody can believe that all this expertise is within the agencies.

Internal agency research funding (too much of it) is also too subject to internal, political control. For example, should an agency responsible for management and policy also be responsible for the research leading to it? Unfortunately, the "outsider" academic and private research institutions are generally ignored in noncompetitive, "inbred" research like this, or in the funneling of funds from "sister agencies" or groups to sustain their own bureaucracies. Thus, funds for FWPR need to be allocated on a more competitive basis and internal research organizations *within* the agencies also given more academic freedom to pursue "discovery." As Gill (1985:586) stated: "Those states with vigorous research sections in the past, but which sacrificed them on the altars of expediency and economy, have lost much of their vitality." We, therefore, need to protect the free research process in FWPR both inside and outside the agencies. And, researchers need to be in the field "snooping around." We also need more "informed devil's advocacy" to maintain vitality in FWPR, and managers/policy makers should not fear it. A fundamental role of university academic freedom is to act as a source of informed dissent or support to governmental agencies. We also need more open critiques of project design and results, not along philosophical lines, but along technical lines.

Lack of independence in agency field station projects by too much centralized influence also damages the FWPR investigative process. In cases where there is too much central agency emphasis on projects of immediate nature (regulatory problems, short–term responses to public and/or political–administrative pressures, etc.), administrators should either face the fact of being purely problem solvers, or begin to support more basic research through more–diverse outlets, but at least make a commitment to it through a competitive process. The applied process is important, as important, but it should not dominate the FWPR process. In fact, the next meeting of the American Fisheries Society (1986) will have as its main theme "bridging the gap between basic science and fisheries management" (Anonymous 1985). That acknowledges another area of need—more cooperation and communication. We really do not (nor will we ever) know enough about contaminants to eliminate the need for pure basic research in FWPR.

As Labisky et al. (1979) stated, academic institutions are an underutilized resource in FWR (and, therefore, FWPR)—it is a resource the agencies are wasting. It is timely that Press (1986) proposed a widened, more competitive system for basic research funding from federal sources in general. Glick (1983:191) was referring to the discovery of the bursa of Fabricius, but his comments also were applicable to FWPR: "The goal of university research should be the search for truth, and scholars should be free to pursue an idea for the sake of the idea. The bursa's secret would still be held by the chicken if truth were not the universities' main goal. . . . It would, therefore, be self–defeating to force universities to adhere to the numerous guidelines practiced by industry and government." Ironically, to protect the research process, this philosophy even needs to extend to research institutions within the governmental agencies themselves, to the extent that it is practical. Perhaps our wildlife profession is in trouble because we have left too much of it to too narrow a field—the agencies.

Admittedly, much of the decline in FWPR may be due to a general deemphasis and disinterest in wildlife pollution problems (or wildlife and fisheries in general) caused by recent budgetary restrictions (see Crawford 1986). In fact, budgetary strategists have just recently instigated poorly planned, additional cuts in federal academic research funds (Norman 1986), further eroding institutional abilities to conduct basic research. It is also somewhat telling that, in the special contaminant session at this meeting, two papers importantly point out research needs more than research results. The real needs for research require that the research process become more efficient (Press 1986), and research/management, agency/institution coordination become closer and more cooperative. We need a system of checks and balances to ensure that the scientific process yields free, untethered knowledge, no matter how controversial or negative to our policies, and as efficiently as possible. Our arguments apply to both applied and basic research.

The spread of fish and wildlife management and study from a few to many agencies, for example at the federal level, is encouraging (from almost solely the USFWS historically to USFWS, Bureau of Land Management, Soil Conservation Service, Forest Service, National Park Service, Environmental Protection Agency, etc., today). It means fish and wildlife conservation (and research) have a wider acceptability and appeal. With the potential "dilution" of fish and wildlife effort away from only a few organizations, then it will also be necessary to promote more activity in FWPR through competitive funding and not to rely on one or a few wildlife agencies to conduct and control most of the research.

Summary

Fish and wildlife pollution research suffers from several major detriments (these detriments are related to problems of wildlife research in a broader sense): (1) declining interests and priority despite continued, unsolved, basic and applied problems; (2) lack of scientific rigor and academic freedom in many cases; and (3) lack of understanding between what managers/administrators/policy makers think research is and what it is "supposed to do." Intra–agency wildlife pollution research probably suffers most because of lack of competitive funding procedures, excessive potential internal control, self–serving, self–perpetuating policies, and lack of funds (which is a symptom as much as it is outside the agencies). Much intra–agency research suffers from lack of "academic freedom" needed by their internal research institutions. On the "outside," academic institutions are far underutilized, despite the large reservoir of expertise available.

The general field of pollution research may still be active, but fish and wildlife pollution research seems to be declining. FWPR has made many significant accomplishments in the past and we can be proud of them. Yet this needs to be recognized by "outsiders." Wildlife pollution researchers must convince society that FWPR, although valid for its own sake in aiming to help understand and conserve fish and wildlife resources, has many additional values outside the resource. People outside the area of fish and wildlife research are failing to recognize the "canary potential" of these resources.

The academic institutions are currently underutilized for a number of potential reasons, yet we also emphasize that research institutions within the agencies are being deemphasized in many cases. The needs and challenges are large and there is "room" for everyone in an expanded, more–serious effort. Regier (1985:25) in evaluating the fisheries profession has said: "My words are not important in the shadow of our justified fears of nuclear conflagration, widespread human famine and continuing abusive degradation of our biosphere. Yet maybe our profession can do its little bit for humanity a little bit better." In FWPR, we can do this. And we can also do our part to understand better and help eliminate where necessary the degradation of our biosphere.

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Endangered Species: Role of University-based Research

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Introduction

University–based scientists will always play a crucial role in research on endangered wildlife species. Although it remains practical for governmental wildlife agencies to include staff specialists that deal with each of the relatively few game species the agencies must manage, it is impossible for them to have enough staff specialists to deal with each of the growing number of species that are endangered and in desperate need of research that will form the basis of recovery efforts. The only pool of professionals possessing specialized knowledge of such a diverse range of organisms is found in universities. University–based scientists not only have the taxonomic breadth to cover the diversity of endangered species, they also include specialists who deal with the functioning of the various ecosystems in which these species reside.

These university–based specialists can not be replaced by wildlife generalists in governmental agencies. Endangered species, unlike most game species, are an unforgiving lot. Often there is little time to work out a management program by trial and error; the initial approach must be a satisfactory one, for second chances are hard to come by in endangered species management. In contrast, many faulty decisions involved in game management, such as a year of underharvest or overharvest, can be remedied in a year or so with no lasting consequences. This type of precision in management requires the input of scientists who are very familiar with a species' life history and ecology. Perhaps more so than in any other area of wildlife management, endangered species require specialists who are found only in universities.

Growing Needs for Endangered Species Research

There is clearly a high–priority need to expand research efforts devoted to endangered species, and most of that expansion should probably take place at universities. Since conservationists first began keeping them, endangered species lists have been steadily lengthening. For birds, the first *Red Data Book*—the official catalogue of the world's endangered species—was published in 1966 and listed 104 species (Vincent 1966). The second edition, compiled 12 years later, listed 240 species (King 1978). During that 12–year period, the number of identified endangered birds had been doubling every 10 years. Similarly, in the years between publication of the first mammalian *Red Data Book* (Simon 1966) and its revision in 1978 (Thornback 1978), the number of listed endangered mammals had been doubling every eight years. There is no indication that the rates at which new species will join the endangered lists are likely to slow; instead, the rates are accelerating.

If research and resulting management do not keep pace with this expanding threat to the world's diversity of wildlife, the consequences will be catastrophic and irreparable. On the basis of these consequences, endangered species should have high priority among competing demands for funding in the wildlife arena.

Priorities for Research on Endangered Species

Because the needs for work on endangered species exceed available sources of funding, researchers should prioritize their activities in order to concentrate research where threats are most severe. There are several possible ways to prioritize work on endangered species. Taxonomic priorities have questionable biological justifications, but it is clear that they have played a dominant role in the allocation of research funding to date. Birds and mammals have received a disproportionate share of attention.

An alternative approach would be to establish priorities on an ecological basis. Highest priority would be given to conservation–oriented research in ecosystems containing high concentrations of endangered species that are threatened by similar problems. One of the advantages of this approach is that research efforts for one animal are likely to produce simultaneous benefits for many other endangered species in the same ecosystem.

An analysis of the listings of endangered vertebrates in the *Red Data Book* series (Honegger 1975, Miller 1977, Thornback 1978, King 1978) clearly reveals where and why the species of concern to wildlife managers are concentrated. In Table 1, we present a profile of the major threats to the 674 endangered vertebrates of the world. Habitat loss is clearly the most important issue, and research into ways to reduce the impacts of development should have a high priority among wildlife researchers. Where should their research be concentrated with respect to the earth's

Table 1. A summary of the major threats to the world's 674 endangered vertebrate species, based on information from the *Red Data Book* series (Honegger 1975, Miller 1977, Thornback 1978, King 1978).

Type of threat	Number of endangered species[a]	Percentage of endangered species[a]
Habitat loss	449	67
Overkilling by man	288	43
Introduced species	127	19
Loss of food supply	25	4

[a]Numbers total more than 674 and percentages more than 100 because many species are subjected to several threats.

Table 2. Ecological distribution of habitat loss as a threat to the world's endangered vertebrate species, based on information from the *Red Data Book* series (Honegger 1975, Miller 977, Thornback 1978, King 1978).

Ecosystem	Number of endangered species[a]	Percentage of endangered species[a]
Freshwater systems	178	40
Tropical forests	112	25
Islands	75	17
Montane systems	16	4
Temperate forests	13	3
Deserts	12	3
Others[b]	82	18

[a]Numbers total more than 449 and percentages more than 100 because some species occur in more than one ecosystem.
[b]Including grasslands, caves, several marine systems, and combinations of terrestrial ecosystems, each of which contains fewer than 3 percent of the total.

major ecosystems? In Table 2, we show the ecological distribution of habitat loss as a threat to vertebrates. Freshwater systems and tropical forests alone contain 290 (65 percent) of the world's 449 vertebrates that are threatened by habitat loss.

We suggest, on the basis of this simple analysis, that the highest priority issues for endangered species researchers should be: (1) mitigating habitat loss in freshwater systems and tropical forests (43 percent of all endangered vertebrates would be included); and (2) controlling introduced species of islands and freshwater systems (an additional 17 percent of all endangered vertebrates would be included). By focusing research efforts in these ecological areas, 60 percent of the world's endangered vertebrates might be helped.

Funding Sources for Endangered Species Research

University–based scientists who do research on endangered species must rely on diffuse and meager funding, much of which comes from sources that are not traditional providers of money for applied wildlife research.

The largest portion of the support for university–based research on endangered species comes from traditional sources within state and federal natural resource agencies, especially the U.S. Fish and Wildlife Service's Office of Endangered Species. During the 1985 fiscal year, the U.S. Fish and Wildlife Service's support of university–based research on endangered species amounted to $1.6 million—6 percent of the agency's total research budget for endangered species.

An increasingly important source of funding from state wildlife agencies is derived from revenues from income tax check–off programs specifically designated for endangered species programs. In 1985, such programs were operating in 33 states. Money raised by these programs has supported a small but growing number of university–based research programs, although specific figures are not available.

The Endangered Species Act of 1973 has greatly expanded the sources of federal support for endangered species research. Section 7 of the Act made all federal agencies—even those not directly concerned with wildlife—potential sources of support. When conflicts occur between an endangered species and an agency's activities, there is often the need for research to clarify issues associated with these conflicts. Involved federal agencies have often turned directly to university–based researchers for help. As a result, such unlikely agencies as the Department of Defense have funded endangered species research.

A number of nongovernmental organizations have also played important roles in supporting research on endangered species. Several of these organizations, such as the World Wildlife Fund, specialize in supporting endangered species projects, and a significant proportion of that support goes to university–based researchers. In 1985, World Wildlife Fund (U.S. Appeal) funded $3.6 million of endangered species research, and 9.7 percent of that support went to university–based scientists. Similarly, in 1985 the New York Zoological Society's Center for Conservation and Wildlife Research supported $1.0 million of research, 19.4 percent of which went to university–based scientists.

A few researchers have been successful in obtaining support for "conservation biology" (a popular euphemism for work on endangered species) from traditional sources of basic research funding, such as the National Science Foundation. Contributions to endangered species research from these sources remain, however, scant and unpredictable.

Because endangered species are evocative symbols to a large segment of the American public, some university–based researchers have appealed directly to the public and private foundations to support their research activities. Perhaps the most notable success has been The Peregrine Fund, formed by Professor Tom J. Cade of Cornell University to raise money for the study and preservation of falcons and other birds of prey. In 1985, The Peregrine Fund attracted $1.1 million, of which 23 percent came from private individuals or foundations.

Especially in developing countries where endangered species problems are typically more serious and intractable, a small but increasing amount of research support has come from development agencies, such as the World Bank and the Agency for International Development. As the disastrous consequences that development projects can frequently have for wildlife have come to light, these agencies have increasingly had conservation "strings" attached to projects. There are currently two new bills in Congress that would require the Agency for International Development to provide not less than $10 million for conservation work in areas where development is being promoted. University–based scientists have been involved in endangered species work supported in this manner.

As the foregoing discussion implies, university–based research on endangered species has diverse sources of support. This diversity is no doubt owing to the evocative character of many endangered wildlife species and the current enthusiasm of the public for efforts to preserve threatened species.

Has Funding Kept Abreast of Needs?

Because the number of endangered species is steadily growing, one might expect that funding for research on these species would also be growing. Instead, several lines of evidence (Table 3) suggest that funding for endangered species research has actually remained relatively stagnant for the past decade. Although overall amounts spent on endangered species have been increasing, there has not been a concomitant rise in the amounts devoted to research. The consequences of this lag in funding of

Table 3. Trends in funding for endangered species research, 1975 to 1985.

Funding source	Total funding for endangered species programs[a]		Funding for research[b]	
	1975	1985	1975	1985
U.S. Fish and Wildlife Service	$12.0	$27.1	5	6
World Wildlife Fund	$1.1	$3.6	21	10
New York Zoological Society	$0.1	$1.0	29	19

[a]In millions of dollars.
[b]Percentage.

research will be felt most acutely during the closing years of this century, when numbers of endangered species are predicted to rise sharply. Lacking an adequate base of information upon which to make conservation decisions, wildlife managers charged with preserving these species will be severely handicapped at the very time when demands on their skills will be greatest.

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Urban Wildlife Management: The Challenge at Home

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Urban wildlife and its habitat are seldom focal points of research and management programs even though, in one way or another, this resource affects the largest portion of the nation's human population. Approximately 8 out of 10 people in the United States are urbanites. The great metropolitan areas of the east and west coasts, the Southwest, and elsewhere are experiencing incredible growth and expansion into surrounding rural land. Development of new housing areas with accompanying shopping malls and support services is consuming open space at an alarming rate and with little regard for the natural resources of the area.

Recent figures (MacConnell 1984) reveal that, since 1951, in the Cape Cod area of Massachusetts, land has been urbanized at the rate of 3 percent per year, largely at the expense of forest and agricultural lands. Other sections of the country having dense human populations are likely experiencing similar changes in land use that drastically impact wildlife.

Wildlife of urban areas include not only the obvious species, but also the more—secretive reptiles, amphibians, mammals, birds and, in some situations, life within local waters.

The Urban Habitat

When new communities are developed or old ones are redeveloped for humans, physical changes in natural environments are not always negative for wildlife *per se*. The impact of development or redevelopment depends on how drastically natural features are changed, i.e., whether such amenities as greenbelts, parks, stream borders, wetlands, or backyard trees and shrubs are retained or eliminated. Favorable wildlife habitat is created in development areas with planting of roadside trees and shrubs or, indeed, by construction of buildings that provide ideal nesting and roosting areas for some species, albeit sometimes unwanted. Wildlife generally exists in towns and cities incidental to infrastructures and to man's associated activities. Features attractive to desirable wildlife are not often incorporated in planning urban growth or revitalization.

Physical characteristics of cities with their problems of waste disposal, air pollution, channeled streams, rapid runoff of water, erosion and sedimentation because of buildings and pavements, exotic trees and shrubs, and concentrated uses of fertilizers and pesticides have direct impact on the relative abundance of wildlife.

Urban environments are interesting and complex as they involve natural resources in relation to political, social and economic aspects. From an ecological standpoint, they are artificial entities without natural successional stages. One only needs to stroll among towering buildings to realize the prevalence of microclimates dominated by strong wind eddies and heat radiation. On downtown streets, we can feel sharp cold winds of winter in the northern climes and the searing heat of pavement during hot weather. To understand fully the intricacies of the urban ecosystem and to predict the response of wildlife, we need to formulate models using results of biological investigations. But of equal importance are the social, political and economic forces that also must be understood.

Research Needs

We know little about the needs, welfare and habits of most wildlife living in urban areas. The reasons are many, but the principal deterrent to advancement of knowledge is lack of funds for much-needed basic and applied research involving several professions.

Nationwide, most wildlife research is done on game species because money is provided directly or indirectly by the prime users—hunters, fishermen and trappers. Though the general public (including urban residents) is interested in wildlife, ways of collecting and funneling funds sufficient to support management and research programs directed to the myriad of wildlife species in urban environments have not been fully developed or implemented. Using state income tax-rebate checkoffs, special taxes on such items as soft drinks or other approaches, over half the states now provide limited funds and programs for nongame, but urban wildlife receives little attention. While urban wildlife benefits some from nongame programs, total support for studying urban wildlife is woefully inadequate.

Results of a survey conducted by the Urban Wildlife Committee of The Wildlife Society and reported on by Lyons and Leedy (1984) showed that, in 1983, only 6 of 42 states responding to a questionnaire indicated that they had specific urban wildlife programs, though 11 others reported that urban wildlife was addressed as a component of some other program. The survey also showed that the support of federal agencies, alike, was extremely limited for urban wildlife research *per se*. Results of a survey being conducted by the 1985–86 Urban Wildlife Committee to determine the nature and extent of urban wildlife programs in universities should be available soon. It likely will show that indicated research needs in the urban wildlife field are far in excess of the funds available. There are enough pertinent problems for researchers in private conservation agencies to play an important role too, as suggested by Miller et al. (1983).

Wildlife in urban settings have values and requirements about which we know very little, and the scope of which goes far beyond investigative abilities of biologists. To understand better the nonbiological parameters involved, input of several professions—i.e., the knowledge, methodologies and interpretive abilities of social and political scientists, psychologists, medical doctors, economists, educators, building architects, landscape architects, meteorologists and engineers—is needed. Outdoor environments of cities and towns are diverse, as are the interests and needs of urban residents. To understand the human to "animal," "animal" to "animal," and "animal" to urban infrastructure relationships, a wide variety of research is prerequisite.

Durward Allen (1974) asked at A Symposium on Wildlife in an Urbanizing Environment, "What will be the demands and choices of the twice as many people living in our towns and cities within a few decades?" This is but one of many pertinent questions that must be addressed through well planned research dealing with urban animals. We must also ask: "What are the internal factors of the ecosystem? What are the positive and negative health values of urban wildlife? What are the needs of individual species of animals? How can habitat be enhanced for desirable species? How can populations of unwanted wildlife be kept at tolerable levels?" Scores of other questions require answers so we can intelligently encourage or discourage wildlife species deemed important to urban life.

Some wild animals—e.g., white-tailed deer, raccoons and gulls—have become so numerous in some urban areas that they are health hazards, destructive to natural and ornamental vegetation, or dangerous to ground and air traffic. We recognize that unwanted wild animals in urban areas, including busy out–lying airports, cannot be controlled by traditional methods, yet suitable alternative techniques have not been developed. Life of urbanites could be made safer and more pleasant if nuisance wild animals could be controlled by new methods acceptable to the public.

We know little about the impact on birds of artificial feeding that is done so commonly. In some suburban areas, nearly 80 percent of the households offer seed to birds during winter. Does such feeding result in higher survival rates and the production of more birds? Has it enabled species like cardinals, tufted titmice and mockingbirds to survive farther north? Does it affect the onset of the breeding season and perhaps result in the production of young before the insects, on which some young birds depend for food, are available?

Heavy populations of urbanites in themselves lead to some wildlife interactions or problems. Some of the problems may be largely a matter of mindset or lack of knowledge about wildlife—undue fear, for example, of getting bit by a rabid raccoon. If, through research and education, residents could be better informed and have a better understanding of urban ecology, urban wildlife management programs would likely be better supported. Also, management programs for wildlife outside of megalopoli would be affected because urbanites constitute the major voter bloc in this country and, therefore, have the greatest influence on political decision making both within *and* beyond city limits. Consequently, basic studies of the value of all wildlife to people of all means are important to biologists and managers developing management schemes.

The value of wildlife to people in urban areas is a wide–open topic for research and extremely important for planning and implementing resource programs in urban settings. What people want and what they are willing to pay or do to have what they want must be determined by sociological studies. Biologists need to know who the clients are, how many there are, what priorities they place on opportunities to observe animals locally, and whether they feel that aesthetic, recreational, educational and other values outweigh property damage and nuisance.

No one yet has convincingly shown the health values of a pleasant environment shared by wildlife and people. Perhaps psychologists and medical doctors could determine if a biologically diversified environment in which urban residents actively participate (e.g., urban fishing, butterfly gardening, general gardening, backyard birdwatching) results in healthier, more–perceptive people and fewer crimes. If this could be demonstrated, it might be much easier to get financial and other support for urban wildlife research, planning and management. Urban wildlife might be a more–important component of the human environment than we realize.

Effects of urbanization on game or other animals within cities and suburbs are little understood. Food habits and behavior of raccoons and crows, for example, are different than they are in urban areas. Are these differences due to the nature of the food supply or because of other factors? We ought to know more about wild animals in urban environments as carriers of diseases and parasites in relation to the same species outside of cities and towns, and the extent to which they transmit diseases to humans and domestic pets. Results of wildlife investigations conducted in rural or wilderness areas are not generally appropriate for interpreting ecological associations or the biology of wild animals within human population centers, nor do they provide the information needed for planning and management in cities and suburbs.

Research should also be directed at the meteorological aspects of urban environments as compared to rural or wild areas. Are microclimatic conditions sufficiently different in northern urban areas to warrant selection of plant species for landscaping that ordinarily would be more suitable for zones to the south? Are edaphic conditions enough different to require that added precautions be taken in planting programs in inner city reconstruction where the soil is compacted and often intermixed with rubble?

Research is needed to provide guidance and detailed information to urban planners and developers about what can be done to retain existing productive wildlife areas, improve existing habitat or develop *new* habitat. Wildlife professionals have little *specific* information that they can give to planners and developers, such as: minimum widths for buffer strips of vegetation along streams or around wetlands to be effective for erosion control and wildlife; the needed frequency of mowing open areas to maintain vegetation at the desired stage; and the types, distribution and abundance of plants that may best provide aesthetic and wildlife values throughout the year.

Guides for urban residents to make yards attractive for wildlife require that studies be made of patterns of vegetative plantings, use of various shrubs and trees by wildlife, and placement and use of different types of bird feeders, nesting boxes and such structures as rock piles and pools.

Some research should focus on architectural design and quality of construction of buildings to make them less inviting to house sparrows, starlings, pigeons and other nuisance birds and mammals. Builders need to know more about size of openings and the nature of exposed ledges, etc., that result in bird use, so construction is of a type to discourage such use.

If valuable wildlife species are to be attracted to urban environments, engineers need to know how best to design stormwater basins, urban marshes and tertiary water–treatment ponds to accommodate waterfowl, shorebirds, amphibians, fish and other wild animals.

Thus, planning and management for urban wildlife will require more than just the biological approach. Drawing on other professions, through cooperative research, can supply answers to many of the problems. Managers of urban wildlife and habitats must have sufficient information to suggest how to make urban areas more pleasant for humans to live.

Cross–disciplinary Opportunities in Research and Management

Wildlife professionals can provide effective management programs for urban wildlife only with substantial assistance from experts in other fields related to the urban environment and its people. The following professionals, with background information and guidance from wildlife biologists, could provide valuable assistance in developing programs related to wildlife:

Landscape architects could aid in the selection and layout of plantings, and in the maintenance of trees, shrubs and other vegetation valuable to wildlife;

Meteorologists could provide information on very local climates, relative to optimal growing conditions for valuable plantings;

Architects could incorporate features in external design of buildings that would discourage unwanted wildlife;

Engineers could locate and design travelways, drainage systems and parkways conducive to wildlife;

Medical doctors could evaluate the benefits of wildlife and related resources on the physical well-being of sick and healthy people;

Psychologists could evaluate the benefits of wildlife and related resources on the psychological well-being of citizens;

Sociologists must be enlisted to determine dynamic public attitudes toward wildlife and wildlife habitats.

Economists must help identify and quantify economic impacts of urban wildlife—both positive and negative;

Educators are an essential informational link to the public;

Lawyers could assist with legal aspects of nuisance animal control, control of animal damage, zoning, acquisition of property and easements, and liability for use of land for wildlife purposes.

Summary

If wildlife management programs are to be applied intelligently in urbanized areas, much additional research is necessary to unravel the complicated urban wildlife-related problems. These problems encompass a broad spectrum, from biology to social sciences, medicine, engineering and law. Biologists alone cannot do the job. Experts from other professions are needed to help, but above all, money for the required research and management programs must be provided on a sustained basis. To people living in cities and towns, wildlife can be a distinct asset in their daily lives or, sometimes, a liability. Wildlife professionals and others, working together, can make an urban environment more pleasant by encouraging populations of desirable species of wild animals adapted to urban life.

Perhaps the greatest value of wildlife to people living in cities and towns was expressed in a statement by Allen (1974) at the 1973 symposium on wildlife in an urbanizing environment: "We have that greater challenge of using wildlife in the dooryard to remind urbanites that there is *still* a world of nature." To us, this suggests that a great deal more research and management needs to be applied to the urban wildlife resource.

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Wildlife Prescriptions for Agricultural, Range and Forest Landscapes

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Farmlands

Certainly, there should be no surprises about the problems of wildlife on U.S. agricultural lands today. One or more (and in many cases, *all*) of the essential habitat elements for wildlife—food, cover, water and living space—have been erased on the majority of our nation's prime farmlands. As is well-documented, clean farming—with attendant losses of woodlots, streamside vegetation and many U.S. Soil Conservation agricultural production practices—has taken control. In retrospect, it seems that conservation response to the "dirty thirties" is down the tube.

In the meantime, we are experiencing accelerated soil erosion, along with loss of wildlife habitat. Going back to fundamentals, topsoil loss equates with the loss of the essence of productivity for all crops—grains, pasture *and* wildlife. Add to this, irreversible losses of prime farmland (and their wildlife) to highways, reservoirs, and commercial and residential development, and the scope of the problem becomes even broader.

How can we address this problem? State and private agencies can provide and have provided refugia for farmland species, via "Acres for Wildlife" and the like. However, if we are to witness a resurgence of farmland species, we must look to much broader programs, especially those of the U.S. Department of Agriculture. Most farmland wildlife species do not respond to a "bit here and a tad there"—they need county-wide efforts, or better yet, state-wide or region-wide efforts.

The track record of USDA has not been all that good. "Farm programs" have ranged from subsidizing intensified use (to the detriment of wildlife and soils), to "set-aside" programs. The effect on wildlife of set-asides, in turn, has varied from program to program, such as the "Soil Bank," which had major positive impacts on farmland wildlife (albeit incidental and largely unplanned), to the PIK program, with essentially near zero benefits for wildlife.

Now, there seems to be hope. The new (1985) Farm Bill provides "sodbuster," "swampbuster," long-term diversions, and other conservation provisions to the potential benefit of wildlife. However, the proof of this pudding will still boil down to how county ASCS committees, soil and water conservation districts, farmers and others will adapt and implement the new "Farm Bill" provisions. What looks good on paper may change a great deal when the plow meets soil.

Regardless, there is critical need for research on the biological and socioeconomic impacts of this new legislation (the Food Security Act of 1985) on wildlife, soils, water quality and agriculture. And, together with such research, we need to gather more data on the influence of "conservation/minimum–tillage" techniques—again on soils, crop production and wildlife. There is a real "need to know," which can only be accomplished by research. We must keep in mind that wildlife serves as a barometer for our future. What harms wildlife, harms us—on farmlands, rangelands and woodlands.

Rangelands

A reasonable abundance of wildlife is compatible with some forms of livestock use on some western rangelands. Pronghorn antelope populations reach sizeable numbers in the presence of cattle grazing in the plains of Wyoming and Trans–Pecos Texas. Cattle grazing and deer are generally considered to be compatible in the Intermountain West, although there is some dissent from this view of interspecific compatibility in the arid Southwest.

But the more general situation is one of competition. Livestock compete with numerous forms of wildlife directly for range vegetation used for food and, over a longer time period, change vegetation composition away from that needed by wildlife species. The great majority of uncultivated, nonurban land in the western U.S. has been grazed by domestic animals for more than a century, and the influence of livestock has been ubiquitous. However, with wildlife today but a small fraction of their pre–Columbian numbers, livestock grazing probably has been the most pervasive influence for ecological change in the West.

These statements are not value–loaded or in any way intended as a condemnation of the livestock industry. The American public has wanted wool, mutton, beef and leather; it has set its priorities and made its tradeoffs. Over most of the history of the West, wildlife production has been incidental to dominant land uses, and not the result of advertent wildlife management programs.

These statements are made to emphasize the strong causal relationship between wildlife abundance and land use, and the consequences of land–use decisions and land–management programs directed at resources other than wildlife. Those decisions and programs, in turn, are importantly determined by land ownership. Roughly half the area of the 11 western states is private land. And most of the land in the five Plains states is privately owned.

Land–use decisions on private land obviously have a more compelling economic motivation than those on public land. Decisions favoring wildlife will depend on the return from that resource to the landowner or, at the very least, they must not interfere with the dominant economic use. There are a few opportunities from which ranchers have realized a financial return from wildlife, notably in Texas, where landowners traditionally charge sizeable fees for hunting. In Wyoming, hunters purchase pronghorn tags along with their licenses. The tags are given to landowners when animals are bagged and subsequently are redeemed from the state for cash. Elsewhere, individual ranchers charge hunting fees.

But, over most of the ranching areas of western U.S., livestock rearing is still the major source of income, and land–use decisions are made accordingly. Of that half of the 11 western states in public ownership, roughly two–thirds is Public Domain, managed by the U.S. Bureau of Land Management (BLM) and roughly one–third is national forest managed by the U.S. Forest Service (USFS). In earlier years, management policies were strongly oriented toward commodity production—livestock and minerals in the case of BLM, timber and livestock in the case of USFS.

In the past several decades, however, these agencies have increasingly adopted a multiple–use posture. In the eyes of some critics, the change has not been extensive enough. But the trend has been in the right direction, and one can look at the glass from the standpoint of how full it is rather than how empty. Between 1973 and 1981, for example, BLM increased its budget for wildlife habitat nearly four–fold—from $3 million to $11 million. Moreover, the lands administered by these agencies had substantially reduced livestock numbers from levels of the earlier 1900s. While these decisions were primarily made in the interests of the range resource, the wildlife resource benefitted.

The resources responded to these changing policies. Despite a widespread stereotype to the contrary among environmentalists, range condition on western public lands has improved demonstrably in the eyes of observers close to the western ranges. Wildlife populations, too, have responded. Pronghorn numbers have increased in several states, as have bighorned sheep.

Agency management policies changed in 1982, particularly in BLM, which witnessed a back–sliding of policies toward commodity uses and away from noncommodity resources. While BLM's operating budget did not change significantly between 1981 and 1985, its Energy and Minerals budget increased by nearly 60 percent, at the expense of renewable resource program funds. Personnel in BLM's wildlife programs have been reduced by a third, and range management has sustained reductions. At the same time, the agency has relaxed its restrictions on mining abuses and livestock trespass.

Changes are not so evident in the USFS. Emphasis is still directed to riparian zone concerns. Thomas Roederer, Deputy Regional Forester for Resources in the Intermountain Region, recently stated that wildlife management will be a major area of emphasis in the region in the future. Yet, in the past few years, the USFS has phased out most of the extensive and excellent range management research that provided important insights for both range and wildlife management in the 1950–80 era.

At this juncture, crystal balls become hazy. One could become pessimistic about the future plight of wildlife on western rangelands. With an agency tilt toward the commodity uses, declining emphasis on wildlife programs, at least in BLM, and budget cuts in all agencies to address the national deficit, one could paint a gloomy scenario for wildlife's future on public land. But an alternate prognosis might also be as plausible. Nearly all the commodity uses of western lands are in difficult economic straits. The livestock industry is suffering some of the same difficulties as the other aspects of American agriculture. Most of the mining and minerals businesses are struggling to compete internationally. Even the energy area, expected 10 years ago to explode on the western scene, is depressed and not expected to improve in the near future.

The result may well be a relaxing of commodity pressures on western lands that will work to the benefit of wildlife. We have already seen an 86–percent decline in the sheep industry in the last 40 years—perhaps a harbinger of other less–drastic changes. After rising steadily for more than a century, cattle numbers stopped growing in the mid–1970s, and have since remained essentially stable in some states and declined in others. Federal land–retirement programs, dairy cattle buy–outs and reversion of irrigated land to natural vegetation as a result of falling groundwater levels may all ease competitive pressure and increase habitat. Conceivably, conditions could improve for western wildlife, not so much because of advertent wildlife management policies and programs but, as so often has been the case, because of pervasive socio-economic trends.

Even if this latter scenario unfolds, there will still be problems. The West's rapidly growing human population will produce increased outdoor recreational demands on resources that are fragile because of their aridity. The challenge will be to regulate use to the maximum degree allowed by *ecological realities*.

Certain ecological changes underway are cause for concern. In the northern Great Basin, the shrub–steppe vegetation has been invaded by exotic, annual plants that increase with such disturbance as grazing. They do not compete successfully with healthy, perennial vegetation except in very wet years. Where and when they do grow, they are fuel for fires that burn out the perennial overstory. The result is a conversion to a uniform, annual vegetation that burns periodically and semipermanently blocks succession of perennials—generally impoverishing the biota.

Clearly, the West is changing ecologically. These changes need to be better understood if we are to promote rational management policies and programs. There is an urgent need for intensified research on the western biota to elucidate the nature of these changes and to develop an understanding of how they can be manipulated for the public good. That need has become all the more immediate with the sharply reduced emphasis on range research in the federal agencies.

Forests

There are four major forestland management and research issues now and for the immediate future. First is the loss of total forest acreage, which, on the global scale, is one of the most important ecological and socio–economic problems of our time. Fuelwood supplies, for instance, have reached crisis proportions in almost all "Third World" countries. Closer to home, 60 percent of North America's remaining wetlands are forested, and these wetlands are being lost faster than are prairie potholes or estuaries.

The second problem is that of fragmentation of remaining forests into patches too small to sustain viable, original biological communities. Problems ensuing from "fragmentation" include altered microclimates, loss of "interior" species and wide–ranging cursorial mammals, and the negative impact on original forest species of aggressive "edge" species, via predation, nest parasitism and competition.

Problem number three is the conversion, via current forestry practices, of original hardwood (or mixed hardwood/conifer) stands to fast–growing conifer plantations. Certain points should be made clear in this regard: (1) as a general rule, hardwood (or mixed hardwood/conifer) forests offer much better wildlife habitat than do conifer "plantations"; (2) conifer plantations are *not* "forests"; and (3) the foresters' "ideal" conifer plantation offers little if anything to or for wildlife. The tradeoff from a pure or mixed hardwood forest to a pine plantation is replacement of rare or uncommon plant and wildlife species by "backyard" or "weed" species (again, both plants and animals).

Fourth among current forest problems is the internal degradation of existing stands. Included are liquidation of old–growth forests, their replacement with single-species plantations, and "Timber Stand Improvement" (TSI), which boils down to eliminating any organism judged less than ideal for "fiber production." Of course, TSI means removing such wildlife habitat as "wolf trees," snags, down wood, etc.

Hence, we end up reporting a national "forest acreage" that isn't forest at all. It is, instead, in many cases, "hardweed" acreage, dominated by invasive, weedy species that have the potential to produce 20 cubic feet per acre (1.4m^3/ha) annual growth—wildlife, biological communities, or not.

We don't need more federal laws to assist wildlife and ecological communities on forest lands. We have the 1960 Multiple Use Sustained Yield Act, the Resources Planning Act with 1978 amendments to the National Forest Management Act, the Forestry Incentives Program (FIP) and, finally, the 1985 Farm Bill.

The problem for farmlands, rangelands and forest lands is not a lack of federal legislation. It is, instead, the failure of such legislation to provide sufficient, substantive support to address wildlife issues, on the land. It is a convenient argument to state that professional wildlifers have not done all they should in terms of "input." Agreed; we have not. Yet, without research dollars so badly needed, what can be expected?

Fish and Wildlife: From Neglect to Action

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Conservationists of every stripe continue to express their concern for the future of fish and wildlife resources. Such cries are scarcely new—their echoes linger in the halls of academe, in sporting clubs, in birding and outdoor societies, and in the voluminous professional and popular literature from an army of writers. We have heard many of these concerns repeated here today, yet the discovery of additional threats to the welfare of fish and wildlife and their habitats continues with regrettable frequency. As never before, the swift currents of human expansion and accelerating technology relentlessly erode the habitat and populations of fish and wildlife across the full sweep of our nation and, indeed, our globe.

The picture is not all black, of course, as the restoration of wood ducks and the replenished salmonid fishery in the Great Lakes are among the successes to which we can point with pride. Yet for every success or even would-be success, more than a score of other management concerns languish for want of an adequate foundation of research. We have heard today of failed arenas—those of contaminants, aquatic and wetland systems, endangered species, and diminished landscapes whether urban or rural—where policies either are unfounded, ill-directed, or altogether lacking in regard to fish and wildlife resources. The alarming plight of wetlands alone illustrates these concerns.

The keynote address for this session underscored three points (Labisky et al. 1986). First, universities possess the critical elements for research—the professional talents of their staff and students aligned with an infrastructure designed for the delivery of research products. A broad spectrum of expertise and facilities lies at hand in academe for the direct and indirect support of fish and wildlife research. Even a partial listing of the supporting areas represents an impressive array of disciplines, including, among others, chemistry, entomology, hydrology, geology, agronomy and geography. Laboratory and other facilities go hand-in-hand with each of these. But perhaps most of all, we underscore the commanding presence of the university library. Moreover, university research exists and indeed thrives in a climate largely free of political or other external influences that at times might compromise sensitive investigations (e.g., lead versus nontoxic shot).

Second, authorization for viable research generally exists, both generically and specifically, in the mandates of the lead federal agencies. Yet, the worthiness of that authority too often remains unaccompanied by the requisite funding. The patient simply withers without the life-blood of research dollars.

Finally, we must link the component of research for fish and wildlife resources with the issues of the day, and not isolate these as independent and therefore "expendable" programs. That is, our concerns must become strong threads in those fabrics having broad and substantial legislative support (e.g., habitat research vis-a-vis many kinds of federal construction and improvement programs).

How might these points be enmeshed into a viable strategy leading to improved funding for fish and wildlife research? Many ideas undoubtedly will come forth in the days ahead. For now, however, we suggest that our political efforts be directed toward strengthening existing legislation with language similar to what was known as the "Stevens Amendment" to Interior's appropriations bill—only with reverse logic. Instead of *denying* the expenditure of funds for a specific purpose (the Stevens measure prohibited funding for the purpose of enforcing federal steel-shot regulations without state-by-state approval), let new provisions *require* that not less than 1.5 percent of the funds associated with land- and/or water-based legislation be earmarked for fish and wildlife research. Thus, legislation such as the recently approved Farm Bill would require an obligatory research component dedicated to fish and wildlife resources in relation to the land-use practices it promulgates. Other parts of such legislation would remain inert if the bill lacked a clearly stated and adequately funded component for natural resources research. Similarly, legislation enacting urban renewal projects might include funds for wildlife research in urban environments, as would those for dams, power plants and other federal projects (especially those requiring environmental impact statements).

Revenues from the sales of special stamps, income tax check-offs and, especially, the bedrock of the "P-R" and "D-J" restoration acts no longer keep pace with demands for information on which to base modern policy decisions. Responsible stewardship assuring the renewability of those natural resources for which we claim professional responsibility clearly requires an unending stream of new knowledge. To meet those ends, basic as well as applied research must proceed unimpeded by shortfalls of funding. In few other disciplines is funding for basic research so lacking as it is in fish and wildlife sciences. Most funding agencies are preoccupied with mission–oriented research, much of which is only short-term in nature, whereas the sectors that might support basic fish and wildlife research are far too limited. Indeed, basic research must go forward for fish and wildlife resources for the same reasons as those that enabled advances in other sciences. The lunar voyage of Neil Armstrong was not possible merely because of a crash course in applied rocket propulsion, but also because of the fundamental academic toil of Einstein, Newton, Galileo and Copernicus. We believe a commitment is needed to fish and wildlife sciences that draws from current authority, timely issues and available talent. Let us proceed from neglect to action.

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Registered Attendance

ALABAMA
Guy Baldassarre, M. Keith Causey, Gene Chelstad, James R. Davis, Mike Lisano, Charles E. Mayo, Luther M. Owen, Jr., John Pritchett, Sam L. Spencer, Lee Stribling

ALASKA
Ed Bangs, A. W. (Bud) Boddy, Thelma M. Boddy, Laun J. Buoy, Dave Cline, Bruce Conant, Greg Cook, Lloyd H. Fanter, Ben L. Hilliker, Phil Janik, Junior D. Kerns, Jim King, Robert L. Newell, W. Lewis Pamplin, Jr., Mike Penfold, Tom Pogson, Ann L. Rothe, Thomas C. Rothe, James S. Sedinger, Gerald F. Shields, Randy G. Tweten, Victor Van Ballenberghe, Gordon W. Watson, Mrs. Gordon W. Watson, Ken Whitten, Vernon R. Wiggins

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